Article published online: 2022-12-09

Understanding the Acceptability of Health Apps among Adolescents: A Qualitative Study

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ACI Open 2022;6:e103–e113.

Abstract

Background Almost all adolescents aged 13 to 17 in the United States have access to a smartphone. While studies have commonly assessed the feasibility or usability of mobile health applications ("apps"), few have examined the acceptability of apps—whether individuals would actually use these health apps in their everyday lives—among adolescent populations.

Objectives This qualitative study aims to understand how adolescents assess the acceptability of health apps in the context of their everyday lives.

Methods Nineteen adolescents in grades 7 through 9 were asked to download a health app before participating in two semi-structured interviews 2 weeks apart. Seven domains from the Theoretical Framework of Acceptability were assessed: affective attitude, burden, ethicality, intervention coherence, opportunity costs, perceived effectiveness, and self-efficacy. A Grounded Theory approach was used to analyze data.

Results The seven acceptability domains plus two additional themes, intervention expectations (what adolescents anticipated given their experiences with other apps) and peer norms (friends' beliefs and attitudes toward the intervention's health topic), were salient.

Conclusion These nine domains of acceptability are relevant to adolescents and should be assessed during health app development by app developers and health researchers to improve adolescents' acceptability perceptions and potentially increase app usage.

Keywords
- mHealth
- smartphones
- adoption
- qualitative

Background and Significance

Mobile health (mHealth) interventions are promising public health and health care interventions because they can be more affordable, easier to use, and more readily adopted[1] compared to in-person interventions. mHealth interventions also facilitate real-time data collection and feedback, lowered participant burden, and increased flexibility for tailoring.[2] Distinct from the broader field of electronic health (eHealth) which involves using the internet and related technologies to organize and deliver health services,[3,4] mHealth is defined as using mobile communications for health interventions and information and involves the use of portable devices that are capable of creating, storing, retrieving, and transmitting data in real time to improve the safety, quality of care, and health of end users.[5] From January 2015 through January 2021, Statista reported that the number of health apps available in the Apple App Store increased from approximately 28,000 to close to 54,000.[6] As the number of available health apps continues to increase, there is growing evidence that health apps are effective in

received
February 4, 2022
accepted after revision
September 11, 2022

DOI https://doi.org/10.1055/s-0042-1758461.
ISSN 2566-9346.

Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

changing an array of health behaviors and improving health outcomes.[1,2,7,8]

In the United States, 95% of adolescents aged 13 to 17 have consistent access to smartphones.[9] Among adolescents with smartphones, 90% say they are on the internet at least several times a day, with half of connected adolescents saying they are on the internet "constantly."[9] Health applications (i.e., "apps"), a specific type of mHealth intervention, have been developed for adolescent populations to address a variety of health topics including human immunodeficiency virus prevention,[10] weight management,[11] and teen pregnancy prevention,[12] and have been effective in changing behaviors among adolescents for obesity prevention, type 2 diabetes management, and medication adherence.[2,7,13] In addition, health apps have the potential for greater reach and lower overall costs compared to other health and health care interventions that also target adolescents.[14,15] However, only 21% of U.S. adolescents have ever downloaded a health app[16,17] and, of these, 47% hardly ever or never use them.[16] To maximize the potential of health apps for adolescent health, researchers and app developers need to better understand how to build health apps that are acceptable to adolescents and engage and retain them. However, acceptability is conceptualized and operationalized inconsistently across the field of public health.

Researchers have started to examine adolescents' perceptions of acceptability of specific health apps using qualitative methods and have identified facets of acceptability that are important. For example, researchers developing a mental health app for adolescents identified that safety, engagement, awareness, and accessibility were some factors that impacted adolescents' perceptions of acceptability for this specific mental health app.[18] Another set of researchers found that perceived health benefits and preferences for social and cultural contexts were important to app acceptability for an adolescent sleep app.[19] A third set of researchers identified appraisal, usability, safety, benefits, and agency and control were the acceptability factors most salient to a sample of adolescents testing a health app for adolescents who self-harm.[20] However, to date there has not been an effort to identify foundational domains of acceptability for health apps among adolescents that cross-cut different topics and expected changes to behavior, which our study seeks to do.

