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Original Paper

Clustering of Obesity-Related Risk Behaviors Among Families With Preschool Children Using a Socioecological Approach: Cross-Sectional Study

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Abstract

Background: Limited attention has been given to assessing home environments of parents with preschool-aged children using a socioecological approach to better understand potential influencers of obesity risk.

Objective: The purpose of this cross-sectional study was to examine the clustering of obesity-related risk behaviors among mothers with preschool children.

Methods: Mothers with preschool-aged children (ages 2 to 5 years) who participated in the online Home Obesogenic Measure of Environments (HOMES) survey were examined in clustering of four healthy recommended behaviors (ie, mother's fruit and vegetable intake ≥ 5 per day, sedentary screen time < 4 hours per day, sugar-sweetened beverage intake < 1 time/day, and increased physical activity level). Frequencies and percents of the clustering variables were conducted along with Spearman rank order correlations to determine significant associations. Ward's method with squared Euclidean distances were performed for the cluster analysis using the four standardized continuous variables. Identification of total cluster number was determined by visually inspecting the dendrogram. Sociodemographic, intrapersonal, social environment, and home physical environment characteristic differences between cluster groups were further examined by independent t tests and chi-square analysis to validate findings.

Results: Of the 496 participants (72.6%, 360/496 white; age mean 32.36, SD 5.68 years), only a third (37.1%, 184/496) consumed five or more servings of fruits/vegetables daily, had low sedentary screen time of < 4 hours/day, and reported moderate to high levels of physical activity (34.1%, 169/496). More than half (57.7%, 286/496) consumed < 1 sugar-sweetened beverage serving daily. A positive correlation ($r = .34$, $P < .001$) between physical activity level and fruit/vegetable intake (≥ 5 servings/day), and a positive correlation ($r = .15$, $P = .001$) between low sedentary screen time (< 4 hours/day) and low sugar-sweetened beverage intake (< 1 serving/day) were found. Ward's hierarchical analysis revealed a two-cluster solution: less healthy/inactive moms ($n = 280$) and health conscious/active moms ($n = 216$). Health conscious/active moms were significantly ($P < .010$) likely to be more physically active, have lower sedentary screen time, lower daily intake of sugar-sweetened beverages, and greater daily intake of fruits and vegetables compared to less healthy/inactive moms. Less healthy/inactive moms were significantly more likely to have a higher body mass index and waist circumference compared to the other cluster; however, there were no significant sociodemographic differences. There were many intrapersonal (eg, importance of physical activity for child and self) and home physical environment (eg, home availability of fruits/vegetables and salty/fatty snacks) characteristic differences between clusters, but few significant differences emerged for social environment characteristics (eg, family meals, family cohesion).

Conclusions: Findings may have implications in tailoring future obesity prevention interventions among families with young children.

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KEYWORDS

obesity; family; preschool children; socioecological; risk factors; environment; home; physical activity; screen time

Introduction

In the United States, more than one-third of children are either overweight or obese [1]. The high prevalence rate among all pediatric age groups, in both sexes, and in various ethnic and racial groups has been at a steady climb over the last three decades and this trend continues to this day [2]. Additionally, the overall estimated annual medical costs and physical and mental health consequences of obesity are very high [3].

An energy imbalance in which too few calories are expended for the amount of calories consumed is often the primary focus of obesity research and interventions; however, the many intrapersonal and environmental (social and physical) factors facilitating this energy imbalance are critical to understand. The socioecological model posits that health and well-being of an individual is determined by multiple levels of influence [4]. At the macro level, factors such as economic policies and political and legal structures (eg, gross domestic product) have a more indirect effect in influencing behaviors. At the micro level, factors of the near physical environment (eg, home, neighborhood), family social environment, and intrapersonal characteristics more directly influence behaviors.

Application of ecological theory in obesity research has indicated that intrapersonal characteristics, social environments, and physical environment factors all play a role in obesity [5]. Environments that lack support for weight-management behaviors make it difficult for individuals to engage in behaviors that prevent weight gain. Currently, obesity prevention interventions in children younger than 5 years of age have shown limited effectiveness in reducing or limiting weight gain [6], perhaps due to little attention being given to the social and physical environments within which diet and physical activity behaviors are endorsed [7].

The research to date on the prevention and treatment of obesity among children and adults highlights the importance of increased consideration of the social and physical environment [8]. At the micro level, the home environment is shared among parents and their children. Parents are considered the “gate keepers” of the home and role models for their children. That is, parents can strongly influence food and physical activity behaviors and practices which, in turn, may influence their child’s obesity risk [9,10]. Prior research has reported a number of parent and social and physical environment factors in the home associated with children’s overweight status, such as limited physical activity supports [11], infrequent family meals [12], low household availability of fruits and vegetables [13], excessive sedentary screen time [12], and less parental modeling of healthy behaviors [14].

Mothers, in particular, can have a strong influence on their child’s weight-related behaviors from a young age that develop during the preschool years and track later into childhood and adulthood [15-19]. Given the home environment may influence child obesity risk, it is important to better understand these factors. Limited attention has been given to comprehensively

assess the home environment of parents with preschool-aged children using a socioecological approach with reliable and validated measures, which is necessary for better understanding the potential influencers of obesity risk among families with young children [20]. Thus, a secondary analysis from a rich dataset of socioecological factors related to the obesogenic home environments of mothers with preschool-aged children (2 to 5 years of age) was examined to assess the clustering of obesity-related behaviors.

Methods

The Institutional Review Board at Rutgers University approved this research study. All participants gave informed consent to participate.

Recruitment

A global research company (ie, Survey Sampling International) whose services include survey participant recruitment, sent invitations to panel members who were mothers in the United States, inviting them to complete the online Home Obesogenic Measure of Environments (HOMES) survey [4,21,22]. Recruitment notices asked mothers to participate in a survey to help researchers “learn more about families with young kids” and to help them develop “a program for parents to build healthier kids.” To be eligible, panel members had to be female, 18 to 45 years of age, English speaking, have at least one preschool child (aged 2 to 5 years), and be the main household food gatekeeper (ie, make most or all food purchasing and meal decisions). Participants and their spouse/partner could not be employed in a health-related profession. As an incentive to complete the survey, participating mothers accrued points from Survey Sampling International that were redeemable for gifts.

Instruments

Details on the development and content of the online HOMES survey and research protocol are described elsewhere [4,21,22]. In brief, the HOMES cross-sectional survey was developed by researchers at Rutgers University as part of a larger research study exploring obesity risk in mothers of young children and included an array of valid, reliable measures that focused on mother’s sociodemographic, health-related, intrapersonal, social, and home physical environment characteristics. Measures were selected to yield an understanding of socioecological factors pertaining to diet and physical activity. All measures were self-reported and underwent rigorous selection to ensure they were valid and reliable. The survey was posted online using Qualtrics platform and pilot-tested with 48 participants to gauge completion time, identify further refinements needed to improve clarity and ease of completion, ensure protocols for scoring of scales were accurate, and conduct preliminary psychometric analyses. Administration of an online format was chosen for ease of data collection and convenience to participants, to help reduce the potential for social desirability bias that can occur during in-person administration, and to increase researcher ability to reach individuals who would be otherwise difficult to

access (ie, distance from researchers or limited time to meet in-person). [Multimedia Appendix 1](#) lists the variables used in this secondary analysis of the online survey including number of items, possible score range, scale type, and internal consistency (Cronbach alpha when applicable).

Sociodemographics and Health-Related Characteristics

Maternal sociodemographic data collected included race/ethnicity, highest education level achieved, number of children in the household, family affluence [23,24], and food insecurity risk [25]. Health-related characteristics assessed were general health status (Centers for Disease Control and Prevention [CDC] Health-Related Quality of Life) [26,27], depression severity (Patient Health Questionnaire-2) [28], body dissatisfaction (Eating Disorder Examination Questionnaire) [29], and primary relative with history of obesity.

Weight Status and Waist Circumference

Mothers reported their current height, weight, and waist circumference. Height and weight were used to calculate body mass index (BMI) as recommended by the CDC [30]. Mothers reported their child's height and weight, which were used to calculate age- and sex-specific child BMI percentile.

Intrapersonal Characteristics

Mothers' weight-related behaviors assessed were physical activity level (streamlined International Physical Activity Questionnaire) [31-33] and sleep quality and duration (Pittsburgh Sleep Quality Index) [34,35]. Maternal dietary intake was assessed using the following food frequency questionnaires: Block Fruit-Vegetable-Fiber Screener, Block Dietary Fat Screener [36-38], and a sugar-sweetened beverage screener [39]. Maternal eating styles measured from the Three-Factor Eating Questionnaire-18 [40,41] were disinhibited eating, emotional eating, and dietary restraint eating. Mothers' self-perceptions assessed were personal organization [42], need for cognition [43,44], parenting self-efficacy [45,46], stress management [47], and stress management self-efficacy (created de novo). Value of engaging in healthy behaviors for self and child (eg, encouragement and facilitation of children's physical activity, importance of modeling physical activity to children, frequency of engaging in active play with children, parent modeling healthy eating) [11,21,48-50] were also measured.

Social Environment

Family meal patterns and family meal environment (eg, frequency of meals, family meal atmosphere) [11,51-55] data were collected. Scales assessing family functioning and engagement included family conflict and lack of cohesion [56-58], and family support for healthy behaviors [59-61].

Home Physical Environment

Evaluation of the home environment's accessibility and availability to physical activity and sedentary activity supports (eg, media devices in the home, TV accessibility for child) [11,48-50,60,62,63] were assessed along with measures of household food availability (eg, fruit/vegetables, sugar-sweetened beverages) [36,39,64-66].

Obesity-Related Behaviors

It was decided *a priori* that healthy recommended behaviors, such as mother's fruit and vegetable intake of five or more per day, sedentary screen time (<4 hours per day), sugar-sweetened beverage intake (<1 time/day), and increased physical activity level, would be the variables used in clustering mother's obesity-related behaviors. Currently, the Dietary Guidelines for Americans [67] recommend adults consume 5 to 9 servings of fruits and vegetables per day and limit the amount of daily sugar-sweetened beverage consumption; thus, a cut-off of five or more fruits and vegetables per day and less than one serving of sugar-sweetened beverage intake per day, respectively, were proxies for healthy behaviors. Although the American Academy of Pediatrics recommends parents monitor and limit their preschool child's screen time to less than 1 hour per day, there are no set time limits for adults [68]. For this reason, a liberal approach was taken in giving a cut-off of less than 4 hours daily of sedentary screen time for mothers. Physical activity levels, using the streamlined International Physical Activity Questionnaire [31-33], were categorized into low, moderate, and high levels using cut-off scores previously set by other researchers [31,33]. That is, self-report physical activity level was calculated as: (number of days walking per week) + 2 * (number of days moderate-intensity activities per week) + 3 * (number of days vigorous-intensity activities per week), with a possible score range of 0 to 42 (categorized as low: 0 to <20; moderate: 20 to <30; high: ≥30 physical activity levels).

Statistical Analysis

Frequencies and percents of clustering variables were examined to describe the sample of mother's meeting these defined fruit and vegetable intake, sugar-sweetened beverage intake, sedentary screen time, and physical activity level behaviors. Before clustering, correlations among the four cluster variables were examined to determine significant associations using Spearman rank order correlations. For cluster analysis, the clustering variables were standardized (*z* scores) to permit comparisons of means and variances [69]. The four clustering variables (ie, mother's physical activity level, sedentary screen time, daily fruit and vegetable intake, and sugar-sweetened beverage intake) were considered as continuous variables in the model. Ward's method with squared Euclidean distances was used for the cluster analysis using the standardized continuous variables mentioned previously. Ward's method was used because it has yielded useful results in previously similar settings [70], and tends to result in clusters of more equal size, which increases the robustness of cross-cluster comparisons [71]. The number of clusters that emerged was identified by visually inspecting the dendrogram and noting the point at which the scree graph angled most sharply upward.

To further establish how the two clusters differed from one another, variables used in the cluster analysis as well as intrapersonal, social environment, and home physical environment variables not used in defining the clusters, were examined using independent *t* tests for continuous variables and chi-square analysis for categorical variables. Given the large number of tests, *P* values were reduced to *P*<.010 to be

considered statistically significant. All analyses were performed using SPSS version 24.

Results

Participant Characteristics

A total of 496 participants (72.6%, 360/496 white; age mean 32.36, 5.68 SD years) with complete and plausible data were included in the analyses (48 had implausible numbers for sedentary screen time [≥ 15 hours per day] and three each had missing data for daily fruit/vegetable servings and sugar-sweetened beverage intake). More than one-third of participants (37.1%, 184/496) met daily fruit and vegetable serving recommendations of five or more and had relatively low sedentary screen time of less than 4 hours per day (Table 1). More than half of participants (57.7%, 286/496) consumed less than one sugar-sweetened beverage serving daily. Sugar-sweetened beverages included soft drinks, fruit drinks, energy drinks, and sugar-sweetened specialty coffee drinks.

Additionally, approximately one-third (34.1%, 169/496) of mothers reported moderate to high levels of physical activity in the last week.

Spearman rank order correlations revealed a positive correlation ($r=.34$, $P<.001$) between physical activity level and fruit and vegetable intake (≥ 5 servings/day), and a positive correlation ($r=.15$, $P=.001$) between low sedentary screen time (<4 hours/day) and low sugar-sweetened beverage intake (<1 serving/day; Table 2).

Cluster Group Characteristics

Ward's hierarchical analysis revealed a two-cluster solution for the participants using the four standardized measures (ie, mother's physical activity level, sedentary screen time, daily fruit and vegetable intake, and sugar-sweetened beverage intake). The two clusters of mothers were broadly divided as less healthy/inactive moms ($n=280$) and health conscious/active moms ($n=216$).

Table 1. Proportions of mother's fruit and vegetable intake, sedentary screen time, sugar-sweetened beverage intake, and physical activity level (N=496).

Description	n (%)
Fruit/Vegetable intake (≥ 5 servings/day)	184 (37.1)
0 to <2 servings	51 (10.3)
2 to <3 servings	72 (14.5)
3 to <4 servings	72 (14.5)
4 to <5 servings	117 (23.6)
5 to 6 servings	79 (15.9)
≥ 6 servings	105 (21.2)
Sedentary screen time (<4 hours/day)	186 (37.5)
0 to 2 hours	30 (6.0)
2 to <4 hours	156 (31.5)
4 to <6 hours	146 (29.4)
6 to <8 hours	68 (13.7)
≥ 8 hours	96 (19.4)
Sugar-sweetened beverage intake (<1 serving/day)	286 (57.7)
Physical activity level	
Low	327 (65.9)
Moderate	115 (23.2)
High	54 (10.9)

Table 2. Spearman rank correlations among healthy behaviors of mothers with a preschool child (N=496).

Variable	1	2	3	4
1. Parent physical activity level	—	.335 ^a	.012	-.026
2. Fruit and vegetable intake (≥ 5 servings/day)		—	.026	-.043
3. Sedentary screen time (<4 hours/day)			—	.150 ^a
4. Sugar-sweetened beverage intake (<1 serving/day)				—

^a $P<.001$.

Table 3. Independent *t* tests and chi-square tests of sociodemographic, intrapersonal, interpersonal, and home environment characteristics of participants by cluster (N=496).

Variable	Less healthy/inactive moms (n=280)	Health conscious/active moms (n=216)	<i>t</i> ₄₉₄	χ^2_1	<i>P</i>
Sociodemographic characteristics					
Age, mean (SD)	32.67 (5.57)	31.97 (5.81)	1.36		.17
Black or African American, non-Hispanic, n (%)	24 (8.6)	23 (10.7)		0.6	.43
White, non-Hispanic, n (%)	216 (77.1)	144 (66.7)		6.7	.01
Low education attainment (some college or less; % yes), n (%)	158 (56.4)	143 (66.2)		4.9	.03
Maternal employment, n (%)				6.5	.01
Do not work	167 (59.6)	104 (48.2)			
Part- or full-time work	113 (40.4)	112 (51.9)			
Number of children in household, mean (SD)	2.14 (0.91)	2.30 (1.13)	-1.77		.08
Family affluence score, mean (SD)	5.48 (1.58)	5.73 (1.55)	-1.73		.00
Food insecurity risk, mean (SD)	1.99 (1.96)	2.00 (1.80)	-0.09		.93
Health-related assessments					
Body mass index (BMI), mean (SD)	28.52 (8.46)	26.41 (6.71)	3.11		.002
Waist circumference, mean (SD)	35.81 (7.79)	33.38 (6.63)	3.74		<.001
Child BMI percentile (n=446), ^a mean (SD)	61.27 (34.33)	66.71 (35.28)	-1.63		.10
General health status, ^b mean (SD)	2.65 (0.83)	2.25 (0.86)	-5.21		<.001
Depression severity, mean (SD)	1.13 (1.48)	0.98 (1.45)	1.08		.28
Body dissatisfaction, mean (SD)	2.73 (1.11)	2.37 (1.09)	3.64		<.001
Primary relative with history of obesity (% yes), n (%)	118 (42.2)	63 (29.2)		8.9	.003
Intrapersonal characteristics					
Maternal weight-related behaviors					
Physical activity level, ^c mean (SD)	10.83 (8.19)	21.37 (8.64)	-13.87		<.001
Screen time,^c mean (SD)	306.8 (174.8)	311.53 (185.09)	-0.29		.77
<4 hours/day, n (%)	105 (37.50)	81 (37.50)		0	>.99
Sleep duration, mean (SD)	6.99 (1.36)	7.02 (1.62)	-0.24		.81
Sleep quality, mean (SD)	3.13 (0.89)	3.40 (0.89)	-3.39		.001
Maternal dietary intake					
Fruit and vegetable (servings/day),^c mean (SD)	3.16 (1.23)	6.38 (1.78)	-22.73		<.001
≥5 servings/day, n (%)	9 (3.2)	175 (81.0)		316.3	<.001
Milk (servings/day), mean (SD)	3.06 (2.93)	4.96 (2.89)	-7.20		<.001
Sugar-sweetened beverage^c (servings/day), mean (SD)	0.76 (0.71)	0.99 (0.98)	-2.89		.004
<1 serving/day, n (%)	165 (58.9)	121 (56.0)		0.4	.52
Maternal eating styles, mean (SD)					
Disinhibited eating	1.94 (0.71)	1.97 (0.81)	-0.34		.74
Emotional eating	2.14 (0.88)	1.97 (0.87)	2.12		.04
Dietary restraint eating	2.36 (0.72)	2.53 (0.75)	-2.53		.01
Maternal self-perceptions, mean (SD)					
Personal organization (self-effectiveness)	3.55 (0.83)	3.82 (0.80)	-3.65		<.001
Need for cognition	3.29 (0.98)	3.75 (0.92)	-5.34		<.001

Variable	Less healthy/inactive moms (n=280)	Health conscious/active moms (n=216)	t_{494}	χ^2_1	P
Parenting self-efficacy	3.99 (0.82)	4.23 (0.75)	-3.42		.001
Stress management	3.87 (0.81)	4.02 (0.70)	-2.12		.03
Stress management self-efficacy	2.49 (0.98)	2.81 (1.01)	-3.48		.001
Health behavior values, mean (SD)					
Importance of physical activity for self	3.17 (0.95)	3.92 (0.79)	-9.60		<.001
Importance of physical activity for child	3.63 (0.86)	4.10 (0.79)	-6.30		<.001
Encourages/facilitates child physical activity	4.10 (0.66)	4.40 (0.62)	-5.06		<.001
Importance of modeling physical activity to child	3.93 (0.84)	4.41 (0.68)	-7.07		<.001
Engages in physical activity with child frequently	3.06 (1.71)	4.40 (1.73)	-8.59		<.001
Models physical activity to child frequently	2.69 (1.17)	3.59 (1.07)	-8.86		<.001
Less frequency of modeling sedentary behaviors	2.81 (2.27)	2.87 (2.11)	-0.293		.770
Social environment					
Family meal patterns, mean (SD)					
Family meal frequency/week	13.04 (5.20)	14.67 (4.49)	-3.73		<.001
Importance of family meals	4.48 (0.62)	4.61 (0.61)	-2.38		.02
Positive family meal atmosphere	4.05 (0.84)	4.23 (0.86)	-2.33		.02
Family functioning and maternal engagement, mean (SD)					
Family support for healthy behaviors	4.47 (0.55)	4.31 (0.92)	2.22		.03
Family conflict	1.88 (0.88)	1.81 (0.94)	0.87		.38
Family cohesion	4.07 (0.75)	4.29 (0.66)	-3.52		<.001
Home physical environment					
Home environment: physical activity, mean (SD)					
Physical activity availability	3.63 (0.73)	3.96 (0.54)	-5.85		<.001
Physical activity accessibility (n=524)	4.14 (1.21)	4.37 (0.99)	-2.28		.02
Media devices in the home, mean (SD)					
Daily screen time child allowed	557.09 (840.51)	380.14 (469.98)	2.97		.003
Home environment: food availability, mean (SD)					
Household fruit and vegetable availability (serving/person/day)	5.59 (2.28)	7.48 (2.23)	-9.25		<.001
Household fatty/salty snack availability (serving/person/day)	7.41 (6.37)	9.52 (8.03)	-3.17		.002
Household sugar-sweetened beverage availability (serving/person/day)	1.65 (1.55)	2.07 (2.02)	-2.55		.01

^aTotal children with biologically plausible data reported by mother (n=446; poor health/inactive moms: n=256, health conscious/active moms: n=190).

^bHigher scores indicate poorer general health status.

^cVariable included in cluster analysis.

Health conscious/active moms were significantly likely to be more physically active, have lower sedentary screen time, lower daily intake of sugar-sweetened beverages, and greater daily intake of fruits and vegetables compared to less healthy/inactive moms (Table 3). These two clusters were further validated when examining associations with maternal health status, weight, and intrapersonal, social environment, and the home physical environment characteristics.

There were no significant sociodemographic characteristic differences between the two clusters, except health

conscious/active moms had a greater tendency to be employed (part-time/full-time) and be white, non-Hispanic. Less healthy/inactive moms were significantly more likely to have a higher BMI and waist circumference, and have a primary relative with a history of obesity compared to the other cluster. However, there were no significant differences between cluster groups on their child's BMI percentile. Additionally, less healthy/inactive moms reported greater body dissatisfaction and poorer general health status compared to health conscious/active moms.

There were many intrapersonal characteristics that differed between the two clusters. For example, less healthy/inactive moms were significantly more likely to have lower sleep quality and consume less daily servings of milk compared to health conscious/active moms. Additionally, health conscious/active moms were significantly more likely to have greater personal organization, need for cognition, parenting self-efficacy, and stress management self-efficacy compared to less healthy/inactive moms. Nearly, all health behavior value variables were significantly different between the two clusters. That is, health conscious/active moms were significantly more likely to place greater importance on physical activity for self and their child, and encourage and model physical activity for their child compared to less healthy/inactive moms.

The only social environment characteristics that differed between the two clusters was family meal frequency and family cohesion. That is, health conscious/active moms had significantly more family meals per week and more family cohesion compared to less healthy/inactive moms.

As anticipated, health conscious/active moms' home physical activity environments had significantly greater availability of physical activity and stricter limits on children's daily screen time compared to less healthy/inactive moms. Additionally, health conscious/active moms had greater availability in the home for fruits and vegetables, fatty/salty snacks, and sugar-sweetened beverages compared to less healthy/inactive moms.

Discussion

Principal Results

Overall, cluster analysis findings demonstrate two distinct patterns of obesity-related behaviors among mothers of preschool-aged children as evidenced by the external validation of clusters when examining associations with maternal health status, weight, intrapersonal, social environment, and the home physical environment characteristics. Comparing behavioral profiles of mothers of young children assigned to groups via cluster analysis adds qualitative insights, which may improve tailoring of interventions intended to effect behavior change. Thus, the two-cluster profiles found in our study may have implications for future obesity prevention interventions among families with young children.

Obesity-related behaviors were not strongly defined by sociodemographic characteristics, variables typically used to tailor nutrition interventions. Instead, a number of health-related variables and anthropometric markers (ie, weight status, waist circumference) were related to cluster membership. For instance, less healthy/inactive moms had a higher BMI, waist circumference, body dissatisfaction, and poorer general health status compared to health conscious/active moms. Given the negative health outcomes associated with membership in the less healthy/inactive moms cluster and mothers' influence on their children living in the same home environments [70], interventions that focus on improving obesity-related risk behaviors of mothers with young children are warranted.

The four obesity-related variables (ie, mother's physical activity level, sedentary screen time, daily fruit and vegetable intake, and sugar-sweetened beverage intake) used to define clusters in this study may be useful markers for tailoring obesity interventions. However, regardless of cluster groupings, a large proportion of participants were still not meeting the recommended daily intakes of fruits and vegetables along with suggested limits of daily sedentary screen time and sugar-sweetened beverage intake [67]. Further examination of cluster groupings by intrapersonal, social environment, and home physical environment characteristics illustrates the complexity of obesity and potential target areas for influencing behavior change among mothers with preschool-aged children. This study found cluster grouping associations at all levels; however, more significant associations were found at the intrapersonal and home physical environment levels suggesting parents might be strong influencers of their child's behaviors.

Comparison With Prior Work

Prior research has found concordance of clustering patterns between children and their mothers suggesting that modeling of obesity-related risk behaviors by parents may be particularly important influences on children's behavior [70]. Although not formerly tested in this study, health conscious/active moms reported significantly greater health behavior values on the importance of modeling physical activity for their child and placing limits on child sedentary screen time compared to less healthy/inactive moms. Both physical activity levels and eating behaviors of parents are predictive of obesity in children [72]. Additionally, prior research has found a positive relationship between family support and increased physical activity along with family-based obesity treatment programs being the most effective at combating pediatric obesity [73]. Thus, obesity interventions that are family based may be more effective when encouraging parents to improve their own obesity-related risk behaviors along with developing the parenting skills needed to model these same healthy behaviors for their children.