Moreover, given that different subgroups of adolescents are adopting health apps at different rates, it is also important to measure the acceptability of health apps to make sure that they are indeed acceptable to their desired subgroups. While there are limited national data on health app trends among adolescents, a recent study analyzed data from the National Cancer Institute's 2015 Health Information National Trends Survey and found that the main adult users of health apps were individuals who were younger (adults between 18 and 44 years old vs. 45+ years old), had more education (some college or college graduate vs. high school or less), reported excellent health (reported excellent, very good, or good health vs. fair or poor health), and had a higher income (U.S. $50,000 or more vs. U.S. $0–49,999).[21] If we generalize these findings to adolescents, they would suggest that the majority of the adolescents who use health apps are likely to be adolescents who report excellent health or who come from households with parents with higher education levels or higher incomes. However, adolescent health researchers are designing health apps for various subgroups of adolescents—not just those who come from families with high incomes or the ones who report excellent health. Therefore, it is important for researchers to be able to first measure how acceptable health apps are among adolescents (and subgroups of adolescents), and then understand what makes some health apps more likely to be accepted by some adolescents than others. This will enable researchers and developers to develop health apps that adolescents will want to use in their everyday lives to achieve the intended health outcomes.

Currently, researchers define the acceptability of interventions differently, both in their conceptual and operational definitions, which is problematic because acceptability cannot be measured consistently without a common definition. Conceptual definitions define a construct in abstract or theoretical terms, whereas an operational definition defines a construct by specifying the procedures used to measure that construct.[22] Many studies claim to assess the acceptability of interventions, but the authors do not include conceptual or operational definitions in their published manuscripts, thus limiting others' ability to compare or interpret results across studies.[23–25]

Objectives

This study aimed to understand how adolescents assess health app acceptability, understood as whether an individual would want to use a particular health app in their everyday life. As a guiding framework, we utilized the Theoretical Framework of Acceptability (TFA), which conceptualizes acceptability as a necessary condition for intervention effectiveness, and includes seven domains of acceptability for health-related interventions: affective attitude, burden, ethicality, intervention coherence, opportunity costs, perceived effectiveness, and self-efficacy (►Table 1).[22] Several mHealth and health app studies have also used the TFA to conceptualize acceptability in their intervention design studies.[26–28] While the TFA was developed based on research with adults, there is no similar framework that exists for adolescents. Therefore, we have chosen to use the existing TFA as the basis for this study and will explore the relevance of these domains for this adolescent population.

Methods

We conducted semi-structured interviews with a school-based convenience sample of adolescents to qualitatively explore the construct of health app acceptability. Adolescents were asked to download and use a mobile app preselected by the research team that corresponded to one of their health interests. We documented acceptability at two

Table 1 Theoretical Framework of Acceptability domains

Domain	Definitions
Affective attitude	How an individual feels about the intervention
Burden	The perceived amount of effort that is required to participate in the intervention
Ethicality	The extent to which the intervention has good fit with an individual's value system
Intervention coherence	The extent to which the participant understands the intervention and how it works
Opportunity costs	The extent to which benefits, profits, or values must be given up to engage in the intervention
Perceived effectiveness	The extent to which the intervention is perceived as likely to achieve its purpose
Self-efficacy	The participant's confidence that they can perform the behavior(s) required to participate in the intervention

in-person interviews 2 weeks apart. The interview guide (**Appendix A**) was based on the TFA and included questions about each acceptability domain. While the authors who developed the TFA listed the acceptability domains, they did not present a visual depiction of the framework. We have created ►**Fig. 1** below to show the relationship between the domains and the larger latent construct of acceptability.

Recruitment

We set out to recruit up to 20 participants. We aimed to recruit a diverse sample based on gender (at least 8 of both male and female), race/ethnicity (at least 2 participants who identified as White, at least 2 who identified as African American, and at least 2 who identified as Latino), and urbanicity (at least 2 participants who attended an urban school, at least 2 participants who attended a rural school). From January to March 2018, the research team emailed the leaders of 10 public and charter schools in central and eastern North Carolina. All 10 schools had at least 25% of their student population qualify for free- or reduced-price meals. Five schools responded and became recruitment sites. From April to May 2018, recruitment letters were sent home with all students in grades 7, 8, and 9. Interested participants completed an eligibility screener form that asked for demographic information and also asked participants to rate how much they cared about six health topics: exercising, eating healthy, staying hydrated, monitoring menstrual cycle for pubertal biological females (not prepubertal biological females or biological males), getting enough sleep, and reducing stress or anxiety (four-point Likert scale from "A lot" to "Not at all" with an "N/A" option for the menstrual cycle question). Interested participants submitted the eligibility screener to a designated teacher or school administrator along with completed parental consent and participant assent forms. In order to be eligible, participants needed to be in grades 7, 8, or 9; have their own smartphone; and not be in the Occupational Course of Study at school. This study was approved by the Office of Human Research Ethics at the University of North Carolina at Chapel Hill (IRB 17-2975).