Over time, diets have changed dramatically during the preschool period with an increase intake of added sugars that persists into adolescence [74]. Interestingly, health conscious/active moms had greater home availability of fruits and vegetables per family member, but also greater home availability of low nutrient-dense foods, such as sugar-sweetened beverages and salty/fatty snacks. Having greater availability of these food items does not necessarily correlate with greater food consumption of these low nutrient-dense food items. Future research should further explore whether greater availability of high nutrient-dense versus low nutrient-dense foods in the home has any direct effect on food intake and, in turn, obesity risk.

Limitations

Taking a simplistic approach can obscure true interrelationships between health behaviors [75]. Considering the complexity of behaviors is important when developing obesity prevention interventions; however, it is also important to note that cluster analysis is an exploratory technique. The cluster profiles observed in our study may have differed with the inclusion of different variables, clustering algorithm, or sample. Other limitations are the cross-sectional design that limits the ability

to make inferences of causality from the observed associations, and the potential for reporting error and bias given all information was self-reported by participants. Although the sample included mothers of preschool-aged children who had demographics similar to the overall US population, findings may not be generalizable to fathers or families with children of different ages and in other countries.

Conclusions

Despite these study limitations, this is one of only a few studies that have examined the clustering of obesity-related risk behaviors in mothers of preschool-aged children. Additionally,

this study took a socioecological approach to comprehensively examine an array of obesity-related risk behavior factors among mothers with preschool-aged children using reliable and validated measures. Given the strong influence mothers have on their child's weight-related behaviors during the preschool years and subsequent years following into adulthood [15-19], study findings further suggest targeting obesity prevention interventions using a socioecological approach that encourages mothers to model positive health behaviors for their children at the intrapersonal, social environment, and home physical environment levels. Future research assessing the value of this socioecological approach is warranted.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Descriptive Statistics of Sociodemographic, Intrapersonal, Interpersonal and Home Environment Characteristics of Participants (N=496).

[PDF File (Adobe PDF File), 42KB - [pediatrics_v1i1e10320_app1.pdf](#)]

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Abbreviations

BMI: body mass index

HOMES: Home Obesogenic Measure of Environments

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Original Paper

Combining Activity Trackers With Motivational Interviewing and Mutual Support to Increase Physical Activity in Parent-Adolescent Dyads: Longitudinal Observational Feasibility Study

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Abstract

Background: An essential component of any effective adolescent weight management program is physical activity (PA). PA levels drop dramatically in adolescence, contributing to the rising prevalence of adolescent obesity. Therefore, finding innovative interventions to address this decline in PA may help adolescents struggling with weight issues. The growing field of health technology provides potential solutions for addressing chronic health issues and lifestyle change, such as adolescent obesity. Activity trackers, used in conjunction with smartphone apps, can engage, motivate, and foster support among users while simultaneously providing feedback on their PA progress.

Objective: The objective of our study was to evaluate the effect of a 10-week pilot study using smartphone-enabled activity tracker data to tailor motivation and goal setting on PA for overweight and obese adolescents and their parents.

Methods: We queried enrolled adolescents, aged 14 to 16 years, with a body mass index at or above the 85th percentile, and 1 of their parents as to behaviors, barriers to change, and perceptions about exercise and health before and after the intervention. We captured daily step count and active minutes via activity trackers. Staff made phone calls to dyads at weeks 1, 2, 4, and 8 after enrollment to set daily personalized step-count and minutes goals based on their prior data and age-specific US national guidelines. We evaluated dyad correlations using nonparametric Spearman rank order correlations.

Results: We enrolled 9 parent-adolescent dyads. Mean adolescent age was 15 (SD 0.9) years (range 14-16 years; 4 female and 5 male participants); mean parent age was 47 (SD 8.0) years (range 36-66 years). On average, adolescents met their personalized daily step-count goals on 35% (range 11%-62%) of the days they wore their trackers; parents did so on 39% (range 3%-68%) of the days they wore their trackers. Adolescents met their active-minutes goals on 55% (range 27%-85%) of the days they wore their trackers; parents did so on 83% (range 52%-97%) of the days. Parent and adolescent success was strongly correlated (step count: $r=.36$, $P=.001$; active minutes: $r=.30$, $P=.007$). Parental age was inversely correlated with step-count success ($r=-.78$, $P=.01$).

Conclusions: Our findings illustrate that parent-adolescent dyads have highly correlated PA success rates. This supports further investigation of family-centered weight management interventions for adolescents, particularly those that involve the parent and the adolescent working together.

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KEYWORDS

adolescent obesity; activity trackers; dyads; motivation; physical activity; adolescent health; pediatric obesity; fitness trackers; parent-child relations; motivation; exercise

Introduction

Childhood and adolescent obesity have a significant lifelong impact on both the individual and the health care system. The prevalence of adolescent obesity (12-19 years) in the United States is approximately 21%, up from 5% only 30 years ago [1]. Obese adolescents are more likely to have both acute and long-term chronic health problems related to their obesity, including prediabetes, cardiovascular disease, and psychological comorbidities [2].

A crucial component of any effective adolescent weight management program is physical activity (PA) [3]. Yet PA levels drop dramatically in adolescence, contributing to the rising prevalence of adolescent obesity [4-6]. While the US national guidelines typically recommend 60 minutes daily of PA or 12,000 steps per day for children and teens [7-10], research indicates that even a modest amount of PA can have health benefits for high-risk youth [3]. Additionally, studies of step counts have found that a more modest daily step count (10,000-11,700 steps/day) may be appropriate for overweight adolescents [11]. Finding effective and sustainable ways to increase PA among these high-risk youth, at this crucial developmental stage, requires novel and innovative interventions. Nonetheless, despite this growing epidemic, developing effective interventions for this population remains a challenge [12].

The growing field of health technology, including smartphone apps and activity trackers, provides potential solutions for addressing chronic health issues and lifestyle change, such as adolescent obesity. These types of apps appeal to and are accessible to the adolescent demographic. As of 2015, the Pew Research Center found that 73% of US adolescents have access to a smartphone [13]. Additionally, a wealth of options that specifically target increasing PA, such as wearable activity trackers, are gaining popularity [14]. These trackers can be used in conjunction with smartphone apps to engage, foster support, and motivate while simultaneously providing feedback on progress. Many available wearable activity tracker apps include behavioral change techniques such as self-monitoring, feedback, and goal setting but often do not provide sufficient motivation to encourage consistent activity over time [15]. Enhancing these basic behavioral change techniques with personalized, tailored interaction with the study team, as well as participation within a parent-adolescent dyad, is a potential strategy to increase PA in this population.

To effectively leverage this technology, it must be combined with established tenets of childhood obesity management. In addition to the roles of diet and PA, one such tenet is the caregiver's or parent's role in weight management [16,17]. In our previous research, we found that caregivers want to be involved in a weight management intervention for their adolescent child, at the level of both development and administration of the weight management intervention [18].

Despite evidence of the important role of the parent in their child's weight management [16,17], only a small percentage (12.3%) of mobile apps that have addressed pediatric obesity involved the family [19]. To address this growing epidemic of adolescent obesity, we evaluated the feasibility and preliminary efficacy of a novel intervention that combined this critical element of parental support with motivational interviewing techniques driven by participant activity tracker data.

Methods**Study Population**

Our pilot study recruited parent-adolescent dyads from participants in an earlier caregiver survey study [18] and from 2 ambulatory office sites in our hospital's catchment area. Eligible adolescents were between 13 and 16 years of age and had a body mass index at or above the 85th percentile for their height and sex. We selected this minimum age because the activity tracker used, Jawbone UP MOVE (Jawbone, San Francisco, CA, USA), is only approved for use by individuals aged 13 years and older. We selected this maximum age because preliminary caregiver survey data [18] suggested that older adolescents' lifestyles generally would not be conducive to participating in an intervention with their parent. Eligible participants needed to speak English, have a regular health care provider for medical clearance, have access to a smartphone, and be willing to speak to a research assistant on a regular basis.

Development of Motivational Scripts and Intervention Tools

We used data from an electronic medical record database review, a caregiver survey study, a health care provider focus group, and key informant input from experts in epidemiology, psychology, and pediatric weight management to inform development of the 10-week, multimodal intervention for parent-adolescent dyads. An electronic medical record clinical data analysis of all patients seen within Stony Brook Children's Hospital's outpatient pediatric offices (Stony Brook, NY, USA) and inpatient unit in 2013 provided insight into demographics and general trends in the catchment area's overweight and obese population. Next, a self-administered caregiver survey [18] and a small focus group of pediatric weight management providers helped us better understand the best modes of intervention delivery, potential barriers, and further content development. We reviewed the quantitative and qualitative data from these preliminary steps with key informants to develop the pilot intervention.

We selected the Jawbone UP MOVE activity tracker after carefully reviewing consumer reviews, literature searches [20], and multiple rounds of prepiloting. Additionally, we considered the affordability factor for both the study and accessibility for our patients in the future when selecting the device. According to a study of reliability and validity of several activity trackers, the Jawbone UP was considered reliable (intraclass correlation

coefficient between 2 tests was good: 95% CI 0.66-0.91) and valid (achieving a <1% error deviation from the reference standard during walking on a treadmill at a speed of 3 mph) [20]. This study was approved by the Stony Brook University School of Medicine Institutional Review Board prior to enrolling any participants.

Intervention Design

The 10-week intervention paired overweight and obese adolescents with a parent to participate in daily PA using the Jawbone UP MOVE activity tracker and its associated smartphone app. After a brief eligibility survey administered either by phone or in person by a trained research assistant, parent-adolescent dyads were enrolled in the study. Once they had signed medical clearance forms, enrolled parent-adolescent dyads came to Stony Brook University Medical Center for an in-person orientation with a research assistant. At the orientation, both parents and adolescents were queried about their current PA behaviors, barriers to change, perceptions about exercise and health, sleep patterns, and fitness goals. A similar survey was completed at the end of the 10-week intervention as a debriefing session. We provided both members of the dyad with their own personal activity tracker (Jawbone UP MOVE with wristband) with clear instructions on how to use it. The research assistant configured the activity trackers' settings and apps to reflect evidence-based, age-appropriate recommendations for goal steps and active minutes [7-10] (see Table 1 for app settings). Privacy and sharing settings and notifications reflected unique barriers and concerns relative to the adolescent population (ie, not collecting food and drink information so as not to encourage calorie counting in this population). The research assistant became "teammates" via the app with each member of the dyad to track progress and tailor follow-up phone call interviews based on tracker information collected during the interim between participant contact. At the orientation, the research assistant also reviewed local community resources for PA, the Office of the US President's Council on Sports, Fitness & Nutrition (PCSFN) recommendations, and an electronic healthy recipe resource [21].

Daily step count and active minutes were reviewed within the Jawbone smartphone app and then manually recorded by the research assistant into a study tracker diary. These data, along with age-specific goals and personalized fitness goals, drove algorithmic motivational telephone scripts after weeks 1, 2, 4, and 8. At each of these sessions, the research assistant used these data to set daily personalized step-count and active-minutes goals with each participant within the dyad. Goals were established as follows. (1) If the participant reached the national guidelines for age (as defined by the Centers for Disease Control and Prevention [CDC] and the PCSFN for active minutes, and by PCSFN for daily step count), they were encouraged to continue to perform at this level. (2) If they met their previous goal but still were not reaching the national guidelines for age, they were recommended to walk an average of 1000 additional daily steps for the following week or to add an average of 5 active minutes per day for the following week, or both. (3) If they did not meet their previous goal, they were recommended to try to add 1000 daily steps or to add an average of 5 active minutes per day for the following week, or both. Additionally, the research assistant and participants worked together to identify new activities and exercises to try both alone and with their parent. Each of these sessions (after weeks 1, 2, 4, and 8) included a follow-up survey with reflective questions to address noncompliance issues in terms of PA and tracker use and plans for PA during the intervening time between study contacts. We also sent a brief email reminder at week 6 with a review of each participant's fitness goals and the study contact information in case the participant experienced any issues or concerns. In a final debriefing, either via phone or in person, both parents and adolescents completed another set of questions about their current exercise and PA behaviors, barriers to change, perceptions about exercise and health, and fitness goals. As an incentive to participants, we gave each parent and adolescent a US \$20 gift card and let them keep their activity trackers in exchange for their successful study participation. We conducted a follow-up interview with participating parents a few months later to determine their sustainment of PA changes.

Table 1. Jawbone UP MOVE app activity tracker setup.

Setting	Description
Goal: steps	8500 steps (parent) 12,000 steps (adolescent) This is the recommended goal based on the Office of the President's Council on Sports, Fitness & Nutrition.
Goal: weight	Current weight This was not a weight loss intervention; this was an exercise intervention. We did not want the participants to become overly focused on or discouraged by weight goals that are not realistic to accomplish in a 10-week study.
Privacy and sharing	Sleep, steps, and workouts We were not collecting the following information through sharing: food and drink information, weight changes, and mood. This was primarily a physical activity-based intervention. We did not want adolescents focused on their weight and counting calories as the primary aim of this study. Therefore, we were not collecting or encouraging the dyads to record that information. We offered a healthy recipe website as a resource as a part of the intervention independent of the Jawbone app.
Notifications	Smart coach, team activity, duels, move goal, workout summary, daily sleep recap, and battery level. We used all the notifications because we knew that some participants may want all these features and later change them to access them. We did not want some participants to have access to certain features and others not.
User settings	Standard settings: reported height, reported weight, sex, date of birth.

Measures

Primary outcomes were the percentage of successful days, defined as days when participants reached either their personalized daily goals or those set for their age by the national guidelines (average daily step counts defined by the PCSFN and daily active-minutes goals defined by both the CDC and the PCSFN). We defined this as either their personalized goal set with the research assistant during their last motivational interview or their ability to achieve the national guidelines goal of 8500 steps and 30 minutes for parents or 12,000 steps and 60 minutes for adolescents. A secondary analysis explored using a reduced step-count goal for adolescent participants to 10,000 steps per day or their personalized set goal if their average step count was less than 10,000 steps per day. This secondary analysis was based on research that evaluated step-count goals specifically for overweight adolescents [3,11]. We also calculated average daily steps and average daily active minutes for both parents and adolescents. This measure was calculated using captured data from the activity tracker smartphone app and dividing the total number of steps or active minutes by the number of days the activity tracker was worn. That measure showed incredible variability and was affected by compliance issues, particularly low daily step counts that were counted but likely reflected poor compliance on a given day.

Additional secondary outcomes were activity tracker compliance, self-reported weight change, parental and adolescent perceptions of overall health and fitness level, barriers to PA, evaluation of program efficacy, usefulness and appeal, and effect of the intervention on bonding within the parent-adolescent dyad. Such measures were not previously validated but are original questions that we developed based on key informant input from a group comprising a psychologist, 2 pediatricians, and an epidemiologist. We adopted self-reported preintervention PA questions from the Women's Health Initiative Physical Activity Questionnaire [22]. We entered data into the StudyTRAX research platform (Studytrax, Macon, GA, USA) manually from paper copies of surveys and from the research assistant's review of daily activity tracker data. Double data entry was performed for all data by 2 independent, trained research assistants. Any discrepancies were addressed by reviewing the paper copies or the smartphone app data.

Statistical Analysis

We calculated descriptive statistics for characteristics and outcome measures: frequencies, percentages for categorical variables, and mean (SD) for continuous variables. Due to the small sample size and the exploratory nature of this pilot study, we conducted all statistical analyses using nonparametric methods; for example we also evaluated dyad correlations using Spearman rank order correlations. Dyad correlations used weekly averages. We adjusted *P* values using the Bonferroni method within the same family of hypotheses and considered *P* values less than .05 to be statistically significant. All analyses were performed using SAS v9.4 (SAS Institute).

Results

Participant Demographics

Table 2 presents study participant demographics. A total of 9 adolescents (4 female and 5 male) and parent dyads (all female) participated. Interestingly, all parent participants in the dyads were mothers. The adolescents' mean age was 15 (SD 0.9) years (range 14-16); the parents' mean age was 47 (SD 8.0) years (range 36-66). One adolescent and 1 parent were of Hispanic or Latino origin. In terms of race, 5 adolescents categorized themselves as white, 2 as black or African American, and 2 as other, with corresponding results for the parents. Self-reported mean weight loss over the 10-week intervention period for adolescents was 4.3 (SD 5.1) lb (2.0 [SD 2.3] kg); adjusted *P*=.56, and self-reported mean weight loss for parents was 9.1 (SD 9.2) lb (4.1 [SD 4.2] kg); adjusted *P*=.08. All parents and adolescents described their perceived weight at the end of the intervention as either the same as or improved over the start of the intervention. Self-reported baseline PA data from a preintervention survey showed that only 22% (2/9) of adolescents and no parents endorsed doing moderate to vigorous activity for 5 days per week or more at the start of the study. Of the 9 parents, 7 reported doing moderate to vigorous activity on zero days of the week. Only 33% (3/9) of adolescents and 11% (1/9) of parents reported that they did an hour or more of moderate to vigorous exercise when they did engage in it at all.

Table 2. Demographic characteristics of adolescents and their parents participating in the study.

Characteristics	Adolescents, n (%)	Parents, n (%)
Sex		
Male	4 (44)	0 (0)
Female	5 (56)	9 (100)
Race		
Black or African American	2 (22)	2 (22)
White	5 (56)	5 (52)
Other	2 (22)	2 (22)
Ethnicity		
Hispanic or Latino	1 (11)	1 (11)
Non-Hispanic or Latino	8 (89)	8 (89)

Table 3. Weekly success rate of step count and active minutes for adolescents^a.

Week	Percent step success, mean (SD)			Percent active-minutes success, mean (SD)	
	12,000 steps or personalized goal	10,000 steps or personalized goal	Personalized goal only	60 minutes or personalized goal	Personalized goal only
1	18 (20)	32 (34)	17 (38)	70 (26)	71 (46)
2	39 (27)	41 (29)	40 (40)	52 (32)	49 (50)
3	36 (28)	39 (27)	37 (49)	59 (23)	57 (50)
4	49 (40)	49 (40)	50 (50)	61 (29)	61 (49)
5	42 (24)	46 (22)	41 (50)	48 (23)	50 (51)
6	31 (39)	31 (39)	32 (47)	49 (31)	55 (50)
7	24 (35)	24 (35)	25 (44)	51 (31)	48 (50)
8	19 (28)	26 (36)	22 (42)	34 (29)	39 (49)
9	35 (40)	35 (40)	44 (50)	44 (28)	53 (51)
10	46 (41)	46 (41)	52 (51)	50 (41)	60 (50)
Total	35 (19)	39 (20)	35 (48)	55 (17)	55 (50)

^aRaw data are available on request from the corresponding author.

Table 4. Weekly success rate of step count and active minutes for parents^a.

Week	Percent step success, mean (SD)		Percent active-minutes success, mean (SD)	
	8500 steps or personalized goal	Personalized goal only	30 minutes or personalized goal	Personalized goal only
1	21 (25)	21 (41)	79 (32)	82 (39)
2	47 (28)	46 (50)	80 (20)	82 (39)
3	26 (28)	26 (44)	81 (16)	84 (37)
4	31 (35)	31 (46)	84 (15)	84 (37)
5	53 (32)	53 (50)	89 (16)	90 (30)
6	51 (35)	53 (50)	91 (13)	93 (26)
7	51 (35)	52 (50)	87 (18)	89 (32)
8	45 (39)	42 (50)	88 (25)	89 (32)
9	41 (25)	40 (49)	68 (31)	67 (48)
10	35 (41)	36 (48)	63 (39)	67 (48)
Total	39 (24)	40 (49)	81 (16)	83 (38)

^aRaw data are available on request from the corresponding author.

Success in Meeting Goals

Table 3 and **Table 4** list the number of successful days for both average daily step count and average daily active minutes for the participants. On average, adolescents met their personalized daily step-count goal or the minimum goal set by the PCSFN on 35% (range 11%-62%) of the days they wore the activity tracker. Parents met the personalized daily step-count goal or the PCSFN goal on 39% (range 3%-68%) of the days that they wore their activity tracker; on 55% of the days, adolescents (range 27%-85%), and on 83% of days, parents (range 52%-97%) met their active-minutes goals. A secondary analysis of the adolescents' step count using either the 10,000 step or the personalized step-count goal showed that adolescents met their personalized step-count goal on 39% (12%-72%) of days they wore a tracker. All participants reached more recent

literature-supported step counts (10,000 for all children, 8500 for adults) at some point in the intervention but were unable to sustain these step counts consistently.

Figure 1 shows mean daily step counts and **Figure 2** shows mean daily active minutes for all participants. By the last week, adolescents had an average daily active minutes total of 101 and parents had an average of 59 minutes over the course of that week, both well above the national guidelines (CDC and PCSFN) for their respective age groups. For average daily step count over the course of the final week, the adolescent group averaged 8652 steps per day and parents averaged 7044 steps per day.

Most importantly, weekly parent and adolescent step count and active minutes were significantly correlated (step count: $r=.36$, adjusted $P=.002$; active minutes: $r=.30$, $P=.007$); children of

parents who were more successful in achieving their goals were also more successful in achieving their own goals. While overall parent and adolescent PA was significantly correlated, there was much day-to-day variability, as Figure 1 shows. Parental age was inversely correlated with step-count success ($r=-.78$, $P=.01$). While activity tracker compliance was the primary study barrier, it was fairly high for a behavioral intervention, particularly for the parents. On average, parents wore their tracker 92% of the time and adolescents wore their trackers 76% of the time (Figure 3). The 3 adolescents with the lowest step-count performance noted barriers to exercise (2 noted time, 1 noted feeling tired), while all other adolescents noted no barriers to exercise.

Postintervention Survey

In the postintervention survey, which was completed by 8 of the 9 parents who participated in the program, walking was the most common exercise added to the participants' exercise regimen since starting the program. Of the 8 adolescents who completed a postintervention survey, 7 stated that they added walking to their PA regimen. A total of 6 of 8 parents stated that they had started walking with their children regularly since starting the program. Cycling was the second most common new exercise added by parents and adolescents, with swimming, running, and aerobics as other mentioned activities. Of note, neither cycling nor swimming could be recorded as an activity by the study-selected tracker.

Figure 1. Mean daily step counts for adolescents and parents.

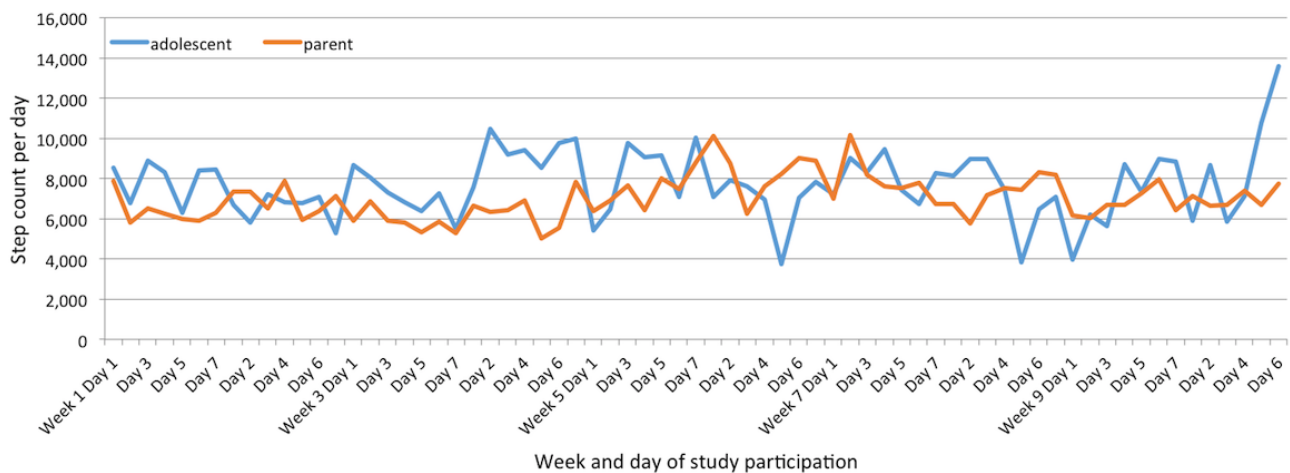


Figure 2. Mean daily active minutes for adolescents and parents.

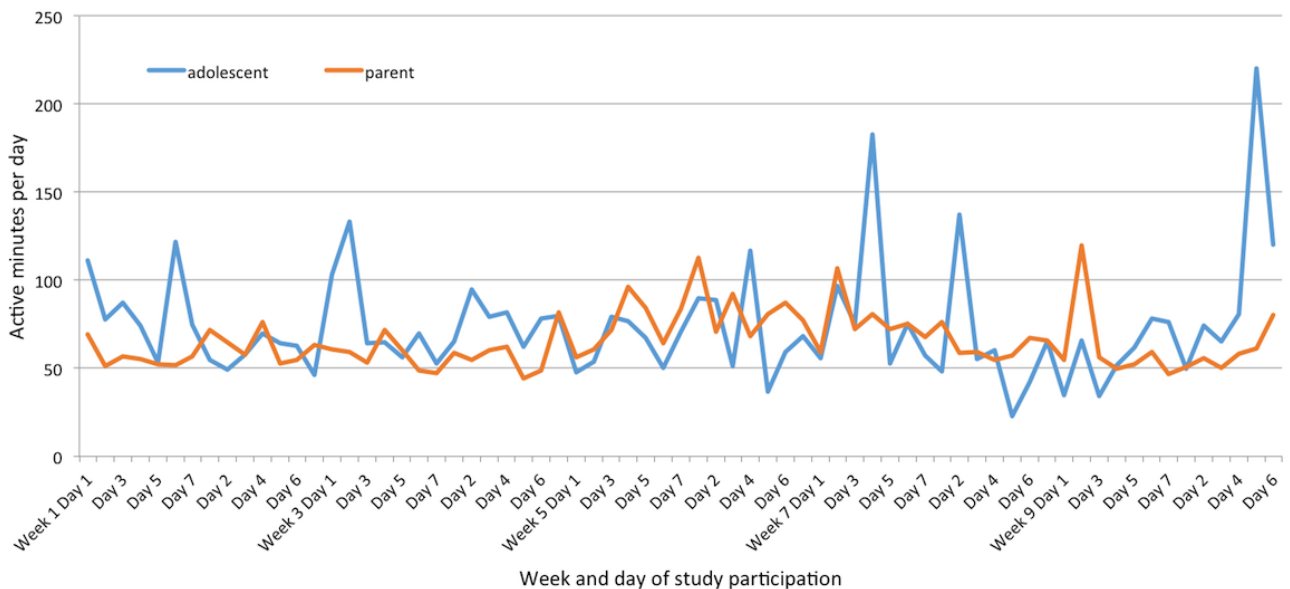
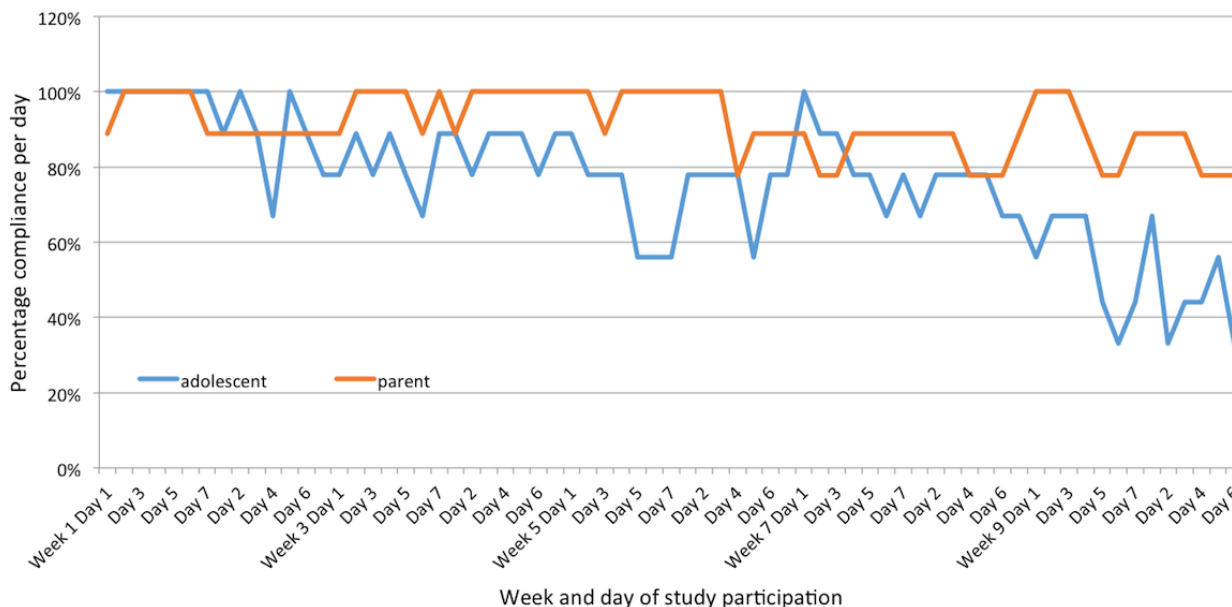


Figure 3. Percentage daily compliance for adolescents and parents.

In terms of overall program satisfaction, both parents and adolescents enjoyed the program, rating multiple areas of content helpful on a postintervention survey. Both adolescents and parents rated the program as being most helpful in the following ways: improving health, having fun, and spending time with the other member of the parent-adolescent dyad. When rating programmatic components on a scale of usefulness from 1 to 5, participants rated items that were tailored or personalized (ie, in-person orientation, motivational phone calls) more highly than generic items (ie, healthy recipe websites, community fitness handouts). Parents were more likely to feel comfortable keeping up with the changes they had made, rating themselves an average of 8 out of 10 on a likelihood scale. Adolescents were less confident in maintaining the changes, rating their likelihood to maintain change as 5 out of 10.

These results were underscored again in a brief follow-up questionnaire completed by 7 parents approximately 3 months after the intervention ended. All parents (7/7) reported that they had made changes to their overall health and fitness routine as a result of the study. Of these 7 parents who completed the follow-up interview, 6 stated that their children had made changes to their overall health and fitness routine as a result of the study, and 5 parents noted that other family members had made changes as a result of the parent-adolescent dyad participating in the study. Changes mentioned included increased health awareness, increased walking or joining a gym, and healthier diets. A total of 5 of the adolescents used the tracker for some period of time after the study (ranging from a few weeks through continued use at the time of questionnaire completion). The most common reasons for discontinuation were lost trackers, the desire to purchase a different brand of activity tracker, and broken bands.

Discussion

Principal Findings

Our study found that both adolescents and parents achieved step goals at least a third of the time (35% and 39%, respectively) and active-minutes goals more than half of the time (55% and 83%, respectively), with both percentages for step count and active minutes being higher in the parent group. Most importantly, we found that parents' and adolescents' step-count and active-minutes success rates were significantly correlated.

A review of daily step count and active minutes showed great variability. Both adolescents and parents met US national guidelines' daily active-minutes goals across week 10 but were not at the national guidelines for daily step count. The variability and lower step-count performance were likely affected by compliance issues and the inability of the activity tracker to capture all activities in the form of a step count.

Comparison With Prior Work

Prior studies have shown that, in general, PA decreases during adolescence [4-6]. In 1 study, adherence to PA guidelines for active minutes fell from 49% (6- to 11-year-olds) to 12% (12- to 15-year-olds) in boys and from 35% (6- to 11-year-olds) to 3% (12- to 15-year-olds) for girls [5]. Another study of PA by Nader et al found that, by 15 years of age, adolescents were engaging in moderate to vigorous PA for only 49 minutes per weekday and 35 minutes per weekend day [6]. Beets and colleagues found in a study of PA among children in 13 countries that mean steps per day decreased through adolescence to a value of approximately 8000 to 9000 steps per day by age 18 years [23]. A US National Health and Nutrition Examination Survey review of the 2005-2006 data cycle found a similar decline in adolescence with average daily step counts at age 16 years of 9376 for girls and 10,668 for boys [24]. These studies indicate that reaching the formal national guidelines for PA is an incredible challenge in the average adolescent population. Therefore, the fact that our participants, who were in a higher

risk category, reached their set goal, or that of the national guidelines, at least a third of the time for step count and greater than half of the time for active minutes is promising. The discrepancy in the 2 PA measures (step count vs active minutes) likely reflects the inability of the tracker to capture all PA activities, such as swimming and biking, in terms of step count. Dyads were able to manually enter the time that they participated in these activities toward their active minutes for the day.

While national guidelines formally recommend 60 minutes of daily PA and 12,000 steps for children [7-10], Janssen and Leblanc's systematic review found that just a few hours a week of PA could be effective, particularly for high-risk groups such as ours [3]. Additionally, multiple studies have suggested that 10,000 to 11,700 steps might be a more appropriate range for adolescents, especially for overweight adolescents such as those participating in this pilot study [11,25]. In light of this additional research, we revisited the adolescents' success rates using a goal of 10,000 steps per day. In these supplemental analyses, by decreasing the step-count target to this revised level, we were able to demonstrate that the performance of our participants was slightly higher, with 38% successful days in the 10,000 step-count group.

The most interesting finding of our study is the strong correlation of both step-count and active-minutes success for the parent and adolescent as a dyad. The existing literature on parent and child or adolescent PA correlations is limited, has mixed findings, and often has focused on younger populations [17,26]. McMurray and colleagues found that, in 7- to 10-year-old children, parent and child PA levels were correlated, especially on weekend days [17]. Jago and colleagues found that, while sedentary time of parents and children is correlated, PA was not [26]. Both of these studies focused on younger populations. Our study is unique in that it focused on adolescents, who are at a crucial tipping point in their PA habits. Additionally, our study paired parents and adolescents together to create a framework of mutual support, which is also supported by the literature [27,28]. Pyper et al found that 3 parent support behaviors contributed to predict their child's PA: taking their child to places to be more active, encouraging their child to be active outdoors, and taking part in PA with their child. Of these 3 behaviors, taking part in PA with their child was the least-reported behavior in their study and the one the authors suggested needs to be explored most [28]. While it is likely that all 3 of these behaviors occurred in the context of our study, the third behavior is most central to the framework of our intervention.

Our study is also unique in that it is, to our knowledge, one of only a few studies to date that evaluated the use of wearable activity trackers in the adolescent population [29,30]. One such study that is underway in Australia, and whose results are not yet available, is the Raising Awareness of Physical Activity (RAW-PA) study. Like our study, the RAW-PA will use wearable activity trackers in the adolescent population to look at the impact on PA [31]. However, our study is unique in that we looked at the role of these devices for both the adolescent and their parent in an intervention framed around parent-adolescent dyads.

Limitations

Limitations of our study include the small sample size, lack of substantial baseline PA data, and issues related to compliance with the wearable activity trackers. While compliance was a primary barrier to data capture, overall tracker compliance was similar to that in other studies of adolescent activity tracker use [30,32]. Common problems included issues with syncing the tracker to the Jawbone UP MOVE app to record data, lost trackers (n=5) and broken tracker bands (every dyad had a physically broken band at some point, with approximately 15 broken during the study). These common issues led to missing data for multiple participants. The activity trackers were not sophisticated enough to be able to record certain activities. Our population reported both bicycle riding and swimming as common activities, and these often were not accurately reflected in step count, which could potentially result in underreporting of PA. Since the trackers were not waterproof, participants reported having to remove the tracker for any water sports, such as swimming or playing at the beach, which also potentially resulted in underreporting of activity, since participation spanned the summer months. Dyads were instructed to record these activities as active-minutes time, but not all did so consistently. We hypothesize that, if more of these activities had been captured, the success rate would have been much higher, particularly for step-count percentages. Additionally, it was difficult to assess whether low step count reflected low activity or partial compliance, which may have contributed to underreporting as well.

Baseline PA data are difficult to obtain in any activity tracker study without complicating the results. A study in older adults by Gualtieri et al showed that activity trackers as a concrete reminder can alone increase motivation for PA in research participants [33]. Additionally, as this was a small pilot study and not a randomized controlled trial, we used self-reported measures of baseline PA data. However, having some quantitative baseline PA data will be important for future studies and may require a "burn-in" period where participants are advised to wear the activity tracker and follow their normal routine without the other additional motivation or mutual support mechanisms.

The lack of automation for recording tracker data and interview results created time-intensive processes requiring substantial personnel resources to conduct the tailored motivational interviews, ultimately limiting the number of participants that could be recruited at any one time and the number of encounters for motivational interviewing. These fewer interactions between participants and study personnel often translated into lost opportunities to address tracker compliance issues or to motivate participants to sustain their step-count and activity goals when they made them. Additionally, weight information was self-reported due to our inability to bring participants back at multiple intervals. Based on lessons learned, for future studies, we are looking to provide families with home-based smart scales that integrate with the wearable trackers to obtain accurate weight changes during the intervention period.

Conclusions

Our findings indicate that parent-adolescent dyads have highly correlated PA success rates. This supports further investigation of family-centered weight management interventions for adolescents, particularly those that involve the parent and the adolescent working together. Future studies will include a more detailed account of baseline PA data prior to distribution of the activity trackers, followed by a 1-week period of asking participants to wear their tracker without any motivation or goal setting to obtain some objective quantitative information about their baseline activity. Additionally, the next steps will be to

automate the compilation of tracker data and enhance the process of tailored motivation through the development of an app. This more intensive interaction will provide for more rapid intervention for adherence and goal setting and maintenance. While the step-count and active-minutes features from the Jawbone remain on most commercially available trackers, we would use more sophisticated activity trackers. Such trackers will be more durable and waterproof, thus enhancing compliance and complete collection of activity data across the spectrum of activities that adolescents and their parents engage in throughout the year.

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Conflicts of Interest

None declared.

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Abbreviations

CDC: Centers for Disease Control and Prevention

PA: physical activity

PCSFN: President's Council on Sports, Fitness & Nutrition

RAW-PA: Raising Awareness of Physical Activity

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Review

eHealth Interventions for Anxiety Management Targeting Young Children and Adolescents: Exploratory Review

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Abstract

Background: Advances in technology are progressively more relevant to the clinical practice of psychology and mental health services generally. Studies indicate that technology facilitates the delivery of interventions, such as cognitive behavioral therapy, in the treatment of psychological disorders in adults, such as depression, anxiety, obsessive-compulsive disorder, panic symptoms, and eating disorders. Fewer data exist for computer-based (stand-alone, self-help) and computer-assisted (in combination with face-to-face therapy, or therapist guided) programs for youth.

Objective: Our objective was to summarize and critically review the literature evaluating the acceptability and efficacy of using technology with treatment and prevention programs for anxiety in young children and adolescents. The aim was to improve the understanding of what would be critical for future development of effective technology-based interventions.

Methods: We conducted an exploratory review of the literature through searches in 3 scientific electronic databases (PsycINFO, ScienceDirect, and PubMed). We used keywords in various combinations: child or children, adolescent, preschool children, anxiety, intervention or treatment or program, smartphone applications or apps, online or Web-based tool, computer-based tool, internet-based tool, serious games, cognitive behavioral therapy or CBT, biofeedback, and mindfulness. For inclusion, articles had to (1) employ a technological therapeutic tool with or without the guidance of a therapist; (2) be specific for treatment or prevention of anxiety disorders in children or adolescents; (3) be published between 2000 and 2018; and (4) be published in English and in scientific peer-reviewed journals.

Results: We identified and examined 197 articles deemed to be relevant. Of these, we excluded 164 because they did not satisfy 1 or more of the requirements. The final review comprised 19 programs. Published studies demonstrated promising results in reducing anxiety, especially relative to the application of cognitive behavioral therapy with technology. For those programs demonstrating efficacy, no difference was noted when compared with traditional interventions. Other approaches have been applied to technology-based interventions with inconclusive results. Most programs were developed to be used concurrently with traditional treatments and lacked long-term evaluation. Very little has been done in terms of prevention interventions.

Conclusions: Future development of eHealth programs for anxiety management in children will have to address several unmet needs and overcome key challenges. Although developmental stages may limit the applicability to preschool children, prevention should start in early ages. Self-help formats and personalization are highly relevant for large-scale dissemination. Automated data collection should be built in for program evaluation and effectiveness assessment. And finally, a strategy to stimulate motivation to play and maintain high adherence should be carefully considered.

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KEYWORDS

child; adolescent; anxiety; anxiety disorders; telemedicine; eHealth; mobile applications; review

Introduction

Anxiety disorders are among the most common diagnosed mental health problems in children and adolescents [1]. A lifetime prevalence as high as 30% prior to 18 years of age has been reported in American adolescents from the general population, with a median age of onset of 6 years [2,3]. Furthermore, the prevalence of subclinical anxiety has been estimated at a much larger proportion, reaching 40% in children. The most frequent diagnoses are separation anxiety disorder, specific and social phobias, generalized anxiety disorders, agoraphobia, and panic disorder, with these last 3 tending to have a higher incidence in adolescence than in childhood [2].

Cognitive behavioral therapy (CBT) has been demonstrated to be effective in treating children and adolescents with anxiety disorders [4,5]. Other approaches, such as biofeedback, mindfulness, and other relaxation techniques, have also been commonly used [5,6] having shown some efficacy [7-9]. However, the vast majority of children do not receive treatment: a national survey in the United States estimated that up to 80% of youth with a diagnosable anxiety disorder never received specialized mental health care [10].

Such a low access to treatment may have several origins: cost, especially relevant for families and countries with socioeconomic difficulties; geographic location as an impediment to physically accessing care; shortages of specialized providers compared with demand and poor coordination among different services such as schools, primary health care providers, and social services; issues related to stigma associated with receiving mental health services and poor acceptance of treatment, especially among adolescents; and access that is particularly inadequate for vulnerable groups [11-13].

Lack of an early mental health intervention has a significant impact on children's quality of life and may disrupt their development. Persistently elevated levels of anxiety in children can have an impact on academic performance with school difficulties, and impaired social and emotional functioning [14,15]. Furthermore, the presence of anxiety disorders in young age, as well as subclinical anxiety symptoms, appears to be associated with the risk for the development of anxiety and mood disorders later in life, with a peak in 13- to 15-year-olds [15-17]. It is therefore important to find means to increase the availability of treatment for youth with anxiety.

Recently, there has been broad interest in the use of digital technology to deliver therapies, with the goal of facilitating access to therapy and reducing costs. CBT has been noted to be well suited for remote delivery due to its highly organized content and demonstrated efficacy [18,19], to the point that UK National Institute for Health and Clinical Excellence guidelines have been issued for computerized CBT for depression and anxiety, at least for adults [20].

The use of computer-based health intervention is particularly suited for youth. Nowadays, digital games play an essential role in people's lives worldwide [21-23], with millions of people from all sociodemographic groups playing digital games in their leisure time [24]. Smartphones are extensively used worldwide [25], and a growing number of health apps for mobile phones and tablets, including mood diaries and mindfulness exercises, are now available [26,27]. Furthermore, serious games can add the element of fun, a component that motivates and enhances learning and behavior change [28].

With this work, we aimed to collect information related to available technology-based programs for anxiety management in young individuals. Our goal was to evaluate existing tools and identify their strengths and weaknesses, with the objective of identifying areas for future research and development. It is important to note that this work built on the results of a recent metareview on eHealth interventions, which included a variety of mental health problems, such as attention-deficit/hyperactivity disorder, autism, depression, psychosis, eating disorders, and posttraumatic stress disorder [29], in addition to anxiety, which was the sole focus of our review. Moreover, previous reviews either targeted adolescents and young adults [29], as opposed to this study, which focused on young children as well, or focused exclusively on CBT-based eHealth interventions for anxiety and depression [30], whereas this study included a variety of approaches that were used for anxiety management, such as biofeedback and mindfulness, in addition to CBT.

Methods

Because of the small number of published studies (in particular from peer - reviewed sources) and their heterogeneity, as there were significant differences in the methods and data used, the literature did not lend itself to a more thorough systematic literature review or a meta - analysis [31]. As it was not possible to apply traditional methods of systematic reviews, such as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement, we undertook an exploratory literature review that built on the approach set out by Arksey and O'Malley [32].

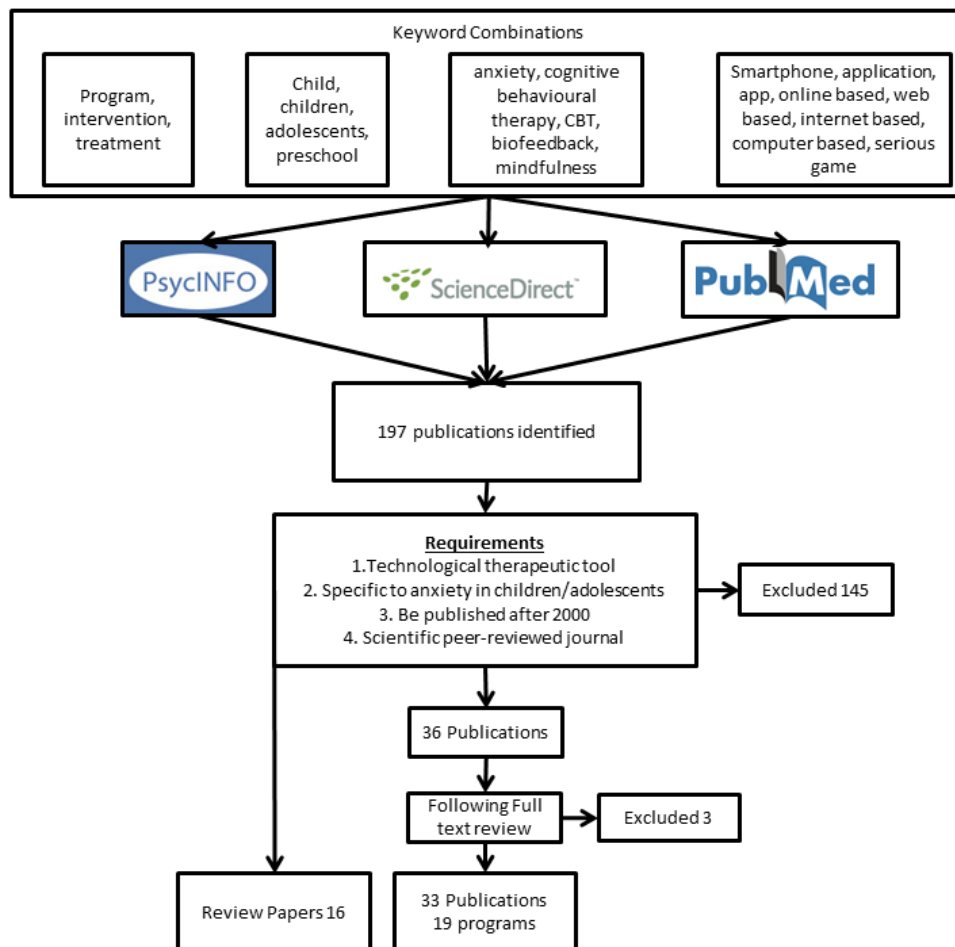
We first conducted a systematic literature search in 3 scientific electronic databases: PsycINFO, ScienceDirect, and PubMed; we subsequently also searched Google Scholar. To retrieve articles, we used keywords in various combinations: child/children, adolescent, preschool children, anxiety, intervention or treatment or program, smartphone applications or apps, online or Web-based tool, computer-based tool, internet-based tool, serious games, CBT, biofeedback, and mindfulness. We combined keywords using Boolean operators, for example, "children OR child AND anxiety AND (intervention OR treatment OR program). In addition, we searched a clinical trial register (ClinicalTrials.gov) to detect either ongoing or completed trials that had not been published yet. In the identified articles, we examined references to trace pertinent articles that we might have missed in the search. After

retrieving the articles, we removed duplicates and reviewed the remaining titles, then screened the abstracts for potential relevance and carefully read full-text articles relevant to the topic. For inclusion, articles had to (1) employ a technological therapeutic tool with or without the guidance of a therapist; (2) be specific for treatment or prevention, or both, of anxiety disorders in children or adolescents, or both; (3) be published between 2000 and 2018; and (4) be published in English and in scientific peer-reviewed journals. We excluded gray literature and white papers from the review. We excluded programs for obsessive-compulsive disorder and posttraumatic stress disorder because of their low prevalence rates in early childhood and the specificity of both assessment and therapeutic approach. We used no other search limits.

Results

Most programs that we found on the Web were directed at adults or did not specify an age range, with a much smaller number being specifically designed for children. We initially found and examined 197 articles deemed to be relevant. Of these, we excluded 164 because they did not satisfy 1 or more of the requirements outlined above. The final review comprised 19 programs, including technological tools and data for therapeutic treatment or prevention (Figure 1).

Figure 1. Study flow diagram.



To create a taxonomy, we first grouped the programs based on the therapeutic approach they used: most of them fell into two categories, namely CBT and biofeedback. Second, there are 3 age groups that need to be considered when developing a computer-based treatment, reflecting developmental stages: preschool children (2-5 years), children (6-12 years), and adolescents (13-18 years). It is important to note that we use the term *program* to refer to an intervention and the term *tool* to refer to any technology-based components, such as an app for mobile devices, or a CD for desktop or laptop computers. [Multimedia Appendix 1 \[33\]](#) shows a glossary of terms used when evaluating programs.

Cognitive Behavioral Therapy–Based Programs

CBT has been shown to be highly effective in treating and preventing anxiety disorders among children and adolescents [4,5,34,35] and it is regarded as the first-line choice for this patient population [36].

Our search found 14 technology-based treatments that used CBT as their theoretical framework. Half of them covered the age group of 6 to 12 years. [Table 1 \[37-61\]](#) summarizes the main characteristics of all CBT-based treatments.

Table 1. Cognitive behavioral therapy (CBT)–based programs: technology-based tools used in support of traditional CBT therapy programs.