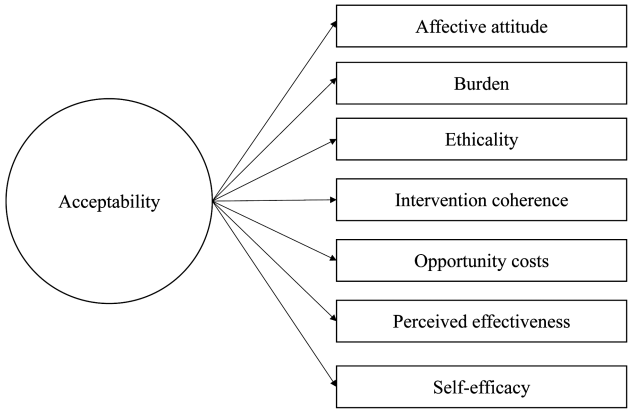

Fig. 1 Theoretical Framework of Acceptability. This figure depicts the seven domains of acceptability put forth by Sekhon et al.

Data Collection

Each participant was contacted by phone or emailed to schedule their first in-person semi-structured interview. This interview covered smartphone, app and health app use, decision-making processes for downloading and using apps, and health interests and concerns. Then, participants were asked to choose one app from the six preselected apps that corresponded to a highly ranked health topic of interest from their initial screening. The health apps chosen for this study were recommended by *Teen Vogue*[29] or were listed as top Health & Fitness apps in the iTunes App Store at the time of the study.[29,30] Health apps were chosen to cover a variety of health topics and ones with more ratings were prioritized over those with fewer for the same health topic. The six health apps included: BodySpace (exercising), Fooducate (eating healthy), Headspace (reducing stress or anxiety), Sleep Cycle (getting enough sleep), Spot On (monitoring your menstrual cycle), or WaterLogged (staying hydrated) (Bodybuilding.com, n.d.; Day Logger, n.d.; Fooducate, n.d.; Headspace Inc., n.d.; Planned Parenthood Federation of America, n.d.; Sleep Cycle AB, n.d.). It was confirmed that apps recommended by *Teen Vogue* were still highly rated (4+ stars) in both iTunes and Google Play App Stores at the time of the study.

Participants used the app for 3 to 5 minutes and then answered questions about each of Sekhon et al's seven acceptability domains.[22] For sample questions that align with each of the TFA domains, see ►**Table 2**. At the end of the interview, participants confirmed a date and time for

Table 2 Interview guide questions for Theoretical Framework of Acceptability (TFA) domains

TFA domain	Sample interview guide question
Affective attitude	How do you feel about using the app itself?
Burden	How hard do you think it will be for you to use this app every day?
Ethicality	How well does this app help you do something that is important to you?
Intervention coherence	Describe how you think this app works.
Opportunity costs	What might you miss out on by using the app?
Perceived effectiveness	Do you think this app will help you [insert app purpose]? Why or why not?
Self-efficacy	How confident are you that you can [insert behavior desired by app]? For example, how confident are you that you can use the app to track your food calories?

the second interview 2 weeks later, and were instructed to use the health app as much or as little as they desired before the next interview.

In the second interview, participants were asked about their health app experience, including many of the questions from Interview 1. Participants were asked if they still had the app on their phones and whether they had used the app at least once since the first interview. Those who had deleted the app were asked to explain why.

Interviews lasted an average of 24 minutes (range: 18–40 minutes) and took place at the student's school to lessen transportation barriers. Participants received a $30 VISA gift card after the second interview for the completion of both interviews. Interviews were recorded and transcribed verbatim by the first author.

Analysis

We conducted an *abductive analysis*—an analytic approach with foundations in Grounded Theory—to construct our theory.[31] Abductive analysis is "a creative process of producing new hypotheses and theories based on surprising research evidence" and combines both deductive processes and inductive processes.[31] We chose an approach with foundations in Grounded Theory in order to distance ourselves from the technical literature and personal experience to see new possibilities in the data; avoid standard ways of thinking about phenomena; and stimulate the inductive process.[32] We developed a codebook by breaking data into "manageable pieces" and ideas were grouped under themes (i.e., parent codes) that corresponded to each of the seven TFA constructs[33] (deductive), and other "surprising" ideas were grouped into new constructs through open coding (inductive).[32] For example, deductive coding led to grouping together quotations that described barriers to using the app like, "It'll be hard to use the app," and these quotations were grouped within the larger theme of "burden." Following the abductive approach,[32] the analysis also allowed for the emergence of potential new constructs related to acceptability. The codebook was developed by all co-authors and used to systematically code all transcripts using Atlas.ti version 1.0.36. In addition, the first author memoed and diagrammed relationships among the analytic concepts (i.e., axial coding). The transcripts, memos, and diagrams were reviewed by all co-authors and we reached consensus with regards to the study findings. The codebook of parent codes and sub-codes are contained in **Appendix B**.

Results

The demographic forms and characteristics of the first 20 enrollees were examined and the inclusion and recruitment criteria were met with regard to sample diversity. There were three enrollees who were waitlisted. Twenty enrollees were emailed and invited to participate and the first author interviewed 19 participants representing a diverse sample of adolescents with regards to gender, age, race/ethnicity, and the rurality/urbanicity of the school they attended (►**Table 3**). Given the focused nature of our topic of study (acceptability of health apps) and our target population, this sample size was sufficient to reach saturation, as determined by hearing repetition of key themes and limited new information provided during interviews 16 through 19.[34,35]

The majority of the participants identified as Black or African American ($n = 11$; 61%), three identified as Hispanic/Latino (17%), and most were age 14 ($n = 11$; 61%). More than half lived in a rural county ($n = 10$; 56%) and the majority had iPhones ($n = 17$; 90%). Prior to the study, only three participants had a health app installed on their phone (FitBit, $n = 1$; Sweatcoin, $n = 2$) beyond the phone's preinstalled generic health apps.

Each participant downloaded one of the six preselected health apps that aligned with a health topic they indicated interest in via their eligibility screener: BodySpace[36] ($n = 6$), WaterLogged[37] ($n = 4$), Headspace[38] ($n = 4$), Fooducate[39] ($n = 2$), Sleep Cycle[40] ($n = 2$), and Spot On[41] ($n = 1$). All 19 participants completed both interviews; 68% ($n = 13$) reported using the app at least once after their first interview.

Themes

In addition to the seven TFA domains, two additional themes emerged from the analysis: (1) intervention expectations (whether the app met, exceeded, or fell short of what adolescents anticipated given their experiences with other apps) and (2) peer norms (friends' and classmates' beliefs and attitudes about the intervention's health topic). These two themes were added as domains in an expanded TFA (►**Fig. 2**).

Table 3 Study participant characteristics ($n = 19$)

	Characteristic	*n*	%
Gender	Male	10	52.6
	Female	8	44.4
	Nonbinary	1	5.3
Grade	7th grade	4	21.0
	8th grade	9	47.4
	9th grade	6	31.6
Age	13	6	33.3
	14	11	61.1
	15	2	11.1
Race	American Indian/Alaska Native	1	5.6
	Asian	1	5.6
	Black/African American	11	61.1
	Native Hawaiian/Other Pacific Islander	0	0
	White	5	22.2
	Other	1	5.6
Ethnicity	Hispanic/Latino	3	16.7
Rurality/urbanicity	Rural	10	55.6
	Nonrural	9	50.0
Type of smartphone	iPhone	17	89.5
	Android phone	2	10.5

Updated Theoretical Framework of Acceptability for Health Apps among Adolescents

We found that some participants' views on intervention coherence and perceived effectiveness changed between the first and second interviews, but that the views on the remaining domains were consistent over time. Change status was classified as "some change" when participants used language like "more" or "less" (e.g., "Now I know more about how the app works compared to last time" or "I think that this app would be less effective than I originally thought because it doesn't send me reminders") when comparing their current to earlier views. These findings are summarized in ►Table 4. The following results are presented according to the updated framework's nine themes.

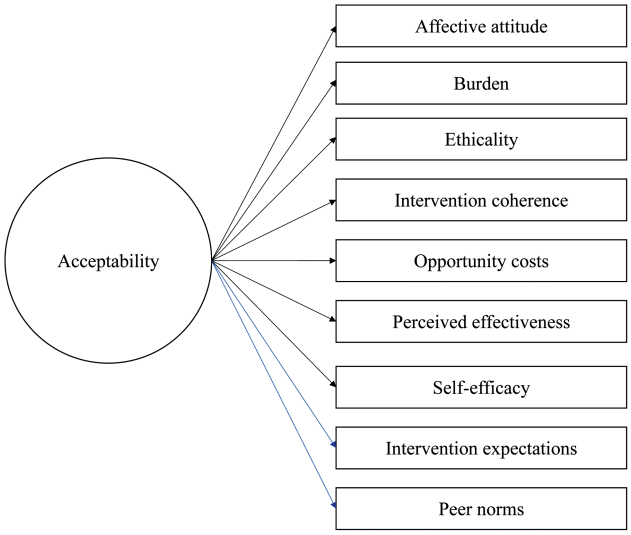

Fig. 2 Updated Theoretical Framework of Acceptability for health apps among adolescents. This figure depicts the seven domains of acceptability put forth by Sekhon et al as well as the two additional domains of intervention expectations and peer norms given the a results of our study.