First author, year, reference ^a	Tool name	Target population	Theoretical framework and platform	External support	Automated decision support and data collection	Cost and number of users	Country and language	Structured pilot or trial
Khanna, 2008 [37]; Khanna, 2010 [38]; Storch, 2015 [39]; Crawford, 2013 [40]; University of South Florida, 2016 [41]	Camp Coping A-Lot (based on Coping Cat)	7-13 y; anxiety disorders	CBT-based CD-ROM-assisted treatment; 12 sessions	Professional and parents; no equipment required	No	US \$200 for base package	US; English	Feasibility acceptability study: n=30 (7-12 y); Pilot single group: n=17 (7-13 y) RCT ^b trials: n=49 (7-13 y), N=100 (7-13 y); RCT: n=188 (7-13 y)
Pramana, 2014 [42]; University of Pittsburgh, 2014 [43]	SmartCAT (based on Brief Coping Cat)	7-13 y; anxiety disorders	CBT mobile phone app (Android, iPhone under development) and therapist portal; 8 sessions	Professional; no equipment required	No		US; English	Feasibility study: n=9 (9-14 y); single group: n=40 (9-14 y)
Brezinka, 2014 [44]	Treasure Hunt	9-13 y; anxiety and depression	CBT Web-based computer game with 6 levels; 2.5-dimension Flash with ActionScript (Windows and Mac)	Professional; no equipment required	No	Free access to therapists; >2700 accredited users in 45 countries	English, German, Dutch, and Greek	Nonrandomized, uncontrolled applicability study: N=124 professionals; n=218 children (6-19 y) (through 42 professionals)
Spence, 2006; [45]; March, 2009 [46]; Donovan, 2014 [47]; Spence, 2011 [48]	BRAVE	8-12 y, 13-17 y (+parents); anxiety disorders	Web-based; 12 sessions	Therapist program (minimal contact via phone or email); self-help program; no equipment required	No	Free (available only in Australia)	Australia; English	RCT: n=72 (7-14 y); RCT: n=73 (7-12 y); RCT: n=115 (12-18 y); RCT: N=52 families (children 3-6 y)
Whiteside, 2016 [49]	Mayo Clinic Anxiety Coach	children and adolescents; anxiety symptom management	Mobile phone (IOS) app	Self-help; no equipment required	No	US \$4.99; >169 (5-17 y; 2012 data)	US; English	Randomized, active comparator: n=10 (7-17 y)
Patwardhan, 2015 [50]	REACH	4th and 5th grade children (9-11 y); anxiety prevention and early intervention	Android platform	Not specified; no equipment required	No		US	Usability study: n=22 (9-11 years); Usability study: N=132+, 45 service providers
Vigerland, 2013 [51]; Vigerland, 2016 [52]	DARE program	8-12 y; treatment of anxiety	ICBT ^c ; Web based	Minimal support therapist contact; combined parent-child intervention; no equipment required			Sweden; not specified	Pilot, uncontrolled: n=30 (8-12 y); RCT: n=93 (8-12 y) with 182 parents

First author, year, reference ^a	Tool name	Target population	Theoretical framework and platform	External support	Automated decision support and data collection	Cost and number of users	Country and language	Structured pilot or trial
Morgan, 2016 [53]; Morgan, 2017 [54]	Cool Little Kids	3-6 y; parents of anxious children	ICBT; Web based	Minimal support therapy; no equipment required	No		Australia; English	Randomized, uncontrolled: n=51 parents (children 3-6 y); RCT: N=433 parents (children 3-6 y)
Coyle, 2011 [55]	Pesky gNATs Island	9-17 y; treatment of anxiety	3-dimensional game CBT + mobile app (IOS and Android)	Professional; no equipment required	No	£150	UK and Ireland; English	Case studies: n=6 and n=15 (11-16 y); Professional survey (216 professionals working with adolescents)
Stallard, 2011 [56]	Think, Feel, Do	11-16 y; treatment of anxiety and depression	Computerized CBT-based CD-ROM	Minimal involvement from facilitators (non-CBT clinician): teachers, nurses, psychologist assistants, etc; no equipment required			UK; English	Pilot RCT: n=20 (11-16 y)
Cunningham, 2009 [57]; Wuthrich, 2012 [58]	Cool Teens Program	14-17 y; treatment of anxiety	Computerized CBT-based CD-ROM; Macromedia Flash MX (Windows and Mac)	Minimal therapist contact and phone; no equipment required			Australia; English	Pilot case series: 5 case studies (14-16 y); RCT: n=43 adolescents (14-17 y)
Calcar, 2009 [59]	MoodGYM	Early intervention anxiety and depression	Web-based self-help CBT based	Teacher supervision	Answers to exercises and quizzes collected throughout the program	Free	Australia; English, Chinese, Finnish, Norwegian, Dutch	RCT: N=1477 (12-17 y)
Tillfors, 2011 [60]	Unnamed program for SAD ^d	Treatment of SAD	Internet-delivered CBT	Therapist	No		Sweden	RCT: N=19 (15-21 y)
Cox, 2010 [61]	Kids-accident website	Treatment of anxiety and posttraumatic stress disorder	Website; CBT based and resiliency theory	Parents (booklet)	No		Australia	RCT: N=85 children and adolescents (7-16 y)

^aReferences [41,43,49] were found in clinicaltrials.gov and results have not yet been published.

^bRCT: randomized controlled trial.

^cICBT: internet-delivered cognitive behavioral therapy.

^dSAD: social anxiety disorder.

Table 2. Results from clinical trials: summary of published studies with efficacy data and anxiety diagnosis as primary outcome.

First author, year, reference	Program name	Sample	Study design	Diagnosis	% Primary diagnosis reduction at posttreatment ^a	% Primary diagnosis reduction at follow-up ^a
Khanna, 2010 [38]	CCAL ^b	N=49, 7-13 y, 67% male	RCT ^c : 3 arms (16 CCAL, 17 individual CBT ^d , 16 CESA ^e)	DSM-IV ^f SA ^g , SoP ^h , GAD ⁱ , SP ^j , PD ^k	At 12 weeks—CCAL: 81%, individual CBT: 70%, CESA: 19%	
Crawford, 2013 [40]	CCAL	N=17, 7-13 y, 71% male	Pilot: single arm	DSM-IV SA, SoP, GAD, SP	At 12 weeks—87%	
Storch, 2015 [39]	CCAL	N=100, 7-13 y, 56% male	RCT: 3 arms (49 CCAL, 51 treatment as usual)	DSM-IV SA, SoP, GAD, SP, PD	At 12 weeks—CCAL: 55.1%, treatment as usual: 17.6%	
Spence, 2006 [45]	BRAVE	N=72, 7-14 y, 58% male	RCT: 3 arms (22 clinic, 27 clinic plus internet, 23 waitlist control)	DSM-IV SA, SoP, GAD, SP	At 10 weeks—clinic: 59.1%, clinic plus internet: 51.9%, waitlist control: 13%	At 6 months—clinic: 68.2%, clinic plus internet: 55.6%; At 12 months—clinic: 77.3%, clinic plus internet: 66.7%
March, 2009 [46]	BRAVE	N=73, 7-12 y, 45% male	RCT: 2 arms (40 ICBT ^l , 33 waitlist control)	DSM-IV SA, SoP, GAD, SP	At 10 weeks—ICBT: 30%, waitlist control: 10.3%	At 6 months—ICBT: 75%
Donovan, 2014 [47]	BRAVE	N=52, 3-6 y and parents, 46% male	RCT: 23 ICBT, 29 waitlist control	DSM-IV SA, SoP, GAD, SP	At 10 weeks—ICBT: 39.1%, waitlist control: 24.1%	At 6 months—ICBT: 52.2%
Spence, 2011 [48]	BRAVE	N=115, 12-18 y, 41% male	RCT: 3 arms (44 clinic, 44 ICBT, 27 waitlist control)	DSM-IV SA, SoP, GAD, SP	At 12 weeks—clinic: 29.5%, ICBT: 34.1%, waitlist control: 3.7%	At 6 months—clinic: 50.0%, ICBT: 54.5%; At 12 months—clinic: 68.2%, ICBT: 68.2%
Vigerland, 2013 [51]	DARE	N=30 (+57 parents), 8-12 y, 43% male	Single arm	DSM-IV SP	At 6 weeks—33%	At 3 months—47%
Vigerland, 2016 [52]	DARE	N=93 (+182 parents), 8-12 y, 45% male	RCT: 46 DARE, 47 waitlist control	DSM-IV SA, SoP, GAD, SP	At 10 weeks—DARE: 20%, waitlist control: 7%	At 3 months—DARE: 50%
Wuthrich, 2012 [58]	Cool Teens	N=43, 14-17 y, 37% male	RCT: 24 Cool Teens, 19 waitlist control	DSM-IV any anxiety disorder	At 12 weeks—Cool Teens: 41%, waitlist control: 0%	At 3 months—Cool Teens: 26%, waitlist control: 0%

^aProportions of children who were free of their primary anxiety diagnosis.

^bCCAL: Camp Cope-A-Lot.

^cRCT: randomized controlled trial.

^dCBT: cognitive behavioral therapy.

^eCESA: computer-assisted education, support, and attention control.

^fDSM-IV: *Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition).

^gSA: separation anxiety.

^hSoP: social phobia.

ⁱGAD: generalized anxiety disorder.

^jSP: specific phobia.

^kPD: panic disorder.

^lICBT: internet-delivered cognitive behavioral therapy.

Cognitive Behavioral Therapy–Based Programs for Children

We identified 7 programs for children aged 6 to 12 years old (see Table 1). Of the 7 programs, 3 were developed as mobile

phone apps: SmartCAT [42], Mayo Clinic Anxiety Coach [62], and REACH [50].

Of the 3 apps, only REACH appeared to have a gaming component embedded, and was developed for prevention and

early intervention purposes. The other 2 were built mainly to support the patients completing tasks and exercising the acquired skills in the real world. They provided psychoeducational contents, instructions, self-tests, and to-do lists. Anxiety Coach was a self-help app that focused on exposure exercises, while SmartCAT was used in a treatment program and included the app, the therapist portal, and a secure 2-way communication system, through which the therapist could monitor child activity, manage reward points, and send materials and messages to patients. To our knowledge, none of the mobile phone apps had published data derived from trials examining their efficacy. However, studies on the use of the apps, their utility, and users' satisfaction yielded promising results [42,50,62]. The 4 computer-based programs Camp Cope-A-Lot [37-40] Treasure Hunt [44,63], BRAVE [45-48], and DARE [51,52] foresaw the involvement of therapist and parents at variable levels. BRAVE also had a self-help version.

The Camp Cope-A-Lot program presented a certain level of personalization, including elements that were customizable by the user to match their specific needs (eg, exposure tasks, speed at which they progress).

All but Treasure Hunt published efficacy data, with an effect in reducing anxiety diagnosis ranging from 20% to 80% (see Table 2 [38-40,45-48,51,52,58]). For Treasure Hunt, data from more than 200 children and 40 therapists indicated the program to be helpful in treatment, increasing child motivation, and strengthening the therapeutic relationship.

No significant differences were found in the controlled studies when comparing efficacy between computer-based and traditional face-to-face CBT approaches [38,39,45,46]. Interestingly, data from BRAVE showed that efficacy was maintained and even improved at follow-up (6 and 12 months), probably due to slower completion for the internet-based approach [45,46]. The relevance of the influence of time emerged also from the DARE studies [51,52].

Cognitive Behavioral Therapy–Based Programs for Adolescents

We identified 7 programs for the reduction of anxiety in adolescents, all based on CBT principles.

The BRAVE Web-based program had 1 version dedicated to children and 1 for adolescents (and their parents for each version). Graphics, sound, content, and examples that were used were appropriate for the developmental and cognitive levels of the 2 age ranges [48]. Another 2 programs were delivered via CD-ROM: Cool Teens [57] and Think, Feel, Do [56]. Think, Feel, Do was a software package developed to target both depression and anxiety symptoms in children and adolescents. Both programs foresaw therapist involvement and used a combination of multimedia types covering key CBT topics. Pesky gNATs Island [55] was a 3-dimensional computer game also based on CBT concepts developed to support traditional physical intervention through a therapist. It was coupled with a mobile app for iPhone and Android phones and tablets, available for free for patients playing the game with a therapist.

Results from efficacy and acceptability studies showed the computer-based programs to be acceptable to this age group

and to have a favorable impact on clinical improvement [48,56,57,58].

Another 2 Web-based programs were a program (unnamed) addressing social anxiety [60] and the kids-accident website targeting posttraumatic anxiety [61]. The first one was based on a self-help manual with online feedback and targeted social anxiety only [60]. It appeared to mostly deliver content through text, with limited interaction and no gamification. The kids-accident website by Cox and colleagues [61] was based on CBT and resiliency theory. Data on efficacy of these programs showed preliminary evidence of effect. Finally, the MoodGYM program was tested in an adolescent school-based population to reduce symptoms of anxiety and depression [59], and showed some advantage—although not significant—of the intervention condition compared with the waitlist control on anxiety scores. MoodGYM is a Web-based, self-directed CBT program designed to prevent or decrease the symptoms of anxiety and depression in adolescents.

Cognitive Behavioral Therapy–Based Programs for Preschool Children

Several traditional programs for early intervention and prevention for young children were developed and showed preliminary evidence of their efficacy [64]. These focused on improving parent-preschool child interaction, by targeting the parent's skills.

We located only 2 technology-based programs targeting the preschool age group. Cool Little Kids Online [53,54] was useful to parents for the acquisition of skills and strategies to help their child. Also, a modified version of the BRAVE Web-based program, with a parent-focused approach, was tested with preschool children and showed efficacy [47].

Biofeedback-Based Programs

Biofeedback is a technique that teaches users to recognize and control their bodies' functions, such as heart rate, respiration, muscle activity, and skin temperature, with the use of electronic instruments. It is commonly used for stress reduction, as it helps people control their stress response, by recognizing when they are stressed and employing relaxation techniques to reduce their physiological arousal [65].

We found 2 games specifically designed to address anxiety in children using biofeedback: Relax to Win [66] and Dojo [67,68]. In these games, players acquired relaxation techniques, such as deep breathing and progressive muscle relaxation, and practiced them. Generally, the games visually reproduced challenging or stressful situations that the player could overcome through control of their own physiological and emotional conditions; they progressed successfully through the game if they are able to keep calm. A device captured skin conductivity and transferred data to the mobile phone, triggering real-time feedback. The studies conducted on Relax to Win and Dojo did not allow reaching conclusions regarding their effectiveness, and further studies are needed to assess the ability of this approach to reduce stress in children and to contribute to the management of anxiety.

Another program incorporated several strategies into a game aimed at school-aged children (8-12 years) with anxiety: Mindlight used neurofeedback, exposure training, attention bias modification, relaxation, and mindfulness techniques. Data from a randomized controlled study showed promising, although not conclusive, efficacy results [69,70]. One also indicated that Mindlight was as effective as traditional CBT in the prevention of anxiety [70].

Table 3 [66-70] summarizes the biofeedback-based programs.

Other Approaches

Other computer-based programs based on theoretical approaches other than CBT, such as mindfulness, have been studied (see Table 4 [71-73]). With respect to mindfulness, the clinical application of and research on mindfulness-based interventions has been growing in the last decades, and as a recent meta-analysis of Web-based mindfulness-based interventions for improving mental health including anxiety showed, data indicate their effectiveness in reducing anxiety and depression symptom severity, with effect sizes between 0.3 and 0.8 [6]. However, this meta-analysis focused on adults and not on youth. Even though several reviews and articles on mindfulness-based

apps are available that may target children [74], we found no published results of randomized controlled trials on their effectiveness or on their usability and acceptability.

A Web-based self-help program [71] based on problem-solving therapy was developed for the treatment of depression and anxiety symptoms. It simply provided content through text and provided feedback from the clinician through email. It did not yield evidence of efficacy.

Finally, we identified a therapeutic 3-dimensional game for adolescents, based on solution-focused therapy, called Personal Investigator [72,73]. Solution-focused therapy is a goal-oriented form of therapy based on the assumption that individuals have some knowledge of what they would improve in their life and have the skills necessary to develop solutions. It focuses more on the present rather than the past and on creating future solutions than on analyzing problems. In this game, the teenager played the role of a personal investigator hunting for solutions to personal problems. The game was used during sessions with therapists. Data suggested that the game may favor engagement, high motivation, and enjoyment of the user and a rapid development in the therapeutic relationship [72,73].

Table 3. Biofeedback-based serious games, for children and adolescents: summary of features of technology-based tools using biofeedback.

First author, year, reference	Tool name	Target population	Theoretical framework and platform	External support	Automated decision support and data collection	Country and language	Structured pilot or trial
Sharry, 2003 [66]	Relax To Win	Children, relaxation training	Biofeedback, computer video game (3-dimensional); 5 sessions	Professional; required equipment: electrocardiogram, electroencephalogram	Yes, biofeedback	English	1 case study (12-year-old boy)
Scholten, 2016 [67]; Schuurmans, 2015 [68]	Dojo	11-15 y; anxiety reduction	Biofeedback, 3-dimensional game	Equipment: biofeedback hardware IOM (Wild Divine)	Yes, biofeedback	Netherlands	Pilot uncontrolled: N=8 (mean 14.38, SD 1.6 y); RCT ^a : N=138 (11-15 y)
Schoneveld, 2016 [69]; Schoneveld, 2018 [70]	Mindlight	8-16 (children and adolescents); anxiety symptoms	3-dimensional serious computer game; neurofeedback, CBT ^b -based exposure training, attention bias modification	Professional; Equipment: Neurosky neurofeedback headset		Netherlands; Dutch	RCT: n=136 (7-13 y); RCT: N=120 (8-16 y); RCT noninferiority: N=174 (7-12 y)

^aRCT: randomized controlled trial.

^bCBT: cognitive behavioral therapy.

Table 4. Other approaches: summary of features of technology-based tools using other approaches.

First author, year, reference	Tool name	Target population	Theoretical framework and platform	External support	Country and language	Structured pilot or trial
Coyle, 2009 [72]; Coyle, 2005 [73]	Personal Investigator	Treatment of anxiety and depression	3-dimensional game, solution-focused therapy; Atmosphere JavaScript application programming interface, Macromedia Flash MX	Professional; No equipment required	Ireland; English	Pilot uncontrolled: n=4 (13-16 y); n=22 (10-16 y)
Hoek, 2012 [71]	Internet-based problem-solving therapy (unnamed)	Adolescents; anxiety and depression	Web based	Guided self-help, email feedback from clinician	Netherlands; Dutch	Randomized controlled trial: N=45 (12-21 y)

As a concluding finding, it is important to note that an issue that was emphasized in the case of new technology-based interventions, regardless of the approach that was used or the age range for which the intervention was designed, is related to acceptability and adherence. Dropout is high even in traditional therapy and is generally higher in self-help programs [75].

Although all the programs had positive data on acceptability and user satisfaction, data arising from the studies indicate that adherence should receive some attention. For example, data from BRAVE showed that a large percentage of users did not complete the program in the expected time (at a pace of 1 session per week).

Discussion

Principal Findings

Research demonstrates promise for the use of computer technology in the treatment of adult anxiety [76-78]. A smaller volume of data from fewer studies on the treatment of childhood anxiety is available but is promising [79]. A meta-analysis demonstrated that internet-based interventions are effective in reducing anxiety symptom severity in youth compared with no intervention, and their effect may be comparable with that of face-to-face interventions [80]. However, considering the large number of Web-based programs that can be found on the internet and apps that can be downloaded on mobile phones and tablets, only a minority have been systematically tested and have published data on feasibility, acceptability, efficacy, and effectiveness.

We identified 19 technology-based programs that are available for children and adolescents with anxiety. Much less effort has been dedicated to the development of programs targeting preschool children, and the only ones we could locate (Cool Little Kids Online and a BRAVE version for preschool children) focused on improving parental skills as a way to indirectly help the preschoolers. One possible explanation for this is that the developmental stage of preschool children constitutes a challenge for the application of commonly used CBT programs, which is the evidence-based approach that has been most frequently translated into technology-based interventions [81]. It is important to note that this finding is in agreement with a recent review that evaluated the use of CBT-informed behavioral intervention technologies for the prevention and treatment of depression and anxiety among youth [30], which found that the child population of 5- to 12-year-olds received less attention than children in the age range of 12-17 years. This reveals a gap of addressing the needs of children younger than 8 years for prevention purposes, before instances of stress or subclinical anxiety escalate to clinical anxiety. Therefore, alternative approaches, based on developmentally appropriate games targeting preschoolers, should be developed and examined to determine their potential efficacy in early prevention.

Given the high prevalence of anxiety symptoms and disorders in youth, their negative impact on child development and performance, and the increased risk of developing related mental disorders in later ages, prevention, and early intervention, are very important. Furthermore, the median age of onset has been

reported to be 6 years [3]. Thus, much more effort should be put into the development of programs targeting preschool children. Intellectual, language, and socioemotional developmental domains of preschool children present a particular challenge for an eHealth or mHealth program, and joint parent-child programs need to be developed and evaluated for their efficacy.

In a world where computers, the internet, and mobile devices such as smartphones and tablets are widely used, computer and mobile technology offers a novel format for the delivery of treatment for child anxiety, which offers a reduction in costs, increased accessibility, and potentially standardization of content and delivery [82] and avoidance of stigma [83].

Furthermore, personal computing-based interventions have the potential to be delivered to a very large number of people compared with traditional face-to-face interventions. Data indicate that the average 8- to 14-year-old spends more than 1 hour per day playing digital games [80] and, by the time adolescents reach the age of 21 years, they will have spent at least 10,000 hours playing these games [84]. As of January 2014, 58% of the US population owned a smartphone, and it is predicted that by 2020, 90% of the world's population over the age of 6 years will have a mobile phone [85]. Furthermore, recent data indicate that 45% of US adults own a tablet; this percentage has substantially increased since the Pew Research Center began measuring tablet ownership in 2010, when only 4% of adults in the United States owned a tablet [86].

These data indicate that smartphones and mHealth programs hold great promise for widespread prevention. Despite this evidence, little has been done so far in this area: among all the programs (n=19) that we identified, only 5 used tablets or smartphone technology, of which only 2 (1 CBT-based and 1 biofeedback app) combine mobile technology and gaming.

The vast majority of the programs we evaluated had the aim of treating children or adolescents with anxiety disorders, and almost all were designed to support traditional therapy or foresee the intervention of a therapist. To our knowledge, among the CBT-based programs, only REACH was designed for prevention and early intervention, and only the Mayo Clinic Anxiety Coach was created as a self-help program; BRAVE also had a self-help version. Among the other 5 non-CBT-based programs, 2 (Relax to Win and Personal Investigator) foresaw their use within a traditional treatment program.

An issue that has been emphasized in the case of new technology-based interventions is related to acceptability and adherence. Dropout is high in self-help programs [75], and higher than in traditional therapy. Although all the programs had positive data on acceptability and user satisfaction, the same attention was not given to adherence issues. This gives rise to two considerations. The first consideration is that the pace at which users of a technology-based intervention move forward may be different from traditional face-to-face interventions and may vary depending on characteristics of the program or characteristics of the users. Data showed that it may take anywhere from 18 days to 254 days for people to form a new habit, depending on the behavior, the person, and the circumstances [87]. The second consideration is that, although

games are intrinsically motivating by offering fun and rewards to children, persuasive design elements that maximize adherence and personalization should be considered when developing a game. For example, the developers of REACH used a user-centric approach, with iterative feedback, participatory design, and end-user validation.

Data to understand use of and adherence to the eHealth or mHealth program are needed. Volume, quality, and type of data vary widely across programs. To our knowledge, automated data collection is very limited. Treasure Hunt (XML) and SmartCAT (Web interface) used automated data collection and provided that information to the therapist. Anxiety Coach collected data concerning the download and use of the app. Also for biofeedback-based programs, our understanding is that data were collected for real-time feedback and progression of the game, but were not collected and analyzed for the purpose of understanding the correlation between the use of the program and long-term efficacy of an intervention. Although this raises the problem of privacy and data security, automated data collection has the potential to also assess effectiveness of the programs on a large scale.

Of the 19 programs that we evaluated, 15 reported efficacy data, and randomized controlled trials were performed for all but 1 of them. All CBT-based programs showed positive effects in reducing anxiety, and no difference was noted when those were compared with traditional intervention.

Biofeedback-based programs also showed some evidence of effect in reducing stress. These games, however, addressed only the biophysiological component of anxiety. Relaxation training can be particularly effective in addressing the physiological arousal of anxiety; however, data from the technology-based biofeedback games are yet to conclusively show their efficacy.

The 2 available studies on programs based on other approaches did not demonstrate efficacy. Reasons for not showing efficacy may reside in low sample power, in the weakness of a theoretical approach, or in the program format itself. Further studies are needed to clarify the usefulness of these approaches.

eHealth and mHealth is a rapidly growing field, and several programs have been developed to support the treatment of diseases including psychiatric disorders. In particular, this approach has been shown to be effective in adults with anxiety. As a result, several programs for children have been created in the last decades. Available data indicate this is a promising approach to enhance treatment and make it accessible to a larger percentage of children in need. However, the field is still in its infancy and requires the development of self-help programs in order to be suited for wide distribution for prevention purposes. Conventional prevention approaches are unable to tailor interventions to the diverse needs and learning paces of at-risk

children. eHealth and mHealth programs have this potential: by design, digital games are fun, engaging, and able to elicit powerful emotions; can dynamically adjust the degree of difficulty and reinforce the player's actions; and can be used in natural settings and everyday life, at the pace and needs of the users. Furthermore, they may support learning by eliciting positive emotions [88] and by using a more experiential approach to convey CBT concepts and skills.

As a concluding remark, even though at least 120 apps targeting child anxiety are accessible in widely used marketplaces, namely Google Play for Android and Apple's App Store for iOS, only roughly half of them include at least one evidence-based approach [89]. It is unclear whether the evaluated apps have peer-reviewed publications to support their acceptability, usability, or effectiveness. There is, therefore, a research-to-practice gap that limits the availability of evidence-based treatments for youth anxiety and there are valid concerns about the quality of readily accessible apps for youth anxiety [89].

Challenges

Based on the findings of this review and a previous study [68], this field has several challenges to overcome: privacy and data security; automated data collection for assessing use and effectiveness; users' input by design to maximize acceptability, adaptability to personal differences, and engagement; development of self-help prevention programs; wide dissemination of such programs and special attention given to repurposing to address cultural differences (eg, translation into languages other than English and adapting to local needs and expectations; considering specific difficulties related to minority groups, migrants, and social integration; involvement of government and public health agencies); keeping up with the fast progress of technology; filling the gap for preschool children; and funding to support development and sustainability (ie, long-term plans for software updates; effectiveness studies with large sample size, and long-term longitudinal follow-up).