Affective Attitude

Participants generally did not indicate how the app made them feel, but ascribed adjectives to the apps like "helpful" and "motivating" and used verbs including "liked," "disliked," "enjoyed," and "hated." Many participants articulated why they either liked or disliked the app, and many of the reasons related to other TFA domains or specific features of the app. For example, one participant said, "I like that you can post, go live, and the Explore page is filled with funny videos that everybody sees" (P6, Spot On). Responses to questions about affective attitude did not differ meaningfully from the first to the second interview.

Burden

Many participants said that the health app they downloaded would be easy to use. They referred to the simplicity of the design and the app components (i.e., features). With regard to the visual design, one participant said, "I don't think it'd be

Table 4 Change on acceptability domains between Interview 1 and Interview 2

Domain	Change status between interviews
Affective attitude	No change
Burden	No change
Ethicality	No change
Intervention coherence	Some change
Opportunity costs	No change
Perceived effectiveness	Some change
Self-efficacy	No change

that hard [to use the app daily] because the interface is simple... there are only three categories: Alarm, Statistics, and Trends so you gotta do one of those" (P7, Sleep Cycle). While several participants described benefits of a low burden to use the health app, others did not want to use apps that were too simple. For example, one participant stated, "It wouldn't be hard to use [Fooducate], but I wouldn't want to. I don't like really simple things—it doesn't give you much" (P3, Fooducate). Between the first and second interviews, views on burden remained consistent.

Ethicality

Participants were able to characterize the health topics' importance but did not go further to describe how these health topics related to their personal value systems. For example, one participant said, "Since staying hydrated is an important thing for me, it will help me stay hydrated because if I fill this whole water bottle up with things that I drink, then I'll know that I do good and need to keep it up" (P5, WaterLogged). While participants did not explicitly indicate whether using the apps supported or went against their personal values, some shared that they cared about the health topics, suggesting that the apps aligned with their personal values. Another participant stated, "My health is very important to me because it will carry along with me as I grow up. I care about my body cuz as a female I need to take care of my body" (P6, Spot On). On the other hand, other participants indicated that they sometimes care about the health topic but that it was contingent on other circumstances. For example, one participant said, "It's like during the week days, I don't care about sleep. On weekends I catch up on my sleep" (P7, Sleep Cycle). How participants conceptualized ethicality in relation to the health apps did not differ meaningfully between first and second interviews.

Intervention Coherence

After interacting with the newly downloaded health app for 3 to 5 minutes, approximately three-quarters of the participants were able to describe how the health app worked in detail (74%; $n = 14$). For example, after their brief interaction, one participant described how the WaterLogged app worked as follows:

> You click on water bottle and then it fills it up and if you reach the goal, then you're doing good. If you don't reach your goal, then you need to step it up. You fill the water bottle. Say for example you had just drunk two bottles of water, then you click here and then enter two water bottles...I played with the app and made a mistake. I saw that when you click on the water bottle that the water fills up and was like that's how you do it.–P5, WaterLogged

Many participants offered that they figured out how to use the health app through trial and error, and were able to describe at least one feature of the app. In contrast, approximately one-quarter of the participants (26%; $n = 5$) were not able to describe how the health app worked after interacting with it for a few minutes; these five participants tested three different apps. They described their apps as "confusing" and that they did not know what they were supposed to do in the apps. When asked if more time spent with their app would help, four out of five said no.

At the second interview, perceptions of intervention coherence changed as 18 participants were able to articulate how the app worked compared to 14 participants in the first interview, and descriptions were longer and more detailed than at the initial interview. For example, one participant (P3, Fooducate) described how one could use the Food Finder feature in Fooducate to scan food items and learn about calorie counts for different food options, enter the number of calories consumed in the Health Tracker feature, and then share progress updates in the Community feature.