Conclusions

Smart device use is ubiquitous among children; however, research and development of stress management interventions is not fully taking advantage of new technologies. Data indicate that this is a promising approach to enhance treatment and make it accessible to a larger percentage of children in need. Most interventions, including CBT-based programs and biofeedback approaches, require the presence of human professionals and biosensors, respectively, and are not easily deployable at the population level. There is a clear need and a broad potential for the development of self-help programs, to be suited for a wide distribution, and for prevention purposes, especially at younger ages.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Glossary.

[[PDF File \(Adobe PDF File\), 32KB - *pediatrics_v1i1e5_app1.pdf*](#)]

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Abbreviations

CBT: cognitive behavioral therapy

CCAL: Camp Cope-A-Lot

CESA: computer-assisted education, support, and attention control

DSM-IV: Diagnostic and Statistical Manual of Mental Disorders (Fourth Edition)

GAD: generalized anxiety disorder

ICBT: internet-delivered cognitive behavioral therapy

PD: panic disorder

RCT: randomized controlled trial

SA: separation anxiety

SoP: social phobia

SP: specific phobia

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Original Paper

The Rise of New Alcoholic Games Among Adolescents and the Consequences in the Emergency Department: Observational Retrospective Study

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Abstract

Background: The links between the internet and teenager behavior are difficult situations to control and may lead to the development of new and excessive methods of drinking alcohol during alcoholic games. Findings indicate that reported cases are very useful sources for better understanding of alcoholic games, yielding successful measures promoting health among adolescents. Admittance of adolescents to hospital emergency departments (EDs) after consumption of excessive amounts of alcohol has become the norm in developed countries. The harmful effects of acute alcohol abuse are reported in this paper.

Objective: The aim of this work was to investigate the close connections between new drinking behaviors among adolescents and study the increase in new alcoholic games, together with the challenges that cause acute alcohol intoxication, the influence of the internet and social networks, and their consequences for public health services.

Methods: Data came from prehospital and intrahospital admissions attributable to alcohol consumption. From 2013 to 2015, 3742 patients were admitted to EDs due to acute alcohol intoxication: 830 of them were aged 15 to 30 years, and 225 were adolescents and young adults between 15 and 20 years who had been playing alcoholic games. Retrospectively, diagnostic data associated with extrahospital anamneses were selected by one of the hospital management information systems, Qlik. As a result of our previous experience, questionnaires and face-to-face interviews were performed at a later stage, when a clinical audit for intoxicated adolescent patients was described, with the overall goal of establishing a potential methodological workflow and adding important information to research carried out so far.

Results: Between 2013 and 2015, 830 young patients aged 15 to 30 years were admitted to EDs for acute alcohol intoxication. About 20% (166/830) of the sample confirmed that they had drunk more than 5 alcoholic units within 2 hours twice during the past 30 days as a result of binge drinking. Referring to new alcoholic games, 41% of the sample stated that they knew what neknomination is and also that at least one of their friends had accepted this challenge, describing symptoms such as vomiting, headache, altered behavior, increased talkativeness, and sociability. The median value of the weighted average cost of the

diagnosis-related group relating to interventions provided by hospitals was the same for both genders, €46,091 (US \$56,497; minimum €17,349 and maximum €46,091).

Conclusions: Drinking games encourage young people to consume large quantities of alcohol within a short period of time putting them at risk of alcohol poisoning, which can potentially lead to accidental injuries, unsafe sex, suicide, sexual assault, and traffic accidents. The spread of these games through the internet and social networks is becoming a serious health problem facing physicians and medical professionals every day, especially in the ED; for this reason, it is necessary to be aware of the risks represented by such behaviors in order to recognize and identify preliminary symptoms and develop useful prevention programs. The strategic role of emergency services is to monitor and define the problem right from the start in order to control the epidemic, support planning, coordinate the delivery of assistance in the emergency phase, and provide medical education. Hospital-based interdisciplinary health care researchers collected specific data on hazardous drinking practices linked to evaluation of increased alcohol-related consequences and cases admitted to the ED.

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KEYWORDS

adolescent; neknomination; binge drinking; alcoholic games; social network

Introduction

Alcohol intoxication in adolescents is associated with the main causes of death and serious injury (ie, motor vehicle, bicycle, and pedestrian accidents and suicide), but binge episodes and drinking levels that represent few problems for adults may be dangerous for adolescents. There are many projects investigating the Italian and European problem of alcohol consumption among young people [1], and some alcohol prevention programs are targeted to educational classroom interventions to encourage positive behavioral changes, inform and educate parents and teachers about the spread of new alcohol consumption modes among adolescents, and inform clinicians about the risk and impact in emergency medicine. The strategic role of emergency medicine is to define and monitor the problem as soon as it appears and then limit its spread. The aims of this work were to investigate the connection among new methods of alcoholic consumption, the spread of new alcoholic games among adolescents, and the influence of the internet and social networks and their consequences for public health in terms of numbers of accesses to emergency departments (EDs), the length of hospitalization, and the costs of these services for the Italian health system. These cases may provide important information allowing hospital personnel to recognize and identify the following themes that emerged from our analysis: (1) learning about patients' perspectives by examining their particular cases, (2) knowledge of a critical approach to one's own clinical practice, and (3) perception of enhanced evidence-based practice and shared decision making when intoxicated teenagers are admitted to the ED. Future surveys should identify potential markers of problematic use of social networks, including identification of groups at risk of abuse, and should aim to establish potential prevention strategies in terms of awareness and education that could help to avoid potentially fatal episodes. Little evidence is available, despite the costs of alcoholic game-related risks and the problems of teenagers arriving at the ED. Alcoholic games are often not recognized or identified in the ED, suggesting the need to improve the general education of both patients and physicians. Drinking games, prepartying (ie, drinking before going to a social event), heavy episodic drinking, and alcohol-related problems in students in secondary education have been reported in several previous works [2-8].

The descriptive longitudinal study by D'Amico et al [9] analyzed the various habits of adolescents and identified a close connection between alcohol abuse and consumption of other substances such as tobacco and marijuana, and its authors demonstrated a greater propensity to alcohol abuse in people of Hispanic and African American descent. The authors then stated that the general assumption of most descriptive models of peer pressure is based on adolescents' perceptions of the consumption of alcoholic beverages by their friends, identified as a predictor of long-term substance abuse in adolescents and preadolescents [9]. According to Borsari et al [8], Poliziotto et al [10], and Zamboanga et al [3], binge drinking is associated with secondary education students who were admitted to hospitals with alcohol-related problems, but there are very few reports about alcohol problems due to alcoholic games in adolescents. In recent years, adolescents have been participating in extreme alcoholic games for a variety of reasons (having fun, the idea of competition, etc) [11-13]. Health care intervention regarding alcohol intoxication in adolescents is a critical component in the implementation process in EDs [13-15]. Alcohol-derived injuries and fatalities due to alcoholic games are a serious problem for public health and medical science. Adolescents admitted to EDs for acute alcohol consumption represent an emerging public health problem, and social media games encourage alcohol abuse with alcoholic games, especially king game (Figure 1), power hour (Figure 2), neknomination (Figure 3), tris shots (Figure 4), battle shots (Figure 5), table football (Figure 6), neknomination 2 (Figure 7), and beer pong (Figure 8). Neknomination is a new form of a social online drinking game in which participants film themselves while drinking a pint of alcohol or spirits in one gulp and upload the resulting videos on the Web; the appointed person must complete this task within 24 hours [11,15,16]. Alcoholic games should not be confused with binge drinking because of the different characteristics of clinical prehospital assessment, definition, epidemiology, and risk factors. Clinical data epidemiology and risk factors appearing on emergency medical service charts represent a significant opportunity for research that could lead to effective solutions. The aim of this research was to show health professionals how to analyze the anamnestic data collected in prehospital charts and diagnosis-related group (DRG) codes according to all coded diagnoses, procedures, and

ED development technologies regarding adolescent alcohol consumption patterns during alcoholic games. The importance of considering alcoholic games as a cause of severe and acute alcohol use is shown by the fact that accurate anamneses can reveal a patient's circumstances both prehospital and in the ED. Although emergency medical service data focus on quantitative events whereas clinical data regarding adolescent and alcoholic

games mainly aim at supporting emergency medical service policy decisions and related research, they also represent an opportunity to share best practices in order to find valuable information in the data collected. The important relationships among standardized prehospital care data (clinical, management, administration), research, and clinical decision making is an opportunity to change perceptions in large-scale research.

Figure 1. King game.

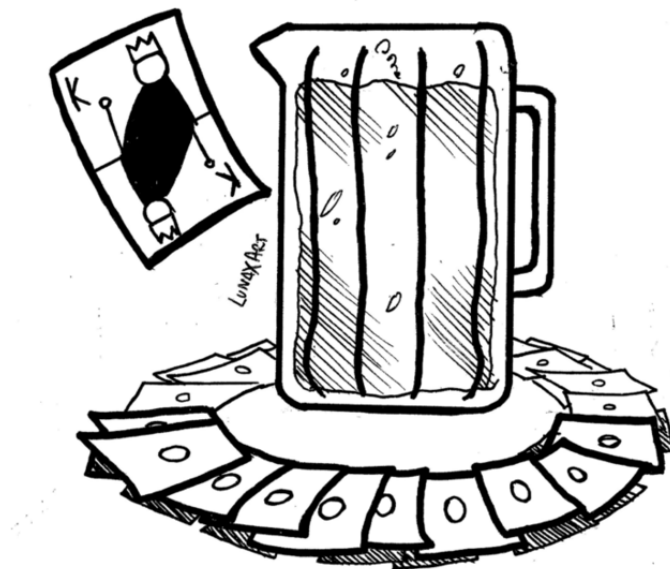


Figure 2. Power hour.

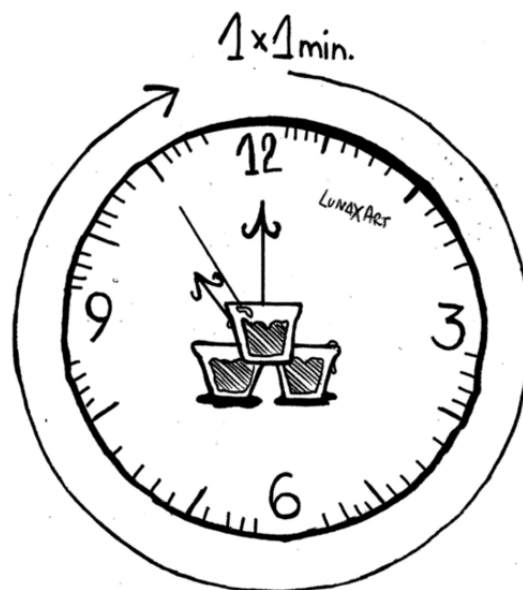


Figure 3. Neknomination.



Figure 4. Tris shots.

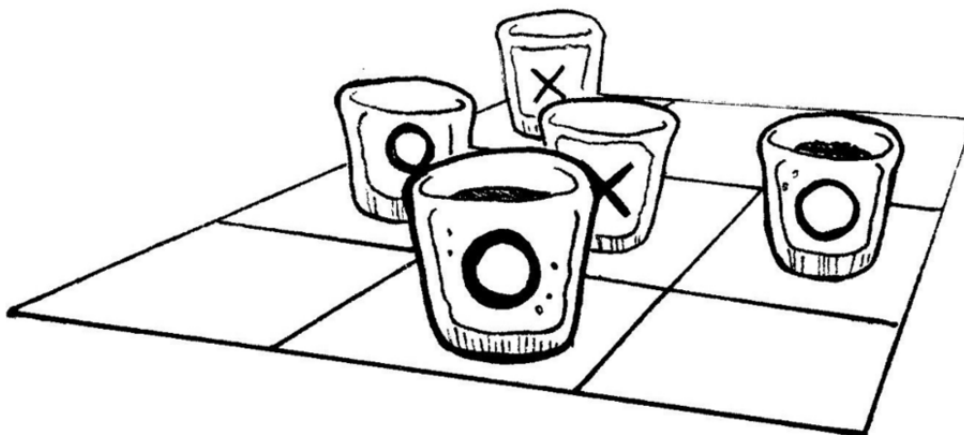


Figure 5. Battle shots.

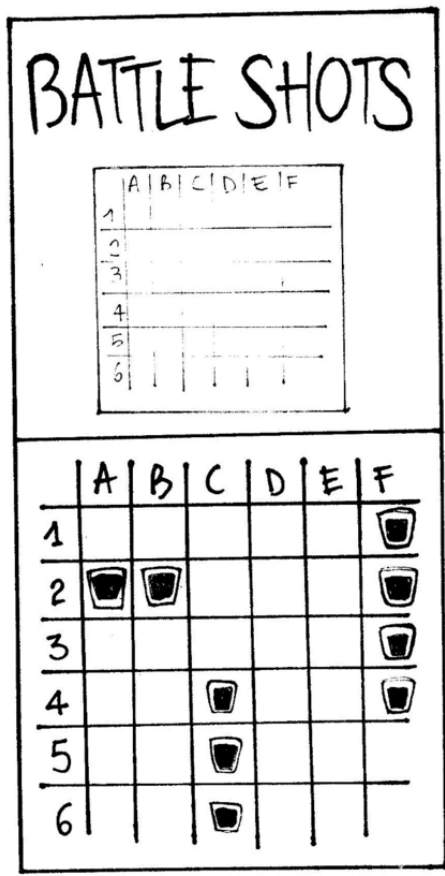


Figure 6. Table football.

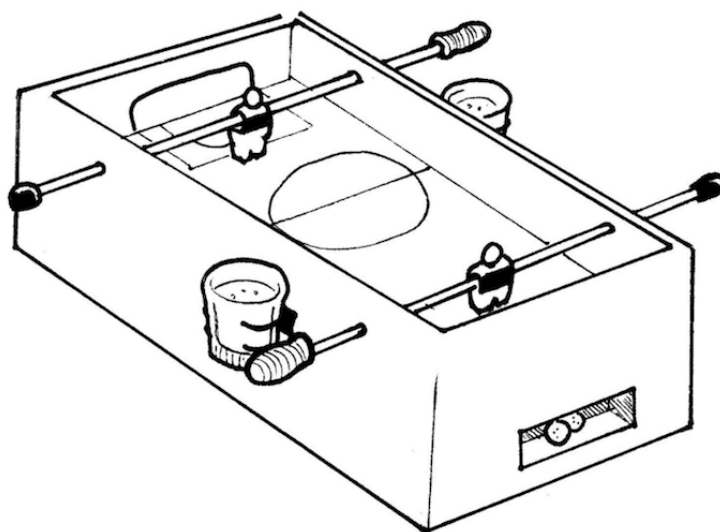
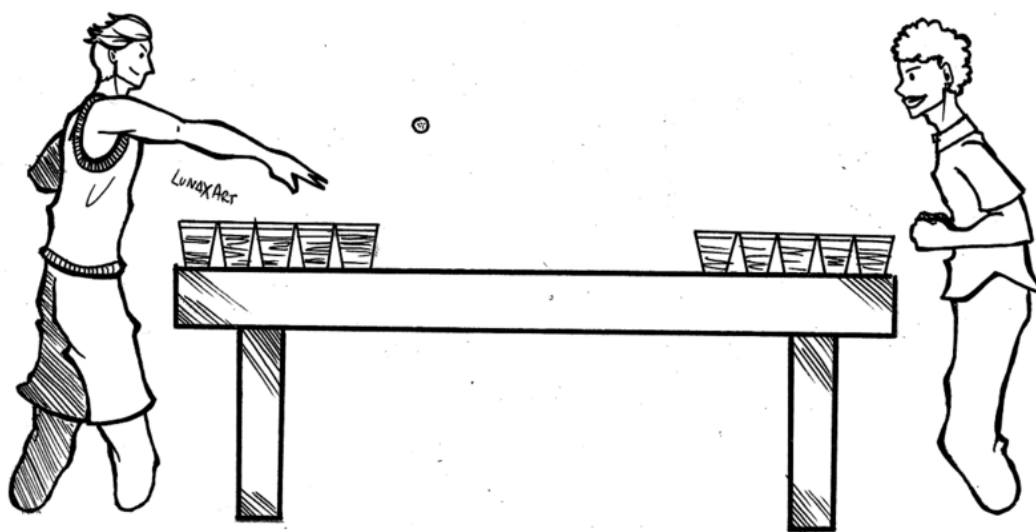


Figure 7. Neknomination 2.



Figure 8. Beer Pong.



Methods

This research is an observational retrospective study conducted at the University Hospital of Padova, Italy. Adolescents and young adults aged 15 to 20 years who accessed the ED of Padova's main hospital answered questionnaires about a particular method of drinking and acute alcohol intoxication. The link between the internet and teenagers is little known and difficult to check, but it may lead to the development of new methods of consumption of alcoholic drinks. Among the intoxicated adolescents reaching EDs, only the cases in which they had posted videos on the Web while they were drinking "several pints of an alcoholic drink in one gulp" were selected. From 2013 to 2015, 3742 patients were admitted to the ED for acute alcohol intoxication, 830 of whom were 15 to 30 years old, and 225 of whom were adolescents and young adults between age 15 and 20 years and had been playing alcoholic games. Acute alcohol intoxication was confirmed according to a blood alcohol content (BAC) test using the alcohol dehydrogenate method and ultraviolet spectrophotometer in the laboratory of the same hospital as the ED before inclusion in the sample. Data were entered in Office Excel 2007 (Microsoft Corp) spreadsheets and analyzed with SAS version 9.2 (SAS Institute Inc) for Windows. Categorical variables (gender, diagnosis at end of observation period, day of the week, BAC, age) included the number of patients per category, and age was used to classify subgroups (15 to 20 years, 21 to 25 years, and 26 to 30 years). The variable blood alcohol level was divided into classes according to article 5 of Italian decree number 151/2003, converted with law number 214 August 1, 2003 (<0.5 g/L, 0.5 to 0.8 g/L, 0.8 to 1.5 g/L, >1.5 g/L). The chi-square test or Fisher exact test were used to evaluate the association between categorical variables. Significant *P* values were less than or equal to .05; minimum, maximum, median, and quantiles were calculated for continuous asymmetric data (duration of hospitalization, weight standard DGR) and were then compared between genders using a Wilcoxon nonparametric test. We selected 225 patients belonging to the 15- to 20-year age group because they were considered the main beneficiaries of new trends about alcohol consumption.

Results

This study reviewed all prehospital ambulance records in Padova together with ED information sources for 2013 to 2015 regarding cases of acute alcoholic poisoning of teenagers due to alcoholic game challenges via the Web; the medical and nursing questions were asked for the purposes of this report. Previous clinical audits on alcoholic games and health-related internet problems in adolescent and young patients in an outpatient setting (lessons at medical school) are published elsewhere [11-16].

There is little information on the epidemiology and etiology of alcoholic games in adolescents in EDs and prehospital settings; the results guided health information ED systems through development and implementation in real-world hospital settings. Our implementation strategy was to develop a multifaceted intervention regarding knowledge, skills, and attitudes among underage adolescents. Diagnosis at entry, characteristics (gender,

age, nationality), clinical anamnestic data required by ED doctors, BAC during the emergency phase, and in-hospital monitoring all indicate the existence of specific categories of acute alcohol use linked with challenges via the internet. Anamnestic data confirmed acute intoxication following alcoholic games. This research aims at focusing the attention of medical professionals on a growing phenomenon among adolescents—the rapid development of the internet and social networks and their consequences [14-16]. From 2013 to 2015, questionnaires were collected when patients entered the ED or later if they were comatose. Data collection of raw material describing the representation of facts in prehospital care associated with more information gathered in the clinical setting (results of questionnaires) influences decision making. In order to understand precisely how dominant the role of social media is, patients were asked to express their opinion on the importance of the influence of the Web among their peers. Evaluation of the impact of social networks on the health and daily lives of adolescents had previously been assessed with questionnaires prepared by a multidisciplinary research group with Spanish colleagues, partly supplemented by some questions pertaining to smoking and alcohol consumption. ED staff completed questionnaires regarding alcoholic games and the resulting acute intoxication. The alcoholic substances involved are in fact poisons. Increasing providers' knowledge of patients arriving at EDs with toxicological syndromes should indirectly improve the development of local diagnostic and management protocols and guide clinical and educational initiatives to reduce morbidity due to toxicological disease after alcohol challenges on the Web. The distribution of gender and alcoholic consumption by age group in a target population is listed in [Table 1](#).

A total of 225 of patients aged 15 to 20 years were admitted in the ED. One important factor to consider is the legal drinking age in Italy is 18 years. Clinical presentation, prompt evaluation of acute alcohol intoxication, and appropriate management are essential to ensure optimal outcomes—in particular, advanced airway management in critical prehospital adolescents can indicate the severity of the patient's condition. The most frequently reported symptoms are unconsciousness or reduced consciousness requiring intubation by emergency medical service physicians in a prehospital setting so that patients then need further treatment and transport to EDs. The varying severity of clinical symptoms includes impaired levels of consciousness associated with seizures, slurred speech, lack of coordination, unsteady gait, nystagmus, attention or memory impairment, tremors, altered behavior, abnormal reflexes, altered perception of reality, absence of perception, and sense of death ([Table 2](#)).

Of the 225 patients, 71 stated that they had drunk great quantities of alcohol while playing alcoholic games: 14 neknomination (19.7%), 4 vodka eyeballing (5.6%), and 53 (74.6%) other alcoholic games.

Of the 830 patients analyzed from 2013 to 2015, of special interest are the 225 in the 15- to 20-year age group because they are the ones mainly exposed to new modes of high-alcohol drinking ([Table 1](#), [Table 3](#)).

Table 1. Distribution of gender and alcohol consumption by age group in a target population between 2013 and 2015.

Characteristic	Age group		
	15 to 20 years, n (%)	21 to 25 years, n (%)	26 to 30 years, n (%)
Gender			
Male	135 (16.2)	186 (22.4)	219 (26.4)
Female	90 (10.8)	126 (15.2)	74 (8.9)
Blood alcohol content (g/L)			
0 to 0.5	13 (1.6)	23 (2.8)	22 (2.7)
0.5 to 0.8	4 (0.5)	7 (0.8)	12 (1.4)
0.8 to 1.5	36 (4.3)	20 (2.4)	27 (3.3)
>1.5	172 (20.7)	262 (31.6)	232 (28.0)

Table 2. Symptoms of youth admitted to emergency department by frequency.

Year	Intoxication, n	Syncope, n	Trauma, n	Coma, n
2013	63	3	12	3
2014	73	3	22	5
2015	29	0	8	4

Table 3. Blood alcohol content of youth admitted to emergency department.

Blood alcohol content	Year		
	2013	2014	2015
0 to 0.5 g/L	6	7	0
0.5 to 0.8 g/L	2	2	0
0.8 to 1.5 g/L	12	16	8

Analysis and knowledge of context and proper presentation of facts and data gleaned from past experience are necessary to improve planning. In particular, researchers should focus on determinants of new modes of binge drinking to investigate acute alcohol assumption as a behavioral consequence of alcohol game challenges. The questions listed in the data survey also examine exactly where these behaviors took place (eg, at parties, clubs, or pubs or even at home, where the risk of drinking alcohol in large quantities is higher). To identify adolescents' worst habits, they were asked if they were aware of similar behavior among their friends or family members. To assess the consequences of substance abuse from a clinical viewpoint, adolescents were also asked if they knew about new games such as neknomination and vodka eyeballing, if they had ever tried them, and if they regretted doing so. Demographically, 15- to 20-year-olds fall into the group with the highest number of orders for BACs at EDs. Hospital discharge folders and mode of access to EDs, diagnosis on entry, characteristics (gender, age, nationality), circumstances, and examinations required by ED doctors and in-hospital monitoring were all examined (ED short observation monitoring, hospitalization, operating theater, transfer to intensive care) along with BACs. We used the hospital database, Galileo DB 41 version 1.4.3.107, to compare missing data, including anamneses (provided directly or by friends) and symptoms attributable to alcohol consumption (vomiting; altered reflexes; impaired vision; perception of

shapes, colors, or sizes; serious impairment of physical or mental condition; marked difficulty in standing or walking; hallucinations; cessation of reflexes; incontinence; and coma). For patients admitted to short stay observation in the ED (97/566, 17.1%), the average hospitalization time was 6 hours. Thirty patients were admitted for trauma, and their median time of hospitalization was 11 days with a 2:1 ratio between males and females and an average DRG weight of €46,000 (US \$56,497) for both genders. The median value of the average DRG weight relative to hospital interventions was the same for both genders (ie, €46,091 (minimum €17,349 and maximum €46,091).

Discussion

Principal Findings

Results showed that it is possible to support planning, coordinate the delivery of assistance, and provide medical education in EDs. Since accurate information is essential for good decision making, a variety of initiatives, programs, and projects have led to noteworthy improvements in educational opportunities—not only for ED personnel but also for pediatricians and public health personnel. Clinicians help with treatments, and playing an essential role is important to ensure a source of health care services and motivational interviewing (which was originally developed to treat and understand alcohol abuse but can also

be applied successfully to our understanding of changes in alcohol-induced behavior). This study may be viewed as the outcome of various activities: the administration of an appropriate and detailed description of attitudes about alcohol consumption among young people, systematic analysis of the related literature, and examination of hospitalization procedures for acute alcohol intoxication at the ED (an aspect which is still poorly understood). Quantification of cases and knowledge of the clinical implications of the various modes of acute alcohol intoxication among adolescents are the focal points for developing methods to deal with these new ways of consuming alcohol. Further alcohol-related social consequences include traffic and domestic accidents, legal and money problems, and gambling. Alcohol abuse can also lead to the development of dangerous behaviors such as increased consumption, unprotected sex (increasing sexually transmitted diseases and unwanted pregnancies), and driving under the influence of alcohol [5-10]. New trends such as neknomination and binge drinking are leading to higher numbers of episodes of drunkenness [16,17]. The current scientific literature contains several articles on alcohol abuse and binge drinking patterns [16-20], but only a few of them deal with alcohol consumption in adolescence and there are few data about the new ways of drinking such as neknomination or vodka eyeballing [16]. An examination of scientific journals in PubMed and Embase databases did not reveal any significant publications on the relationship between clinical sequelae due to neknomination or access to EDs as a result of alcoholic games. Alcoholic games should not be confused with binge drinking, because the characteristics of prehospital clinical assessment, definition, epidemiology, risk factors, and the Web connection all differ. Communications with the public, through the media and in schools, play a key role in gaining reliable information and prompt cooperation, thus limiting the effects of the problem. It has become necessary to invest in the development of specific strategies to stop new drinking habits in adolescents, promoting a healthy lifestyle, providing different access to care pathways, and developing closer cooperation with general practitioners. The excessive and sometimes pathological use of the internet is currently rising among young people in many industrialized countries in Asia, North America, and Europe. It has recently become a serious public health problem, and many authors have started writing about internet addiction. It is estimated that 95% of adolescents connect online every day in different places and with different devices: computers, mobile phones, smartphones, tablets, or e-book readers. The effects of social networks on the health of adolescents and, in general, the influence of this lifestyle are controversial, especially when teenagers have become more independent in their academic and social decisions because they are increasingly exposed to social media trends. While this may seem harmless, it can profoundly affect their behavior. One study examined the MySpace profiles of 400 adolescents and found that 56% of them contained references to alcohol and 49% explicitly required drinking alcohol [21]. Young people today are increasingly inclined to take and share selfies regularly on social networks such as Twitter, YouTube, and Facebook, where all users are represented by their profiles. It has been observed that the internet can significantly influence behaviors and forms of communication among peers. YouTube, which

has been the property of Google since 2006, is currently the most popular video-sharing site in the world, with over 1 billion users per month. Some of the most popular videos on YouTube are music videos, which generate millions of views and comments. However, YouTube has also produced material which may be highly subject to misguided interpretation by users. Although some viewers may be sufficiently well informed to watch videos or advertising with a sense of detachment and a critical spirit, others may be deeply influenced by the spirit of escape, fun, and thrill described in some videos [22]. The real success of social networks lies in the ease of communication among teenagers outside the ambit of school, family, or friends; however, thanks to the virtual network, this now extends worldwide and allows anyone to share photos, videos, or status. Unfortunately, this attitude can also lead to peer pressure and pathological conditioning adversely affecting teenagers' behavior, driving them toward potentially reckless behavior [23]. It is becoming clear that emulating dangerous acts is spreading rapidly all over the world due to the widespread use of social networks (ie, a viral phenomenon). However, little attention is paid to this aspect, although technology companies continue to create apps for smartphones and tablets and adolescents continue to emulate more and more behaviors on the Web. For example, Klout is a social networking service which offers customized statistical analysis on social media. In particular, it estimates users' influence through a Klout Score (0-100) giving the degree of interaction of those users' profiles on popular sites such as Twitter, Facebook, Google Plus, LinkedIn, and Foursquare. This influence derives from the amplitude of network users, the content generated, and the feedback level obtained. Initially, beer was mainly used in alcohol challenges, but the need to dare and be more popular soon brought teenagers to compete in these games with any alcoholic beverage available. The data collected through this study reflect the importance of dealing with the behaviors and health of young people who will be tomorrow's adults [16-17]. It is therefore necessary to improve their living environment with an integrated approach and proper policies to prevent and combat tobacco consumption, obesity, physical inactivity, and abuse of alcohol and other substances. The importance of these sources of influence becomes evident when we examine the various psychophysical changes typical of adolescence (ie, they must be evaluated by medical professionals, because they have a significant impact on the health not only of teenagers themselves but also on society as a whole). Emerging research finds many factors that contribute to excessive alcohol abuse, despite a minimum legal drinking age. Variables including television and internet time and exposure to alcohol brands in movies indicate that about 90% of the alcohol consumed by people younger than 21 years is deliberately drunk so as to reach a BAC of over 0.08% [24-26]. Clapp et al [27] report that underage alcoholic game players obtain alcohol from young adults of legal drinking age and are under severe pressure to take part in neknomination games: in detail, nonhabitual players were invited to take part in a neknomination game or another online drinking game and then pressed to upload a video of themselves while downing that drink. The authors reported that binge drinking is a social experience of drinking, whereas neknomination only involves a person who drinks alone. The

quantity of alcohol consumed during these events is very high, and participants suffer the same effects of binge drinking, since the game only lasts a few minutes. There are many risk factors related to alcohol abuse by young people, and conclusions are often in conflict in the literature: a person's age when they first experience the taste of alcohol and the context in which this happens seem to be linked to the influence of social networks, although with different methods and rules. Another cause of underage drinking is the marketing of alcoholic beverages not only on the Web but in many advertisements, and also, according to the social influence model, highlighted as social norms and life skills. Some restaurants have special discounts during happy hour (one beer or cocktail costs half the normal price) which promote excessive drinking because the intake of a large amount of alcohol occurs in a short period of time. Nekomination, happy hour parties, and later online postings of videos seem to be socially accepted to contemporaries. In Italy, happy hour is a social drinking activity like pregaming (prepartying, pre-funking) for high school and pre-university students, whereas nekomination generally takes place at home and involves younger people. Very little is known about this risky drinking behavior linked with alcoholic games and challenge; here, we consider only teenagers with high levels of alcohol who were admitted to an ED. Despite available studies and research on alcoholic games, our aim is a critical analysis of medical records through an audit which may be useful in changing clinical practice regarding alcoholic games and taking actions to improve practice reflecting variations in clinical presentation and patient characteristics. The tendency to drink too many alcoholic drinks after Web challenges and alcoholic games suggests future research in this area on prevention and interventions, focusing specifically on the dangers. The sample described in this work consisted of adolescents admitted to EDs and the alternative drinking experiences by university-level students described in previous studies or binge drinkers; the drinking behaviors were stimulated by online alcoholic games and have sometimes been associated with frequent changing of sexual partners, but future work may consider distinguishing adolescent nondrinkers from adolescent drinkers, school characteristics, and lifestyle factors. Recent Italian data report harmful uses of alcohol in 6.3% of Italians [28] and a higher rate (13.2%) in non-Italians. In a 6-year retrospective work, Majori et al [29] reported 1547 patients (aged 16 years and older) diagnosed with acute alcohol intoxication in the hospital of Verona, Northern Italy. The use of alcohol has been influenced and promoted by millions of euros of investments in marketing, advertising, and sponsorships aimed at encouraging its consumption. Although these campaigns do not encourage hazardous and harmful alcohol consumption, harmful phenomena are increased by the use of technology and social media. The incidence of acute intoxication represents 10.0/1000 of admittances to the ED, of which about 57% are alcohol-related (ie, between 0.6% and 40% of all ED patients [29,30]). The strategic role of emergency services is to identify and monitor the problem right from the beginning, to support planning and coordinate the implementation of interventions, ensuring the presence and competence of trained operators. In view of published data and previous experiences in the Veneto Region and Padova, we studied this phenomenon in order to

identify the best methods to track trends and define the procedures performed in the ED, interventions during hospital stays, alarm modes, training of new staff, and communications between operators and the local population. A formal evaluation was made regarding acute alcohol intoxication and alcohol misuse in adolescents and the common consequences of alcoholic behaviors in high school or university students while binge drinking, which has become a more frequent cause of overdoses requiring ambulance services in Italy. Internet sites influence the behavior of adolescents, and serious epidemiological surveillance systems and extra-hospital reports (risk analysis, definition scenarios, anamneses, and organizational schemes, in the case of intoxicated patients admitted to EDs) are critically examined and discussed. These findings have several implications for current clinical practice both outside the hospital and in ED settings; in particular, current findings indicate that we must improve our efforts to reduce the negative impact of this practice on adolescents and focus more on several promising directions for future research. Research teams can provide information and educational support to adolescents, but alcoholic games are often played across different platforms. Studying the path of hospital inpatients or those undergoing observation allowed us to identify categories or types of patients similar in intensity of consumption of resources and clinically significant in relation to the extent of trauma or the cause of hospitalization associated with acute alcohol intoxication. These findings indicate that the cases collected were a substantial source of our better understanding of alcoholic games in order to create successful measures to promote a healthy lifestyle among adolescents. The focus on such an important topic is relatively recent for ED staff. This retrospective study stresses the need for definitive studies with larger sample sizes and a random controlled design. Although our experience is not exhaustive, it does demonstrate the importance of physician recognition and identification of intoxication as a result of alcoholic game competition. We did not aim to be exhaustive but only to give interested readers a specific feeling of progress on the topics necessary to stimulate future researchers in related disciplines in policy-making processes.

Conclusions

Excessive alcohol use in adolescents and young people (aged 15 to 20 years) who participate in new alcoholic games and are admitted to EDs is associated with negative consequences and continues to be an important health issue, although very little documentation supports our research. Monitoring of changes in alcohol consumption (eg, heavy drinking occasions, drinking traditions, and different social Web patterns) and studying the adverse health consequences of drinking to excess reveal substantial problems, and new methods must be applied to prevent extreme consequences. Different levels of knowledge and channels of communication should help in developing new methods to prevent alcohol abuse in teenagers. The effective communication of the dangers of alcoholic games can help to implement specially designed alcohol education programs in specific contexts to contribute to effecting changes in behavior. The data stress contextual factors and dangerous behaviors due to alcoholic games by adolescent drinkers, but the accidental

circumstances of admission to EDs present the opportunity to study the extent of drinking groups, group pressure, and social influences and can also highlight problematic behaviors associated with increased levels of this context-specific and hazardous abuse of alcohol. The new alcoholic games encourage young people to consume large amounts of alcohol quickly, putting them at risk of alcohol poisoning which can potentially cause accidental injuries and contribute to higher levels of unprotected sex, suicide, sexual violence, and traffic accidents. This study shows that the frequency of these events is increasing due to the widespread and often indiscriminate use of social media. Greater awareness is needed to prevent future accidents and grant us deeper understanding of which population subgroups are most at risk in order to establish a defensive and preventive education strategy. Emergency physicians (as well as educators and in general all those who work in health care)

have the responsibility to identify and prevent the spread of these patterns of behavior. Health care clinicians should understand the reason why the number of hospitalizations due to alcoholic games has increased; it is the absence of substantial intervention in the educational schooling. We cautiously conclude that our research into the increasing impact of technology on game-related alcohol consumption in adolescents has identified some future steps to development and research, clarifies ED practitioners' need for more information, and provides recommendations for other health professionals. One key factor for success is to tailor future studies, conducted with epidemiological criteria and extended to other countries, all of which will allow us to understand and analyze the true extent of the problem in order to develop prevention campaigns in hospitals and schools.

Conflicts of Interest

None declared.

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Abbreviations

- BAC:** blood alcohol content
 - DRG:** diagnosis-related group
 - ED:** emergency department
-

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Original Paper

Adolescents' Perspectives on Using Technology for Health: Qualitative Study

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Abstract

Background: Adolescents' wide use of technology opens up opportunities to integrate technology into health visits and health care. In particular, technology has the potential to influence adolescent behavior change by offering new avenues for provider communication and support for healthy choices through many different platforms. However, little information exists to guide the integration of technology into adolescent health care, especially adolescents' perspectives and preferences for what they find useful.

Objective: This qualitative study aimed to take a broad approach to understanding adolescents' use of technology for supporting their overall health and to understand whether and how adolescents envision using technology to enhance their health and clinical care, particularly in communicating with their provider.

Methods: Adolescents (13-18 years) were recruited to participate in semi-structured, in-depth individual interviews. Potential participants were approached in-person through the Seattle Children's Hospital Adolescent Medicine Clinic while they were waiting for consultation appointments, through outreach to youth who expressed interest in other local research study activities, and via flyers in waiting rooms. Interviews were recorded, transcribed, and analyzed using a thematic analysis approach.

Results: Thirty-one adolescents (58% female, mean age 15.2 years) were interviewed and described 3 main uses of technology: (1) to gather information, (2a) to share their own experiences and (2b) view others' experiences in order to gain social support or inspiration, and (3) to track behaviors and health goals. Perceived benefits and potential downsides were identified for technology use. Teens desired to use technology with their provider for 3 main reasons: (1) have questions answered outside of visits, (2) have greater access to providers as a way to build relationship/rapport, and (3) share data regarding behaviors in between visits. Social media was not a preferred method for communicating with providers for any of the youth due to concerns about privacy and intrusiveness.

Conclusions: Although youth are avid users of technology in general, in regard to technology for health, they display specific use preferences especially in how they wish to use it to communicate with their primary care provider. Health care providers should offer guidance to youth with regard to how they have used and plan to use technology and how to balance potential positives and negatives of use. Technology developers should take youth preferences into account when designing new health technology and incorporate ways they can use it to communicate with their health care provider.

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KEYWORDS

adolescent; adolescent health services, technology; primary health care, social media; qualitative research

Introduction

Adolescents are avid users of new technologies, with a quarter of adolescents online almost constantly and almost all (92%) online daily [1]. Most teens (84%) have used the internet to search health topics online, 21% have downloaded mobile apps, 12% have played a health-related game, and 7% have worn a wearable health device [2]. Across health topics, teens express a desire for online, accessible information and health interventions which are technology-based as opposed to in person, telephone, or paper.[3] When health websites and text messaging services are made available to teens, they are highly utilized [4-7]. Due to adolescents' frequent use and openness to trying out new technology tools, the trend for technologies directed at health improvement may have an important influence on adolescent health.

Much of the research eliciting adolescents' preferences for incorporating technology in health care has examined the use of patient electronic portals with respect to confidentiality and its influence on adolescent utilization of technology. A systematic review examining pediatric use of patient portals found that in general account activation is low for teens due to barriers such as concerns about confidentiality [8,9]. However, one additional study found when confidentiality was ensured by a patient portal, adolescents used them as frequently as parents of younger children [10]. Other studies have been conducted to quantify what types of technologies adolescents prefer. When considering communication with their provider, one study found adolescents preferred email or text over video communication [3], another found adolescents preferred emails to follow-up after visits over texts [11], and a third found texts were preferred over using social media [12]. While almost all adolescents surveyed in the latter study used social media, only 25% felt social media could give them useful health information [12]. While these studies are useful in summarizing overall adolescent preferences, little attention has been given to what drives adolescents' preferences for technology use and how they use various technological media for their health [13].

Adolescents' predilection for technology suggests they will adopt technology integrated into health visits and health care. As most adolescent health care is centered around prevention efforts, prioritizing use and design of interventions which incorporate technology into behavior change interventions, such as for healthy eating, incorporating exercise, or improving sleep quality may be beneficial. Providers may be able to offer further resources, intervene earlier, and troubleshoot problems in the moment as patients are implementing behavior change more readily using technology than through traditional phone calls and office visits. However, adolescents' perspectives and preferences for what they find useful are needed to guide the integration of technology into adolescent health care. This qualitative study aimed to elicit adolescents' perspectives on how they currently use technology to support their health and to gain insights into what factors may influence their future use

of technology to improve their health or communication with their provider. Gathering more in-depth qualitative information on these topics may be useful in informing clinicians how to use technology to engage with their patients and in providing insights into adolescent preferences for people who design new technology tools for health.

Methods

Recruitment and Participants

A total of 31 adolescents (18 females and 13 males) participated in in-depth semi-structured interviews in Seattle, WA. Potential participants were approached in-person at the Seattle Children's Hospital Adolescent Medicine Clinic while they were waiting for consultation appointments, through outreach to youth who expressed interest in other local research study activities, and through posted flyers in the waiting rooms of the adolescent and sports medicine clinics. Of the 31 participants, 26 were recruited from the waiting room of the adolescent clinic, 5 were recruited from community sources, and 1 was recruited via flyer. Purposive sampling methods were used to ensure the sample included nearly balanced numbers of genders (male and female) and age ranges (13-15 and 16-18 years) as well as adolescents representative of racial and ethnic diversity of the Seattle area.

Adolescents were eligible to participate if they were between the ages of 13 and 18 and could read and speak English. Consent or assent was obtained from adolescents who were interested and eligible. Parental permission was required for participants under 18. As described in the consent and assent forms, the youths' responses were kept confidential except in cases where the youths indicated that they were planning to hurt themselves or someone else. Approval was obtained for all study procedures from the Seattle Children's Hospital Institutional Review Board.

Procedures

Prior to being interviewed, adolescent participants privately completed a tablet-based electronic health assessment called Check Yourself, that covered health behaviors including exercise, nutrition, sleep, safety, sexual activity, depression, and alcohol and drug use [12]. The health assessment provided direct feedback to the adolescents on their health behaviors, including how they compared to recommended guidelines for their age. Following completion of the health assessment, adolescents participated in individual interviews lasting approximately 45-60 minutes. Three study team members—2 female (KK and one other) and 1 male—trained in qualitative interview techniques conducted the interviews. The interviewers did not know the respondents prior to the time of the interview. Only 1 interviewer had medical training as a physician and worked in the adolescent medicine clinic where recruitment took place, however, she was not involved in recruitment and did not conduct interviews with any of her patients. Interviews were conducted between February and July, 2015 and took place primarily in a private room in the same building as the adolescent clinic used for recruitment.

Textbox 1. Questions from qualitative interview guide regarding technology in adolescent health.

- *Have you tried any types of technology, like smartphone or tablet apps or social media, to help you with your health? Tell me about how you used it. What did you like or not like about them?*
- *What role do you think technology (like smartphone and tablet apps and social media) can play in keeping teens healthy?*
- *What technologies would you be most likely to use to communicate with your provider?*
- *What would make you want to use one form of communication over another?*

When scheduling constraints prevented the interview from occurring at the clinic, interviewers met participants in a private and convenient location (eg, a private meeting room at a library).

Interviewers used a semi-structured interview guide which included 3 areas of inquiry: (1) electronic health assessment feedback (results from this published in a previous study) [14]; (2) adolescent preferences for health behavior change support from their provider (results from this have been submitted and are under review); and (3) technology used and preferences for technology use by adolescents for their health. Due to the large volume of data, this paper primarily focuses on the responses given to questions on the third area of inquiry with the specific questions listed in [Textbox 1](#). For the first question, adolescents were asked if they had tried various technologies with card prompts to help orient them to the question. Cards included the following names and/or logos of social media sites or technology types: Facebook, Snapchat, Twitter, Instagram, live Chat (eg, via Skype or Gchat), wearable technology, wifi messaging (eg, Kik or Whatsapp), informational websites (eg, Google, WebMD, Wikipedia, ASKfm), texting service, save-for-later sites and apps (eg, Pinterest, Pocket, Digg), and blogs (eg, TeensHealth, Teen Speak, Tumblr). Interviewers defined “provider” to participants as their primary care physician or someone they see regularly for health check-ups, such as a pediatrician, family medicine doctor, or nurse practitioner. The interview guide was adjusted over the course of the study as questions were added to explore emerging themes or not asked about in-depth after reaching thematic saturation. Adolescents received \$30 for participating.

Data Analysis

All interviews were recorded using a digital audio recorder and were professionally transcribed. Interviewers reviewed each of their transcripts for accuracy, correcting errors, and filling in gaps where possible. All interview transcripts were uploaded into the Web-based qualitative analysis software, Dedoose [15], for coding. One study team member developed the initial codebook of themes following a thematic analysis approach outlined by Braun and Clarke [16]. Using an inductive approach to data analysis, development of the final codebook was an iterative process, with coders proposing new codes to the study team as transcripts were reviewed, updating the codebook to encompass emerging themes and recoding previously coded transcripts. Four study team members participated in coding the data with 2 analysts independently coding each transcript, with coding discrepancies resolved by consensus. The authors collaboratively reviewed all text excerpts within each code to identify themes and key quotes illustrating each theme.

Results

Demographics

The mean age of participants was 15.2 years. As previously published, the sample included 20 participants who self-identified as Caucasian (64.5%), 6 as Hispanic (19.4%), 3 as Asian (9.7%), 2 as African American (6.5%), 1 as Other (3.2%), and 2 as Mixed race (6.5%); see [Table 1](#) [14].

How Teens Use Technology for Health

Teens described using technology in one of 3 main ways to support their health: (1) to gather information, (2) to share their own experiences and view others’ experiences in order to gain social support or inspiration, and (3) to track behaviors and health goals. Each of these uses is discussed below with illustrative quotes in text and additional quotes provided in [Table 2](#). During these discussions, themes also emerged regarding the benefits and potential downsides to using technology for health. These are summarized in [Figure 1](#) and discussed in the following two sections.

Information Gathering

Teens reported seeking resources, ideas, and education using both apps and websites. The most commonly searched topics reported by the youth interviewed were related to nutrition and exercise (ie, healthy foods, portion size, calorie counting, workouts); some also sought information on medical and mental health conditions and consequences to their health from behaviors such as marijuana use. To gather this information, teens reported using various sites including medical websites such as WebMD and Mayo Clinic, Web searches using Google, and Pinterest to “pin” or save healthy recipes or exercise routines. They found YouTube, exercise apps, and Facebook useful for accessing work outs; one teen also used Tumblr, a social media blog, for health information. Teens reported that they valued the accessibility and relatability of online health information:

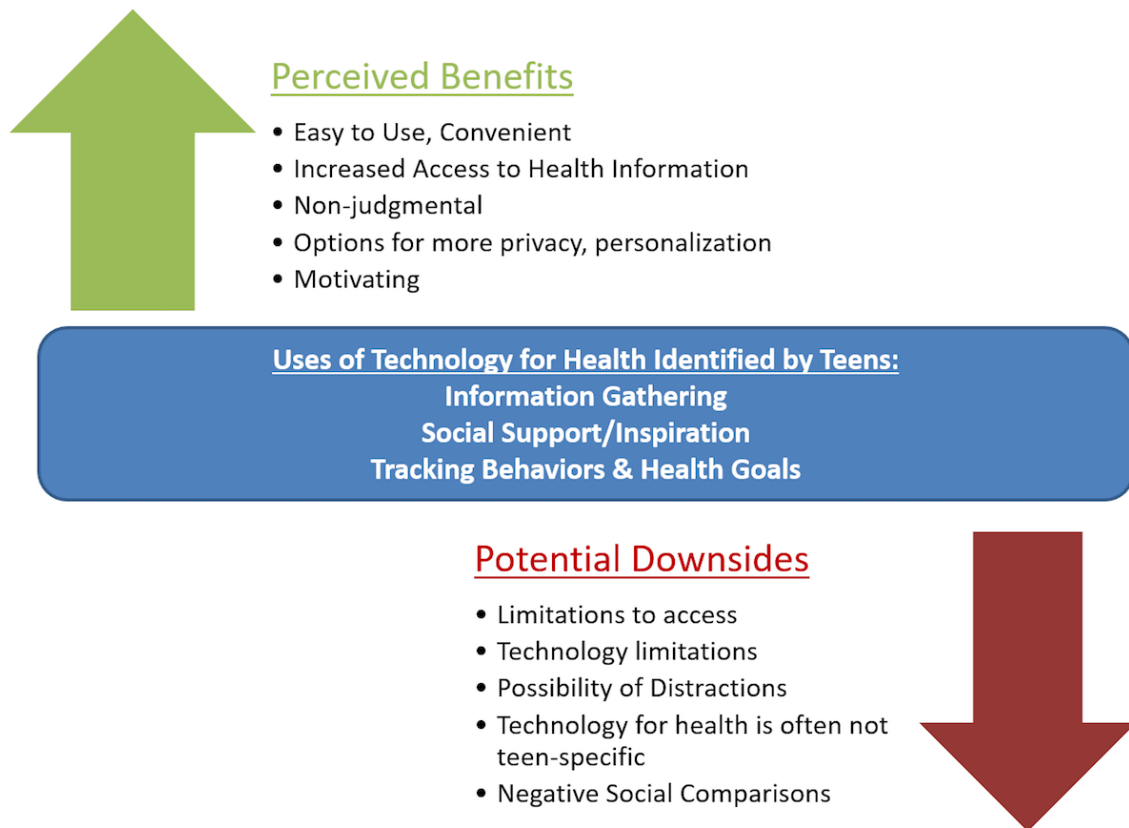
I don't have time and honestly don't want to go to the library to look up a disease. I like that everything is at my fingertips. So, if the doctor tells me that I'm at risk for this and I don't know the name of the disease, and maybe if the doctor is using fancy words that I don't understand. I think it's really nice that I can look up on Google, what is this? And like I'll get Yahoo answers, Google answers, but I honestly like it because it's like real people explaining compared to some weird terminology that I don't know. [ID 925, Female, 17]

Table 1. Participant demographic data (N=31).

Characteristic	Participants
Age (years), mean (SD)	15.2 (1.4)
Age (years), n (%)	
13	5 (16)
14	5 (16)
15	6 (19)
16	10 (32)
17	4 (13)
18	1 (3)
Gender, n (%)	
Male	13 (42)
Female	18 (58)
Ethnicity, n (%)	
Hispanic	6 (19)
Non-Hispanic	25 (81)
Race, n (%)	
African American	2 (7)
Asian	3 (10)
Caucasian	20 (65)
Multiracial	2 (7)
Race not specified	4 (13)

Table 2. Uses of technology for health identified by teens.