Opportunity Costs

Participants raised very few opportunity costs in either interview. Occasionally, participants offered that they may lose out on spending time on other apps (e.g., Snapchat, Instagram) in order to use the health app, or would prefer to do other activities than using the health app. One participant offered what she would rather do than use the BodySpace app: "I prefer going to the gym or getting a Shaun T. [workout] video tape…he dances with it…" (P15, BodySpace). Similarly, others claimed that using the same app would be a "waste of time" but did not offer alternatives to how they would spend their time (P9, BodySpace). Views were consistent across time points.

Perceived Effectiveness

Participants quickly assessed perceived effectiveness of the app, and their responses fell into two broad categories: (1) the app will work for me ($n = 14$) and (2) the app will not work for me ($n = 5$). Among users in the first group, participants articulated what the app would help them do. For example, after testing out the Spot On period tracker app for a few minutes, one participant said, "It'll help me track my period because when I first had [my period] I didn't know what to do and how to respond. I would get upset because I was stressed. I think the app will help me and myself track and be aware of it" (P6, Spot On). Some participants believed that their health app would be effective in changing behavior

Table 5 Illustrative quotes for reasons for perceived effectiveness of health app

Reasons for perceived effectiveness of health app	Illustrative quote
Helps them do something they have already tried to do in the past better	"I work out every day already and if I'm going the same thing every day then I'm just not gonna want to do it. The app has different things so it's gonna push me to try different exercises." (P8, Bodyspace)
Delivers real-time feedback	"It helps me better my sleep so…if I'm sleeping poorly, the app would give you everything that happened through the night so that you can do better." (P7, Sleep Cycle)
Goes at their own pace	"[Bodyspace] motivates me to complete my goals without forcing me to do anything and lets me go at my own pace." (P11, Bodyspace)
Holds them accountable	"I think that this app would be helpful because I could stay on myself about drinking water. And I [am] doing good or bad with my goal?" (P5, WaterLogged)
Motivates them	"I'm very competitive and like to beat stuff and complete a goal. I'm going to set me a high goal so that I can beat that during the day." (P16, WaterLogged)

because the app delivered real-time feedback on how participants could improve their behavior, allowed participants to go at their own pace, held them accountable, or motivated them. ►Table 5 provides examples of illustrative quotes for each of these reasons.

Participants who expressed that their health app would not work for them in changing health behaviors cited several reasons, including the health app does not teach them anything new, they already use another app or do something else that is more helpful than this app to change the targeted health behavior, they do not believe that they are affected by the health problem the app is trying to address, or the app is boring.

In the second interviews, a handful of participants changed their perceptions of perceived effectiveness. Among participants who indicated that the app would be effective for them at the first interview (74%, $n = 14$), a few participants ($n = 4$) changed their minds in the second interview and shared that they believed the app would *not* be effective for them. One participant who originally thought that the BodySpace app would increase her level of physical activity shared that her experience using the app had the opposite desired effect because the app was harder to use than she expected. She said, "I didn't find it helpful for me personally…it made me want to work out less" (P12, BodySpace).

Self-Efficacy

Participants were also able to quickly assess their level of confidence in their ability to use the health app to perform the desired behavior in the app (e.g., track calories, watch a workout video, listen to guided meditations) within minutes of using the app for the first time and talked about their self-rated confidence along with their intent to use the app. Three groups emerged from the first interview: one group of participants was confident that they could use the app and intended to use it; one group was confident that they could use the app but did not intend to use it; and one group was not confident that they could use the app and did not intend to use it.

Participants who were confident that they could use the app and intended to use it (74%, $n = 14$) offered when they planned to use the app next. For example, one participant said:

> [I'm] pretty confident [I can use BodySpace] because I'm always by my phone and it's not that hard to set a goal and make it happen if you're committed to it...I want to see changes in my own self and build muscle and increase my stamina…I'll use it next at home today.–P11, BodySpace

Of the participants who were confident that they could use the app but did not intend to use it after the first interview (16%, $n = 3$), one of these participants stated, "I'm real sure I can use the app but I don't feel like it. Yeah, if I like it and feel like using it, then I'd use it every day, but nah, I don't got no interest in it" (P3, Fooducate). They were able to separate their self-efficacy to use the app from their intentions to use the app.

Lastly, there were two participants (11%) who expressed low confidence in their ability to use the app and therefore did not intend to use the app. When asked about his confidence to use the app after the first interview, one participant offered, "[I'm] not that confident cuz I'd probably forget about it because I don't think it'd help me" (P18, BodySpace). This self-efficacy assessment was related to the participants' perceived effectiveness of the app and the potential to forget about the health app. Several participants noted that they might forget about the app because they have so many apps on their phones.