Theme and examples	Example excerpts
Information gathering <ul style="list-style-type: none"> exercise ideas, recipes, nutrition tips, etc information about symptoms and treatment for common ailments; consequences of health risk behaviors 	<i>Informational websites, WebMD is great. I've used it, it's awesome. [ID 912, Female, 18]</i> <i>I've used Facebook to help me with my health... there was this page about exercise and it had every day they would post little guides on how to do different exercises. I just subscribed to the page and would do the exercises when they came up. [ID 924, Male, 15]</i>
Social support/inspiration <ul style="list-style-type: none"> ability to learn about others and relate to their experiences viewing peer activity may inspire action; for others, did not make a difference 	<i>If you see other people doing it, maybe pictures of other people doing something physical and they look like they're having fun [chuckle]. It might make you more motivated. [ID 915, Female, 13]</i>
Tracking behaviors and health goals <ul style="list-style-type: none"> creating accountability through scheduling and reminders (especially for workouts) using wearable technology to track activity tracking nutrition via apps 	<i>I like Nike Plus because...they give you reminders of like, "Remember you scheduled a run. Like, I would be training for a half marathon or something that I wanted to do once and it was giving me steps that I didn't have to figure out. It was easier for me... And then you get points for it. And like I said, I'm a competitive person so I would love to get as many points as possible. So, I liked that. [ID 938, Female, 16]</i>

Figure 1. Perceived benefits and downsides of technology use for adolescents.

Inspiration and Social Support

In addition to gathering information, teens felt that they benefitted from others sharing their health experiences online, including: getting ideas of what others are doing to support their health; feeling motivated from others' shared pictures (eg, a friend who shared a picture from a half marathon on Instagram [Female, 18]); and feeling social support in their efforts toward better health, especially mental health. For example, one teen shared that Tumblr offers anonymity which allows users to be more comfortable sharing personal stories to wider audiences, as well as access to others who can provide online support:

But then they get a good sense that they're not alone and maybe what that person's going through they can apply it to their own lives...Then when you're on your blog and then you read these things it makes you feel good that hey, I have someone I can talk to. [ID 922, Female, 14]

Although teens mentioned blogging as a way others could share their health experiences, many did not consider popular social media sites as a platform to learn about their health. Teens had various opinions on health technology which includes social components such as the ability to compare their progress with others. Some teens felt they could be inspired by viewing the health activities of others online: "Like well if that person can do it, I could probably do it too" (ID 919, Female, 17), while other teens were not particularly motivated by it:

I don't think that would be a motivator force for me like it is for some people. Some people are like, "Oh,

these people are watching, so now, I got to go do it," and I'd be like, "Beep, the app's closed, whatever." [ID 928, Male, 17]

Tracking Behaviors and Health Goals

Some teens had used technology to track behaviors related to their health goals, such as steps taken, calories burned, portion sizes, water intake, and nutritional information. Various devices were used by the youth including wearables (ie, Fitbit), Wii Active plus, running apps, Google maps, Apple Health kit, Nike Plus, water consumption trackers, and My Fitness Pal. Notifications, reminders, and earning "points" from such programs were motivating to teens and prompted consideration of their goals during the day. Some teens appreciated the reward of receiving immediate feedback offered through tracking technologies:

For me, there's definitely the gratification of like, "You reached 10,000 steps" and it goes off, and so you want to reach that. [ID 928, Male, 17]

Perceived Benefits of Using Technology

When talking about the different technologies used, themes emerged regarding characteristics that made health technology especially useful or appealing to teens (Table 3). Themes identified included: convenience, increased access to health information, the nonjudgmental nature of technology, options for increased privacy and personalization, and the motivating aspects of technological platforms.

Table 3. Perceived benefits and potential downsides in teens' use of technology for health.

Observations and examples	Example excerpts
Potential benefits	
Easy to use, convenient <ul style="list-style-type: none"> teens already using their phones and are proficient with technology some apps are free 	<i>...For the My Fitness Pal thing, having it all in the phone because you always have your phone. So just always having that information with you and it's not on paper or on something that could get damaged...I like technology, as opposed to paper, I'd probably choose technology. [ID 935, Female, 16]</i>
Increased access to health information <ul style="list-style-type: none"> credibility of information important explained in an understandable way information is shareable tracking information brings awareness to eating habits 	<i>...I don't have time and honestly don't want to go to the library to look up a disease. I like that everything is at my fingertips. So, if the doctor tells me that I'm at risk for this and I don't know the name of the disease, and maybe if the doctor is using fancy words that I don't understand. I think it's really nice that I can look up on Google, what is this? And like I'll get Yahoo answers, Google answers, but I honestly like it because it's like real people explaining compared to some weird terminology that I don't know. [ID 925, Female, 17]</i>
Nonjudgmental <ul style="list-style-type: none"> not a parent or teacher telling teen what to do technology could relieve teens from seeing unwanted reactions from providers during face-to-face contact 	<i>...Like some teachers are really biased about it because they are against having sex at a young age so they don't teach you what your other options are, they just say, "Don't have sex." Same like with learning about our bodies, like in health they don't teach you the parts of the vagina or the vulva or stuff... I had to learn a lot of that stuff on my own. I looked it up. I wanted to know what parts there are so I looked it up...on Tumblr. There are a lot of good references in there. [ID 933, Female, 15]</i>
Options for more privacy, personalization <ul style="list-style-type: none"> ability to ask questions or seek information anonymously ability to share or repost useful information 	<i>Well I guess you can hide behind the screen I guess...They don't need to know; like you don't need to see people in order to talk to them...it's just like you don't have to worry about what to wear. [ID 913, Female, 13]</i>
Motivating <ul style="list-style-type: none"> creating competition via tracking points or setting personal goals providing positive reinforcement 	<i>[Nike running app] just tells me how much I run and gives me feedback...It'll say like, "Keep going, you are doing great." Something like that. Positive feedback...Because then you think in the back of your mind, "Oh yeah, you can really keep going and keep going and push harder." [ID 914, Male, 16]</i>
Potential downsides	
Limitations to access <ul style="list-style-type: none"> difficult to find credible health information apps and tracking technologies often come with costs teens cannot always afford 	<i>When you search up something it doesn't really give you the right answer sometimes. [ID 910, Female, 13]</i> <i>...WebMD as far as I know it just tells you you have cancer. I don't actually know if it does anything helpful. [ID 924, Male, 15]</i>
Technology limitations <ul style="list-style-type: none"> having to frequently input information prone to inaccuracy (not having the right foods to log, pedometer sensitivity) need to remember passwords 	<i>The food diary wasn't very accurate because if you type in "cheese," like if you have a sandwich you have to put it in piece by piece and that's kind of annoying, and you always have to remember if you go for a walk to turn on the step counter, but that's pretty much for anything. Overall it was a really good app, but it was just a bit too much extra work for eating and walking. If I eat a sandwich I don't really want to put it in before I forget. [ID 936, Male, 16]</i>
Possibility of distractions <ul style="list-style-type: none"> use of technology for health could draw teens into using phones for example for more entertainment, reducing sleep and activity 	<i>I think it [technology] kind of makes them [teens] more unhealthy because it will stop them from sleeping. Sometimes if my phone starts vibrating and I'm half asleep, I'll wake up and look at it. [ID 936, Male, 16]</i>
Technology for health is often not teen-specific <ul style="list-style-type: none"> tracking technology is usually focused on weight loss instead of consuming healthy foods may be too private or not private enough 	<i>I used [My Fitness Pal]...I also felt that it was motivation in the wrong direction. Like tracking everything that I was eating and mixing all the nutritional information compatible together made me want to eat less which is not good. So I stopped using those apps because I just didn't think they worked for me the way that they were supposed to...I feel that a lot of those apps are focused on losing weight rather than a healthy lifestyle and they don't really give any tips for a healthier lifestyle. [ID 931, Female, 14]</i>

Observations and examples	Example excerpts
<p>Exposure to risky behaviors; negative social comparisons</p> <ul style="list-style-type: none"> teens may see unhealthy messages through peer use of technology teens may misuse technology to continue health risk behaviors 	<p><i>Instagram—I don't see how that could help with health. Have you ever heard of the thigh gap? No? So basically what it is...I was on Facebook and someone liked a photo from Instagram and it showed this picture with her feet put together and a gap between her thighs. I can show you [stands up and gestures to thighs]. So it's like your feet are together and there's a gap right there. And that's called the thigh gap. That came through Instagram. A lot of people were doing a lot of unhealthy things to achieve that. [ID 912, Female, 18]</i></p>

Teens valued technology that was easy to use and fun, especially using games and earning points or rewards which could help them set personal goals and motivate them to do more the next day. Teens appreciated having multiple options of things to do, like exercise routines (eg, Pinterest), and integrating multiple aspects of health data such as calories, exercise, and body mass index. Other appealing characteristics included social support, reminders, getting positive feedback, privacy, and convenience, especially due to the ubiquitous nature of technology:

I think it's nice because for most teens it's in the palm of your hand. You can do it while you're out. It's not like you're like literally carrying a journal around and writing it down. It's discreet, other people don't necessarily know what you're using. [ID 917, Female, 17]

Participants appreciated the way technology made health information easily accessible, understandable, and shareable; they especially valued sources focused on health concerns, such as WebMD, to explain health terms regarding diseases or medications which their provider may have quickly gone over in the clinical setting. One teen specifically preferred the neutrality of phone notification reminders as opposed to human verbal reminders which may come off as admonishing:

Like the reminders help instead of having a person do it because they could be like, "I told you to do this six times and you didn't do it," and my phone [can] just like nicely be like, "You have not done this yet, you need to do this." Be like, "Well, okay." Because positive reinforcement—at least for me—is better than somebody yelling at you and saying, "No, you have to do this and you haven't done this yet, and I'm disappointed." [ID 926, Male, 16]

Anonymity was valued by teens when discussing personal health information, with notable differences between social media sites in potential for unwanted disclosure:

In Facebook, the settings are twisted a little bit so I would be afraid to make a mistake and all of a sudden everyone knows...you have that different identity on Tumblr so say that Pixie12 is talking to her doctor, but you have no idea who that is so it doesn't really matter. [ID 938, Female, 16]

Potential Downsides to Technology

Several teens described that although technology could be used for health, they also recognized possible downsides, as shown in Table 3. Some factors which kept teens from using certain technologies included: limitations to access such as cost;

limitations to the technology itself such as requiring remembering log-ins and passwords or the requirement for frequent or complicated data entry; the possibility of distractions; technology for health not being teen specific; and negative social comparisons. Several teens felt that wearable technology would be useful but, because of the cost, viewed it as inaccessible. Others were frustrated by the lack of accuracy and user-friendliness of the freely available apps:

There is a health app that comes on the iPhone, but it's really inaccurate. Like the steps you are taking, it doesn't accurately count them so it's kind of useless, and I don't know how to use it. [ID 933, Female, 15]

Teens mentioned that if they were drawn to use their smartphone for health, they also may be alerted to other applications and notifications and then use the phone for longer than intended. One teen described how her intention to engage in a healthy behavior (exercise) may be disrupted by smartphone distractions which she feels are difficult to control:

You might get like, "Oh yeah I'm going to go work out." And I've got my phone and it gets in the way because you get sucked in and it's hard to get off. It's addicting. [ID 935, Female, 16]

Another teen made an insightful point that while using technology offers the privacy for a teen to explore and gain knowledge on something they might not otherwise have the courage to ask about; this unmoderated access to information may impede seeking input from others.

You can put yourself in an environment where no one else knows what you are doing on the computer, and so that's a good thing and a bad thing in my opinion. It's a good thing because no one has to know that you are struggling with this problem—[using the internet] could then give you more knowledge on what is happening with you to make a change instead of just ignoring it like you probably would have. But it's also bad because no one knows what you are looking at so you can look at anything. [ID 938, Female, 16]

On the other hand, some teens felt their privacy would not be completely protected since searches may be visible on their browsing history. For example, one teen stated:

A lot of kids don't want to go on their iPads and search "birth control" because it's on the history. [ID 917, Female, 17]

Some teens also mentioned the potential for negative consequences from technology-based health information, such as sharing risky behaviors, promoting body dissatisfaction and

negative competition, losing weight in an unhealthy way, and being exposed to bullying.

Technology for Health Provider Communication

In addition to questions about history of use, teens were asked how they may consider using technology for working with their health provider and what types of technology they would like to use. Three main categories for potential uses of technology with their providers emerged: (1) to have questions answered by their providers outside of visits; (2) to have greater access to their providers as a way to build their relationship/rapport; and (3) to share data regarding their behaviors in between visits with their provider (Table 4).

Several teens spoke about a desire to use technology to get quick and direct responses to questions in between visits. They felt they would benefit from receiving guidance from their provider on reputable internet resources when conducting a search for health information; and from receiving immediate feedback from their provider on whether the severity of a clinical problem warrants an appointment. Teens particularly valued the ability to receive a rapid response to their questions directly from the provider and not another staff member.

If there was an option where I could email my doctor questions I think I would probably do that. And they've never said that they're like, "Call us if you have any problems," but when they say that they mean call the doctor's office and make an appointment, at least from my perspective they're not just there to talk. But, let's just say if I had a question if it was possible to email them and get a direct response. [ID 917, Female, 17]

Preferred technological methods to communicate with a provider varied among teens. Factors affecting preference included the type of question they had as well as the teens' thoughts regarding formality of the interaction. Many teens indicated a preference for text messages when the communication was brief or simple such as in scheduling appointments, prescription reminders, and answers to straightforward clinical questions. They also felt that due to text messages being more informal, they would also be more authentic:

So with a text you can text whatever you are writing, you don't have to worry about saying, "Dear Dr. Blah, Blah, Blah," and then if you need to add in one more sentence you don't need to send a whole new email, you just have to add one more sentence. You can just sort of put it in there. It doesn't look super bad...being less formal is better because when you feel formal you feel the need to be perfect and that's not true. [ID 938, Female, 16]

At times, teens preferred phone or email when they wished to show the provider they had taken more effort to contact them and compose a message when compared to texting. For more

complex questions that might require detail or a lengthy response, teens preferred email communication, in order to safeguard against losing meaning and also to save the information for reviewing in the future. One teen described that opposed to the phone, email could also offer more privacy and its asynchronous nature could help avoid embarrassment:

I just feel like it's [email] almost more like private, and I think it's easier for long responses. If I had a question that they could send me a link to it, it would still be on my phone. I could check my e-mail on my phone. It still would be right at my fingertips, but it would be a little more confined, I guess. It wouldn't be talking on the phone about it as much if it was something I was kind of embarrassed about. I wouldn't have it in text message. Text messages are kind of hard. When I text, I'm not having in-depth conversations with people. It's to have a short little thing. I just e-mail when I have—when it's longer. More important things I guess. [ID 917, Female, 17]

Finally, some teens preferred video conferencing as they felt it was important to see facial expressions and nonverbal cues:

Seeing someone else's facial expression is very important. If you are just texting, a lot of people use shorthand [which] can kind of erase elements of conversation so maybe you can't tell if someone is being sarcastic and you write it down. Like, I totally have this issue. "So, do you sleep well?" "I haven't slept ever in my life." That's obviously sarcastic, but "Did you sleep well last night?" "No, I got up and died" or, "I got up and fell over and hallucinated." You know, something crazy and they accidentally break that down and take it seriously. But, over Skype you can see their face and they can be smiling or laughing or making sarcastic eyebrows, you know what I mean? So that can be helpful. [ID 930, Male, 16]

Social media was not a preferred method for communicating with the providers for any of the interviewed teens due to concerns about privacy and intrusiveness.

I think it [social media] could be done I just don't think it's a preferred way to—because I feel like a lot of teens would think that it might be an invasion of their privacy if their provider followed them on all their social media. Then it might be kind of awkward. [ID 915, Female, 13]

A recurrent concern that arose about using any technology to communicate with providers was potential loss of confidentiality. However, the asynchronous and nonjudgmental nature of electronic communication methods had the advantage of reducing discomfort when teens were anxious about disclosing a sensitive clinical topic.

Table 4. Technology for health provider communication.

Categories for Use	Example excerpts
As a way to have questions answered by their providers outside of visits <ul style="list-style-type: none"> Use of technology could potentially reduce appointment frequency 	<p>...Say you are on good terms with [your provider] and you have some weird boil or whatever, take a photo of it say this hurts, send it to them and they would tell you what they think it is. Kind of like a WebMD that works. [ID 924, Male, 15]</p> <p>Like today I could have stayed home and could have talked to her over the computer instead of coming in for her telling me that I need to do more...For easier appointments, it could be easier to do Facetime. Like not-so-hard appointments where the doctor needs to see exactly what they need to do. [ID 914, Male, 16]</p>
To have greater access to their providers as a way to build their relationship/rapport	<p>I think, especially if they want to be more one-on-one and know every patient that they have, if they're kind of connected and seeing those results, the patient is kind of like earning or like Fitbit gives you little badges, maybe the health care providers like, "Oh, he did this, this was on the plan, let me send him this little badge," and it'll be like, "Wooh"...Stuff like that, or really more personal with the doctor than just being like, "Yeah, I show up at your office every 6 weeks and I have to be here," but actually being connected. [ID 928, Male, 17]</p> <p>...So, maybe a monthly email checking in or something would be good, because then I'd know that this [provider] cares about me as a patient instead of just, "I blend in with all these other kids." [ID 940, Female, 14]</p>
Share data regarding their behaviors in between visits with their provider <ul style="list-style-type: none"> As a way to communicate or provide proof about their behavioral patterns 	<p>...But I actually have information now. So it puts information from the [Jawbone] UP into my iPod and I can show that to my doctor and be like this is my sleep from the night that we just had, this is my sleep from last week, this is my general pattern. Let's talk about that. That's been nice. [ID 912, Female, 18]</p> <p>I think it's [Owl outcomes app] useful because you can monitor how you're doing without having to actually go to the doctor's like every 2 weeks. You can go like every 2 months and still have them know if something's going really bad, then they can contact you. [ID 915, Female, 13]</p>

An additional benefit for some teens was the possibility to connect more personally with their doctors between visits. Teens felt technology offered an opportunity to further build rapport with their provider, particularly if the provider were to reach out to them in between visits. One teen described the possible content of a monthly check-in email:

"Hey, how's your week? Do you have anything new? Do you want to give me a phone call? Is there something we need to talk about? What was your favorite part of this week?" Something where you can build up that relationship and trust, and it's not only associating the doctor with taking your temperature and stuff that hurts. [ID 940, Female, 14]

A final area in which teens talked about the potential for technology to be helpful was in helping them document and share their health behaviors with their provider. Teens felt that tracking such information could help provide objective data to the provider and validate steps they were taking toward behavior change, as well as potentially decreasing the number of in-person visits.

You can kind of keep track [on FitBit] of what you are doing, and the fact that you can log it on your phone, and then you can go back and see what you did, and you don't have to always try to remember that part of it...It's like actual proof because sometimes if you're like, "Yeah, I went and walked five miles one day," the doctor's like, "Did you

really? You don't look like you'd be that person," then you'd be like, "I did." [ID 928, Male, 17]

Discussion

In this qualitative study, teens indicated 3 main categories of technology use for health: (1) gathering information, (2) inspiration and social support, and (3) tracking health behavior and goals. Teens expressed their desire to quickly access nonjudgmental health information in the privacy of their own technology use, but noted some shortcomings of technology for health including prohibitive cost, technology not being youth-friendly, potential for distraction, and exposure to negative behaviors, especially social comparison. Teens were interested in using technology such as email or texting for communication with their providers specifically as a way to get questions answered outside of visits, to have access to their providers to build the teen patient-provider relationship, and as a way to keep their provider up to date with sharing information about progress in health between visits.

In our study, the most commonly mentioned use of technology for health involved use of search engines and websites to learn about health-related issues. This is consistent with a prior study of a nationally representative sample of US teens which found that the vast majority had used the internet for gathering information on their health, despite only 25% being satisfied with the information they found in searches [2]. The perspectives of teens in our study suggests that this may be due to technology

for health not being teen specific and written for adult audiences. This implies that technology developers should include teens in their user-testing and specifically consider their unique needs and reactions. Also, health care providers should assume their patients are using the internet to answer their health questions and check in with them regarding what they have learned and help direct teens to sites that tend to have more reliable and age-appropriate information. Additionally, health care providers and health educators have a role in helping teens develop skills in assessing online health information and health literacy.

Another key finding of our work was that although adolescents appreciated some of the social aspects of technology such as learning about their friends' health accomplishments or feeling they are not alone, for example in mental health symptoms, most did not prefer to use their social media for health and did not want to use social media for communicating with their provider. These results are consistent with a recent cross-sectional survey of adolescents attending a primary care and adolescent clinic in which only about a quarter thought social media would provide useful health information and most would not want to use it to communicate with their provider [17]. Several other studies have also found teens prefer health interventions which do not use their existing social media [3,18,19]. Our study provides an explanation as to why social media does not seem to be the preferred medium for teens. Several youth expressed concerns regarding mixing their private social networks, which they saw as mostly focused on connecting with peers and friends, with health-related initiatives. In particular, adolescents were concerned about their peers seeing health-related information or their providers seeing information intended for peers. Despite these concerns, there still may be a role for social media in health promotion, as several studies have shown teens will engage with others who have a similar health problem in privately moderated social networks [20-22]. Also, in one study, Facebook-based health education posts related to sexual health risk were accessed by teens when the content was obtained in a more passive manner and not shared with their social networks [23].

While recognizing how popular and intriguing technology was to them, teens in our study also identified several possible downsides including distraction from important tasks, such as school work, sleep disruption, and exposure to negative content (eg, risky behavior and overt focus on body image). Increased technology use, especially prior to bedtime, has been associated with sleep disruption [24]. When providers consider the use of health technology with teens, it is important to also be aware of these potential negative effects. For example, if recommending a calorie-counting app or online tool when counseling about behavior change related to weight loss, a provider may consider a discussion about body image and any associated advertisements the tool may have regarding unhealthy dieting. The provider may also help the adolescent think about whether tracking their weight loss with friends through the app may lead to negative social comparison and unhealthy advice on disordered eating or over exercising. Another role for the provider may be to help the adolescent set appropriate goals, knowing that many of the default recommendations used by these tools may be designed for overweight or obese adults.

Although teens recognized potential downsides, many were enthusiastic about using technology to communicate with their provider. Their goals for using technology with providers largely paralleled the reasons they used technology for general health, including getting questions answered outside of visits (gathering information), connecting and building rapport with their provider (inspiration and social support), and sharing data in between visits (tracking behaviors and goals). There was no consistent preference for one type of technological medium (eg, phone, social media, text message, email) for communication over another. More important to teens seemed to be the nature of the content of the communication. As providers consider adding technology, they may want to seek youth input regarding preferred methods. Preference to use technology to communicate may vary based on the health topic [3] and the type of information being exchanged. For example, although teens prefer receiving their sexually transmitted infection test results face to face [25,26], an anonymous question and answer sexual health web portal was very popular [27]. A large multiple focus group study done with adolescents in Ontario similarly found that communication via technology can allow providers to enhance connection and trust with their teen patients and help provide direction to searches and how to critically appraise online health information [28]. Health care providers may not realize the value of using communication through technology to build rapport with their teen patients. To allow for more informal provider-teen interactions, secure messages through patient portals seem to be less used by teens [10], but this may not be because teens do not want to communicate with their provider but possibly due to patient portals not being convenient and as easy to use as communication methods teens are accustomed to (eg, Facebook messenger) due to security standards. Also, the language used to present health information on these portals and website format may not be as easy to use, approachable, and visually pleasing as popular health education websites for young people, such as the online birth control support network, bedsider.org. [29]

This small qualitative study is limited by use of a sample recruited from an urban academic health clinic, and it is possible that the views of adolescents living in rural settings with less access to health care may differ. While our purposive sampling method helped to generate a sample that was representative with a range of respondents, this methodology may be prone to researcher bias. However, our findings are similar to those of a larger quantitative study where samples were recruited from a nationally representative population [2]. Another limitation is that teens in this study were given prompts for particular technological platforms and so they may not have considered other technologies which did not immediately come to mind. In addition, it is possible that taking the health assessment primed teens to be more accepting toward technology for health; however, since most had used technology for health in the past, we do not think this would have biased their responses significantly.

Conclusion

Overall, teens use of technology for health is growing. Health care providers should be prepared to inquire about and provide

advice for how teens are using technology for their health. Teens would like to use technology-based communication tools with their health care providers. This study offers multiple implications for health providers caring for adolescent patient populations and technology developers. First, providers should assume that teens have used or will use the internet to answer health-related questions and should be prepared both to assess the teen's understanding and to help guide the teen to reputable sites. Anticipating these health searches, health care providers can provide specific guidance including directing teens to trusted websites and assisting teens to use the best health-related terminology. Additionally, when recommending sites, providers

should also consider any potential negative consequences and check in with teens regarding their experiences, both positive and negative, with using any recommended sites. Finally, teens are interested in using technology to communicate with providers. Technology developers should consider building more options for teens to communicate with health care providers. As technology grows, more work will need to be done to help providers understand and respond to youth preferences, to develop tools to guide youth to reputable health resources, and to develop strategies for incorporating patient tracking data into clinical practice.

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Conflicts of Interest

CM's spouse is employed by Facebook, and together they own stock in Facebook.