At the second interview, participants' perceptions of self-efficacy to use the app were consistent with what they expressed in the first interview. Among the 14 participants who indicated high self-confidence to use the app and intentions to use the app, 13 (93%) shared that they used the app at least once since the first interview.

Intervention Expectations

This is one of the two new emergent themes. When participants were asked what they liked or disliked about the health app, they often compared the health app to other apps

or indicated whether or not the app met their expectations for that kind of health app (e.g., fitness app, period tracker app). For example, one participant who tested BodySpace said, "…When I think of fitness apps I think it tells you a routine or what you should eat or do and this is more do-it-yourself and to just keep track of what you should do" (P18, BodySpace). In this case, the BodySpace app did not meet his expectation for what a fitness app should do. The same participant went on to complain that "[BodySpace] isn't Instagram" and that users should not be posting pictures of themselves working out in a fitness app. On the other hand, some participants liked that the intervention reminded them of other social media apps. Another participant who tested out the BodySpace app said, "It's like another version of Instagram except it's an exercising app and it seems really cool" (P9, BodySpace).

Peer Norms

This second emergent theme of peer norms about the app's health topic was raised across several interviews. When discussing phone usage in general, many participants indicated that they liked using apps, and social media apps in particular to "see what everyone's doing" (P2, Headspace). Participants often referenced "friends," "other people," or "other teens" when talking about the severity and prevalence of the different health topics, especially when justifying why they cared about particular ones. When talking about the health apps and whether others would use them, participants often described the health apps as "cool" (P2, Headspace; P7, Sleep Cycle), "pretty cool" (P12, BodySpace), "very cool" (P4, Waterlogged), and "really cool" (P9, BodySpace; P13, Headspace).

Discussion

mHealth interventions for adolescents have been effective at changing health knowledge, behaviors, and outcomes ranging from increased sexual and reproductive health knowledge to increased medication adherence to improved self-management for chronic diseases like asthma and diabetes.[7,14,42–45] With 95% of adolescents aged 13 to 17 having consistent access to smartphones,[9] adolescent health researchers who design new health apps can apply the results of this study to improve their acceptability; more specifically, researchers can begin to qualitatively or quantitatively assess the nine domains of acceptability for existing and new health apps and study which of these are most important for adolescents.

Findings from our qualitative interviews confirmed that the seven domains of the TFA were relevant to the adolescents in our sample and led us to better understand how adolescents assess the acceptability of health apps. While the TFA was initially developed for health care interventions, we believe that this framework is appropriate to evaluate the acceptability of health apps and to evaluate interventions targeting adolescents. Moreover, there was evidence to expand the conceptualization of acceptability when applied to health apps for adolescents by including the additional domains of intervention expectations and peer norms. Only perceptions of intervention coherence and perceived effectiveness seemed to change between the initial and follow-up interviews. Additional qualitative and quantitative studies[46] will need to be conducted using this updated framework to confirm whether it is effective to evaluate acceptability for health app interventions, for interventions targeting adolescents, and for health apps that target adolescents. More specifically, it will be important to develop an acceptability scale that includes items covering the nine domains of acceptability and to determine whether the scale demonstrates good reliability and validity for different samples of adolescents and across different health apps.

Researchers such as Alaiad, Alsharo, and Alnsour[47] have conducted related studies to identify the determinants of mHealth adoption and found that performance expectancy, effort expectancy, social influence, perceived health threat, and mHealth quality were predictive of adult patients' intentions to use mHealth interventions in developing countries. Many of these determinants overlap with the domains of acceptability for health apps noted in our study. For example, performance expectancy is related to intervention expectations and social influence is related to peer norms. In addition, our findings align well with many of the motivational factors identified by previous adolescent health researchers focused on mHealth interventions.[18–20] Specifically, Kenny et al[18] and Grist et al[20] identified "young people in control" and "agency and control" as aspects of health app acceptability which directly relate to our self-efficacy domain. In addition, Quante et al[19] and Grist et al[20] both cite perceived health benefits as an important facet of acceptability which overlaps with our perceived effectiveness domain. One area where our findings differ is that we do not have a domain that explicitly captures "social interaction" as Kenny et al[18] propose. Social interactions could be considered within our intervention expectations domain, e.g., features that facilitate social interactions with other users may be expected from health apps. However, this should be further explored.

Peer norms are also important to adolescents, and perceptions of their peers' health norms shape adolescents' own attitudes about health behaviors such as smoking cigarettes, drinking alcohol, using a seat belt, exercising, and healthy eating.[48–51] However, only a few studies among adult populations[52] have assessed the effect of peer norms on health app usage. Moreover, while several mHealth studies cite the importance of cultural norms[53] and social norms[54] in the development of mHealth interventions, norms are often not explicitly measured or their effects studied on mHealth intervention usage. It will be important to operationalize the measurement of peer norms and determine whether they are predictive of actual health app use among adolescents.

Furthermore, while outcome expectations (i.e., anticipated results) have been studied in mHealth,[54–57] examining intervention expectations of health apps is novel. It is important for researchers to better understand what adolescents expect from a health app in order to create features

and user interfaces that meet or exceed expectations. This would, in turn, lead to apps that are more acceptable and will hopefully lead to increased usage and improved associated health outcomes.

In addition, we identified a tension for apps to find the optimal level of complexity, as both confusing and overly simplistic apps seemed to hinder engagement and deter sustained use. Adolescents also sometimes forgot about health apps even if they enjoyed using it in their first interaction and thought it was useful. User testing may also help identify and prioritize ways to remind adolescents about the existence of the health apps (e.g., push notifications, daily content).[58,59]

Lastly, while the premise of this study is grounded in the evidence that health apps for adolescents may be beneficial at changing knowledge, attitudes, and behaviors for specific and even more general health topics, there is also growing evidence that the amount of time that children and adolescents spend on screens is harmful.[60–62] Elevated amounts of screen time are associated with decreased sleep, obesity, anxiety, and depressive symptoms.[60–62] Specifically, social media usage has been linked with increased loneliness, increased narcissism, and decreased self-esteem among adolescents.[63–65] While the research studies about the risks and benefits of screen time and social media usage continue to yield mixed results, it is important to note *how* technology is used and *in what context* technology is used matter and will need to be further studied.[66] All in all, these conflicting findings raise ethical questions for mHealth and health app researchers more broadly about whether they want to encourage a behavior that is linked with a host of negative health consequences even though it may also be linked with positive health outcomes.

Limitations

Several study limitations are important to note. First, participants were recruited from a convenience sample of schools in North Carolina, so it is possible that findings would have been different if the participants had been from different high schools in North Carolina or high schools from other states, especially since we recruited schools where at least 25% of their student population qualified for free- or reduced-price meals. Second, we relied on self-reports at the second interviews rather than app-recorded usage metrics (paradata) to gather data on whether and how much participants used the downloaded health app after their first interview. As such, we were not able to collect usage data from our participants. It is also possible that being enrolled in the study, knowing that they would be re-interviewed, and knowing that they would be compensated in the end impacted their behavior. Therefore, this study itself and our study protocol may have influenced participants' app usage, which we should keep in mind as we design future studies. Third, we selected the six health apps that participants could choose to download. It is possible that we would have had different results if we had selected a different set of health apps or given participants the opportunity to choose health app themselves. Lastly, this was a qualitative study intended to generate theory and requires further psychometric evaluation in a larger sample to test and validate the hypothesized construct.

Conclusion

Study findings can assist adolescent health researchers strengthen the *acceptability* of health apps to make them more likely to be used by adolescents. Nine domains of acceptability are salient as adolescents interact with health apps for the first time, and these domains should be assessed to improve acceptability perceptions. Additional research should be conducted with different samples of adolescents using a different set of health apps to see whether findings are consistent with the ones reported in this study. Moving forward, studies on the acceptability of health apps should include complementary qualitative and quantitative components. As the field of mHealth continues to burgeon, further research will also be necessary to identify, measure, and then improve health apps and other mHealth interventions to make them more likely to be adopted and used in the real world.

Clinical Relevance Statement

Nine domains of acceptability are salient as adolescents interact with mHealth apps for the first time: affective attitude, burden, ethicality, intervention coherence, intervention expectations, opportunity costs, peer norms, perceived effectiveness, and self-efficacy. Researchers, clinicians, and app developers should strengthen and measure these domains as well as assess the relationships between the acceptability, usage, and outcomes of health apps among adolescents.

Protection of Human and Animal Subjects

This study was approved by the Office of Human Research Ethics at the University of North Carolina at Chapel Hill (IRB 17-2975).

Funding

None declared.

Conflict of Interest

None declared.

Acknowledgements

We would like to acknowledge the American Association of University Women for supporting the first author through their Dissertation Fellowship program.

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