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Original Paper

Theoretically-Based Emotion Regulation Strategies Using a Mobile App and Wearable Sensor Among Homeless Adolescent Mothers: Acceptability and Feasibility Study

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Abstract

Background: Many adolescent mothers are parenting young children under highly stressful conditions as they are managing first-time parenthood, poverty, lack of housing, school and work, and challenging peer and familial relationships. Mobile health (mHealth) technology has the potential to intervene at various points in the emotion regulation process of adolescent mothers to provide them support for more adaptive emotional and behavioral regulation in the course of their daily life.

Objective: The goal of this study was to examine the acceptability, feasibility, use patterns, and mechanisms by which a mobile technology used as an adjunct to in-person, provider-delivered sessions fostered adolescent mothers' adaptive emotion regulation strategies under real-life conditions.

Methods: Participants (N=49) were enrolled in the intervention condition of a larger pilot study of homeless adolescent mothers living in group-based shelters. The mHealth technology, Calm Mom, consisted of a mobile app and a wrist-worn sensorband for the ambulatory measurement and alerting of increased electrodermal activity (EDA), a physiological measurement of stress. We examined logs of mobile app activity and conducted semistructured qualitative interviews with a subsample (N=10) of participants. Qualitative data analysis was guided by the theoretical frames of the intervention and a technology acceptance model and included an analysis of emerging themes and concepts.

Results: Overall, participants indicated that one or more of the elements of Calm Mom supported their ability to effectively regulate their emotions in the course of their daily life in ways that were consonant with the intervention's theoretical model. For many adolescent mothers, the app became an integral tool for managing stress. Due to technical challenges, fewer participants received sensorband alerts; however, those who received alerts reported high levels of acceptability as the technology helped them to identify their emotions and supported them in engaging in more adaptive behaviors during real-life stressful situations with their children, peers, and family members.

Conclusions: Calm Mom is a promising technology for providing theoretically driven behavioral intervention strategies during real-life stressful moments among a highly vulnerable population. Future research efforts will involve addressing technology challenges and refining tailoring algorithms for implementation in larger-scale studies.

KEYWORDS

electrodermal response; adolescence; mothers; emotion; parenting

Introduction

Background

Adolescent mothers often experience tremendous stress managing the concurrent developmental transitions of adolescence and new motherhood. A vast majority of adolescent mothers in the United States are between the ages of 15 and 19 years [1] and are single parents balancing new motherhood, school, and work while navigating the normative social and emotional challenges of adolescence [2]. Although they experience stress typical of new mothers [3-5], many adolescent mothers enter parenthood with histories of adverse childhood events including maltreatment, trauma, foster care placement, and homelessness in addition to engagement in sexual and other risk behaviors including substance use and delinquency [6,7]. Adolescent mothers' parenting practices may be compromised by these early disadvantages and current demands, placing them at great risk for neglectful and abusive parenting [3,8].

Managing or regulating emotions is a core developmental skill that develops through childhood and adolescence and is critical for both effective parenting and successfully navigating the transition from adolescence to early adulthood [9-11]. Emotion regulation is defined as the process by which individuals modify the expression and experience of their emotions in ways that are sensitive to situational demands [12]. Effective emotion regulatory abilities among parents are associated with sensitive, positive parenting and better parental mental health, whereas poor emotion regulation places parents at higher risk for child maltreatment [13]. Compared with adult mothers, adolescent mothers are more likely to experience decreased tolerance of children's negative affect and have difficulty engaging in sensitive and empathic parenting [14,15]. Moreover, those with adverse childhood experiences often have a heightened sensitivity to stressful events [16]. Increasing emotional regulatory strategies has the potential to assist adolescent mothers in navigating these transitions and engaging in more effective parenting.

Behavioral interventions targeting mental health issues such as stress can be delivered in the real world, in real time, and *just-in-time*, when individuals actually need support via mobile phones and other technologies [17-19]. Mobile health (mHealth) interventions that adapt to changes in individuals' internal physiological states have the potential to provide personalized support at specific vulnerable periods. To date, the vast majority of adaptive behavioral interventions use wearable, ambulatory technologies that continuously monitor activity level through accelerometers (eg, [20]); fewer have used physiological measures of stress.

Electrodermal activity (EDA) exclusively measures sympathetic nervous system activity, whose general action is to mobilize the body's response to emotional arousal [21]. Under relatively low levels of physical exertion, higher EDA reflects emotional

arousal, particularly stress, including arousal not open to conscious awareness, as well as attention-demanding tasks such as parenting [22]. Traditionally, EDA has been measured in the laboratory under simulated emotionally arousing conditions, but recently, validated, wearable, and wireless methods of ambulatory monitoring of EDA have been developed for use in everyday life [23-25], and they hold great promise for assisting individuals to recognize and regulate strong emotions. However, outside of small, proof-of-concept studies conducted over brief periods of time [23,24,26,27], few studies have examined the continuous, longitudinal use of wearable sensors for monitoring EDA under real-life conditions.

In this report, we examine the feasibility and acceptability of an mHealth technology that consists of a mobile app and wearable sensorband to measure and alert participants of increased EDA. The technology was used as an adjunct to an in-person, provider-delivered intervention for increasing emotion regulation and positive parenting and reducing risk behaviors among homeless adolescent mothers.

Emotion Regulation

The extended process model of emotion regulation (EPMER) [12] is a theoretical framework that delineates a sequence of 3 dynamic and recursive steps in the emotional regulatory process: *identification*, *selection*, and *implementation*. Each step represents a potential target for regulation. In the *identification* stage, individuals detect the emotion and valence (ie, largely positive or negative). In the *selection* stage, individuals determine a strategy for regulating the emotion, including the following: *situation selection* and *modification*, which entail selecting or changing the emotion-generating environment or context; *attentional deployment*, which includes directing or shifting one's attention to influence the emotion; *cognitive change*, which entails altering one's cognitive appraisal of the situation to influence the emotional impact; and *response modulation*, which entails directly influencing the behavioral or physiological aspects of the emotional response. Finally, in the third stage, the regulation strategy is *implemented* in ways that are appropriate to the context. The effective regulation of emotions increases the probability that individuals will enact more adaptive behaviors [28].

Strategies for Increasing Emotion Regulation: Cognitive Behavioral, Mindfulness Meditation, and Mindful Parenting

Cognitive behavioral therapy (CBT) [29,30] and mindfulness meditation [31-33] have been found to work synergistically to increase adaptive emotional regulation at various stages in the emotion regulation process. CBT-derived techniques include both cognitive and behaviorally focused strategies for examining and reappraising automatic thoughts and assumptions and building stress reduction and coping skills for dealing with situation-specific stressors. Mindfulness meditation involves training to increase mindful awareness of moment-by-moment

experiences in a nonjudgmental, accepting manner [31]. The cultivation of mindfulness has been demonstrated to increase cognitive and emotion regulatory skills among adolescents, most notably, attention regulation and inhibitory control [34,35], and decrease negative emotionality [36,37]. Moreover, strategies to increase mindfulness in parenting have been found to increase parents' emotional awareness and self-regulation in parent-child interactions; reduce automatic, negative reactions toward children; and increase parental sensitivity [38,39]. Receiving physiological feedback about emotional states can add potency to CBT and mindfulness meditation strategies.

Applying Intervention Strategies to Interactive Digital Technologies

Despite the proliferation of mHealth technologies, theories of technology-based behavior change have only emerged recently [40-43]. The effective translation of behavioral interventions to interactive digital technologies may be highly dependent upon the fit between the target behaviors, the specific theoretically grounded behavior change strategies employed in the technology, and the relationship between the functional aspects of the technology and user preferences.

Finally, blended interventions that incorporate both provider-delivered intervention and mHealth technology are less frequently reported, yet have great potential to assist individuals to practice skills learned with providers in the context of their natural environments. Some initial evidence suggests that blended interventions may be more efficacious for reducing stress compared with technology-only interventions [44], especially among adolescents [45].

Thus, in a real-world study of homeless adolescent mothers, we used quantitative and qualitative data to examine (1) participants' engagement with the technology components of the intervention and (2) the ways participants experienced the theoretically based emotional and behavioral regulatory strategies through the technology component. Specifically, we were interested in understanding the mechanisms by which the technology components fostered emotional regulation strategies.

Methods

Participants

Participants in this study were enrolled in the intervention condition (N=49 adolescent mothers) of a pilot randomized controlled trial for homeless adolescent mothers living with their children in transitional living programs (TLPs) in a northeast state. The description and results of the randomized controlled study are not reported in this manuscript but are forthcoming. TLPs are large group home shelters that are staffed 24 hours per 7 days a week and house between 8 and 20 adolescent mothers and their children. Adolescent mothers and their children are eligible for voluntary shelter in the TLPs if the adolescent mothers are aged between 13 and 21 years, homeless, and eligible for public assistance, and have custody of their children [46]. Adolescent mothers typically reside in

the TLP with their children for 6 to 8 months, although the lengths of stay vary widely.

Between 2013 and 2015, adolescent mothers participated in a baseline interview, which included survey items of demographic/background characteristics and an assessment of EDA (described below) and received a US \$40 stipend. The in-person intervention was conducted weekly in a group format for 1.5 hours in the common room of the TLP. Participants received a study smartphone (typically during session 1) and a sensorband (typically during session 2). Adolescent mothers also participated in 2 follow-up interviews at 3 and 6 months post baseline and received a \$25 stipend for each interview. The study phone was provided for the duration of the study (6 months) and the sensorband was provided for the first 3 months (study flow chart, [Multimedia Appendix 1](#)). Participants who were emancipated minors or who were 18 years old or older provided informed consent for participation in all study activities. Informed consent for participants under 18 years was provided by the participants' caseworker or parent/legal guardian (if available), and these adolescent mothers also provided informed assent for participation. The New York University's institutional review board (IRB) and the IRB of the state's child welfare agency approved all aspects of the study.

To examine participants' experiences with the technology, a subsample of adolescent mothers who used one or more components on at least one occasion were randomly selected from each of the TLPs to participate in an in-depth, semistructured qualitative interview after their 3-month follow-up assessment. Of the 21 available participants, we conducted interviews with 10 participants who received \$25 for their participation.

Description of the Blended Intervention Developed for This Study

Power Source Parenting is a theoretically based parenting intervention aimed at highly vulnerable adolescent mothers and delivered by trained interventionists [47]. Calm Mom is the companion mHealth technology consisting of a smartphone app developed for the study and an integrated wearable sensorband that continually measures EDA [23,48]. The Calm Mom technology is designed to reinforce the emotional regulatory and positive parenting skills learned in the Power Source Parenting in-person sessions by delivering intervention material, just-in-time, when adolescent mothers need to support to enact these skills in between Power Source Parenting sessions.

Intervention techniques in the Power Source Parenting in-person sessions involve CBT and mindfulness meditation strategies aimed at increasing positive child management and mindful caretaking skills, increasing knowledge of normative child development, and providing strategies for dealing with stress, risk behaviors (eg, substance use, delinquency), and challenging relationships with peers, family members, romantic/sexual partners, and their child's father. The manualized intervention consists of interactive group exercises, discussions, role plays, brief videos, and outside readings [47], as well as formal sitting meditation focusing on the breath and body awareness.

Figure 1. Calm Mom sensorband.

Calm Mom consists of a mobile app developed for the study and a biosensorband (see [Figure 1](#)). The sensorband is worn on the wrist or ankle and continuously measures EDA, sending this wirelessly via Bluetooth [49] to an Android-based smartphone (technical specifics and cost have been described elsewhere) [23,24,48]. Pilot testing of the sensorband was conducted with a small number of participants in the target population before initiation of this study [48].

In an effort to provide a variety of features, Calm Mom elements were delivered to participants in 3 different ways, using both push-in (notifications and requests are sent by the system) and pull (requests are made by the user) designs. Of the 3 elements, 2 were delivered independent of the sensorband via the mobile app alone: (1) a nightly report alert delivered at 9 PM every evening (push-in) and (2) a self-report, which participants were free to initiate at any time (pull). The mobile app combined with the sensorband elicited a sensorband-triggered alert that signaled the participant when her EDA reached an individually determined threshold and invited her to make a report on the app (push-in). Each element began with a screen on the app that asked, “Would you like to make a report?” If participants answered “no,” the app closed. If they answered “yes,” they were asked to rate their feelings using a slide bar (see [Figure 2](#)), using a scale of 0 (“Bad”) to 100 (“Good”), with neutral (50: “Okay”) as the default (50 and above is considered within the positive range). As seen in [Figure 3](#), the nightly report was brief and consisted of an affirmational message congruent with the valence.

Self-reports and sensor-triggered alerts involved more content on the app, and in an effort to minimize participant burden, we alternated the length of reporting for the sensorband-triggered alert and self-report on odd ([Figure 4](#)) and even days ([Figure 5](#)). Specifically, on odd days, participants were asked to rate their feelings on a slide bar (as described above). If the valence was in the positive range, an affirmational message popped up.

If the valence selected was in the negative range, adolescent mothers would be asked to report the problem type via radio buttons from a list of 6 main problem areas that adolescent mothers typically encounter (eg, child, boyfriend, school/work) and read a motivational/coping message (eg, “No matter how you’re feeling right now, remember that you love your baby”) and a behavioral skill (eg, “Freeze, breathe, and choose”) previously learned in the in-person sessions and related to the problem type chosen. Alternatively, on even days, adolescent mothers were asked to rate their feelings as above and then watch a brief (<20 sec) video of inspirational and behavioral messages congruent with the valence reported delivered by ethnically/racially diverse adolescent mothers. Both nightly reports and sensorband-triggered alerts provided a “snooze alarm” period, enabling mothers to put the alert on hold for up to two 10-min periods.

Measures and Data Sources

An assessment of baseline EDA was conducted to determine participants’ individual EDA threshold using a cognitive stress task and physical activity. Participants were asked to sit quietly in a comfortable position for a few moments, and after signing informed consent/assent, the research assistant then placed the sensorband on the participant’s right wrist while she sat quietly for a few moments. Participants then engaged in a computerized Stroop color word task in which they were asked to read the names of the colors as quickly as possible in 1 min, and a brief physical task (eg, walking up and down the stairs quickly) was performed for approximately 4 min.

Data were obtained from 3 sources: (1) survey results conducted at the baseline interview of participants in the intervention arm for demographic information and a quantitative acceptability measure at the 3-month follow-up interview, (2) logs of the technology activity, and (3) semistructured qualitative interviews from the subsample of adolescent mothers who used the technology on at least one occasion.

Figure 2. Rating feelings screenshot.

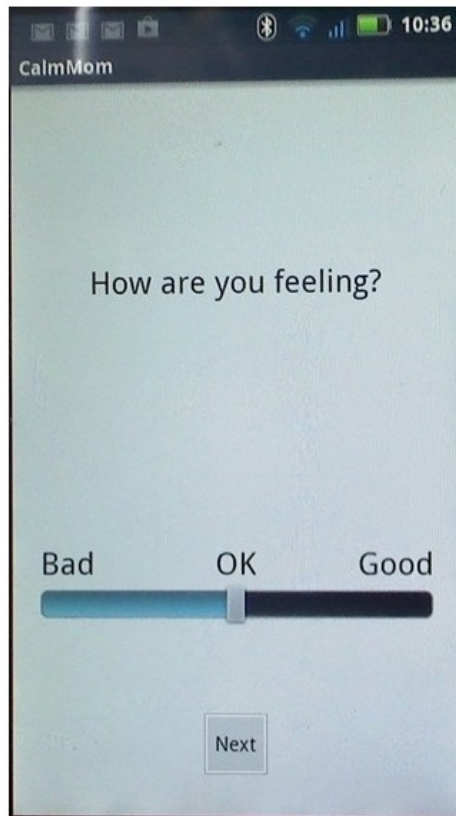


Figure 3. Flowchart for nightly report.

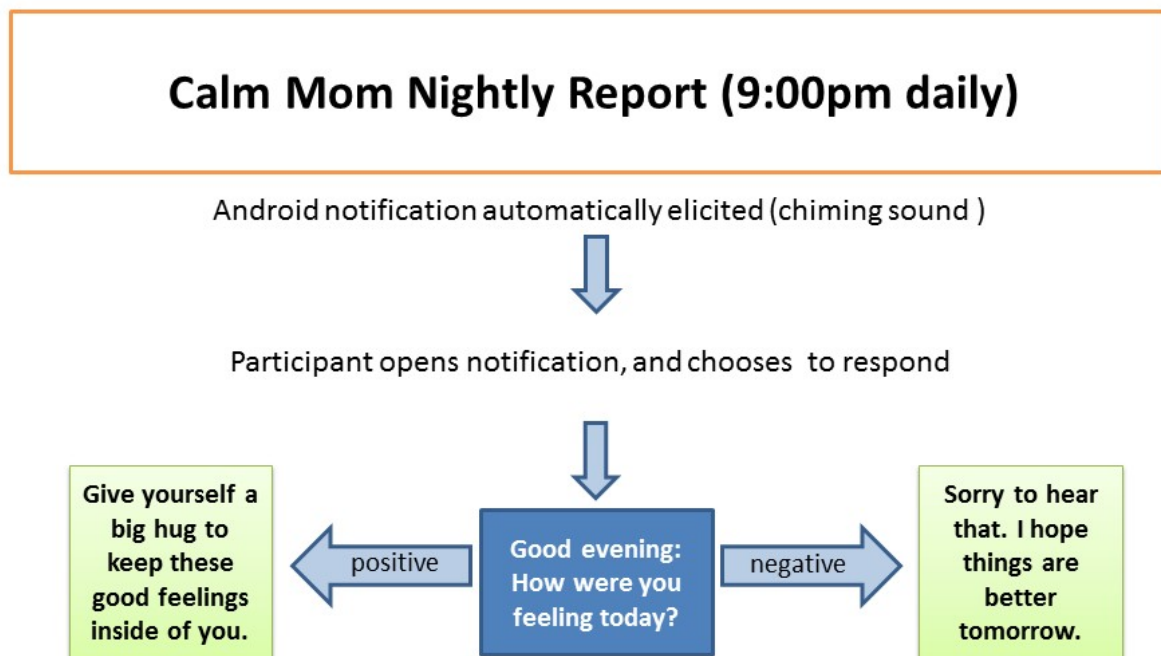


Figure 4. Flowchart for sensor-triggered or self-report on odd days.

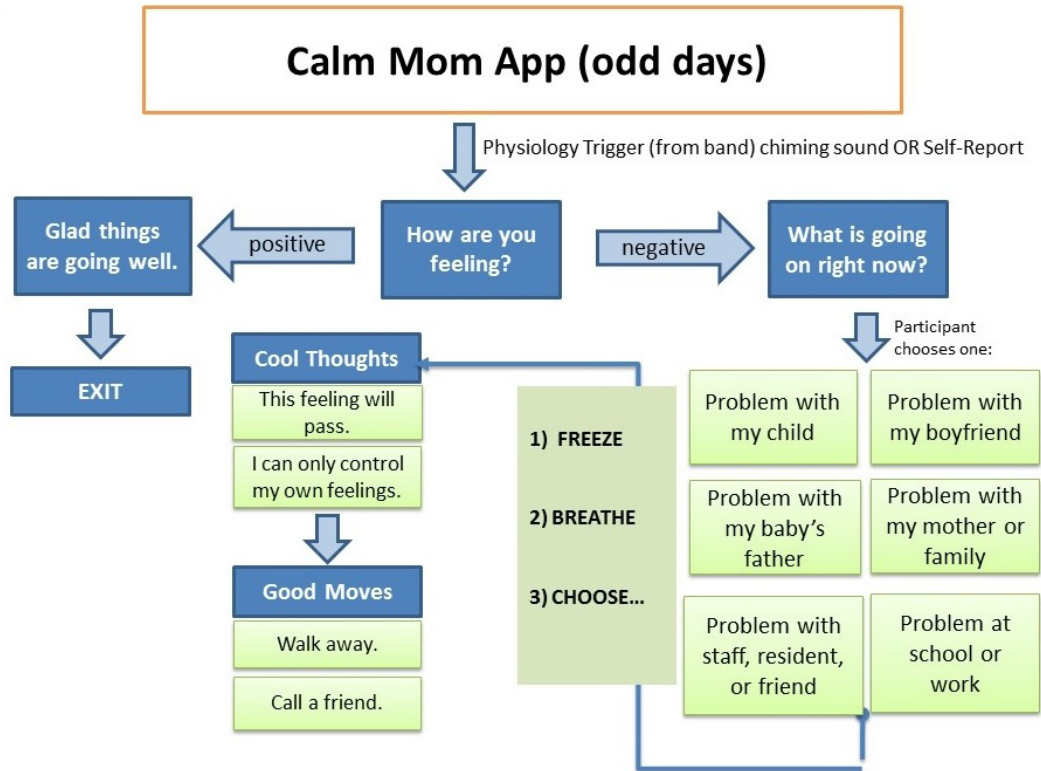
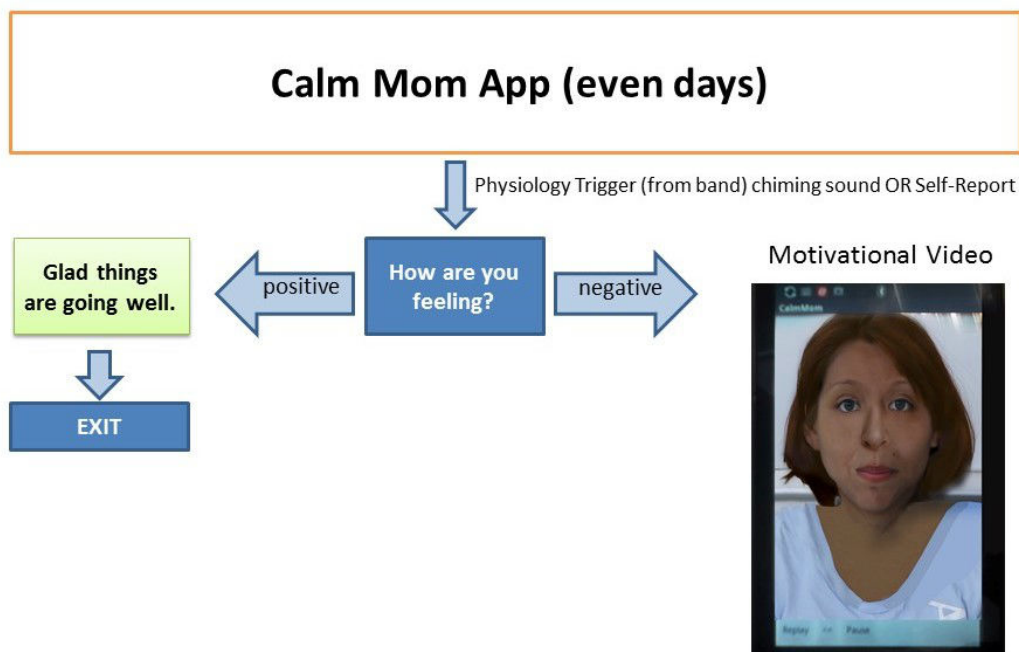


Figure 5. Flowchart for sensor-triggered or self-report on even days.



The acceptability questionnaire consisted of 8 items developed for the study with the item wording and response categories derived from the client satisfaction questionnaire [50]. The questions asked about participants' satisfaction of the blended intervention as a whole, satisfaction and usefulness of the mobile app and the sensorband for reducing their stress and dealing with their children, and the frequency to which participants used specific skills from the in-person intervention that also appeared on the mobile app (eg, "Freeze, breathe, and choose"). All items were rated on a 4-point scale with higher scores indicating

greater satisfaction ($\alpha=.89$). All questions were administered on a laptop computer with headphones, using audio-assisted interviewing.

We examined logs of the technology activity and calculated descriptive statistics for amount and frequency of use of each element, valence reported, and screen time.

The qualitative interview questions were guided by the EPMER [12] to gain an understanding of participants' experience with the technology for increasing their emotion regulation skills at

different points along the emotion regulation process. We also utilized aspects of the empirically derived unified theory of use and acceptance of technology (UTAUT) [51] to describe participants' reactions of the technology components of the intervention. Masters-level interviewers trained in qualitative interviewing administered the interviews that lasted approximately 45 min. The interviews were transcribed and entered into Dedoose [52]. A "start" list of initial codes based on the UTAUT and the EPMER was created by the research team. The start list codes consisted of labels containing one to several words assigned to sections of the text that described that code. Guided by grounded theory [53], the research team then met to review the codes, develop the codebook, apply the start list codes to the text, and create new codes based on emergent themes.

Results

Participants

There were 49 adolescent mothers enrolled in the intervention condition and their mean age was 18.54 years; 21% (10/49) of participants identified as white, 33% (16/49) black/African American; 42% (20/49) Latina, and 4% (3/49) other race/ethnicities. Approximately 40% (20/49) of adolescent mothers spent time in foster care in their lifetime; 62% (31/49) were held back a grade in school on at least one occasion. Most adolescent mothers had one child whose ages ranged from 0.2 months to 63.61 months (mean 16.4 months).

Use of the Technology

Mobile App and Study Phone

Of the 49 participants assigned to the intervention condition, 4 were discharged before receiving a phone, 1 participant did not use the phone, and there were technology problems with 4 phones; therefore, we present data on 40 participants who had readable data.

Use of the Calm Mom Mobile App

Due to the varying amount of time adolescent mothers spent at the TLPs, participants had their study mobile phone between 15 and 316 days (mean 155.8; standard deviation [SD] 75.16) and in total spent 605.67 min (mean 14.77 [SD 14.39], range 0.62-76.34) using the app. Participants used at least one of the elements on the app on average; 44% of days they had the study mobile phone (SD 24.82).

Mobile App Only Reports (Nightly and Self-Reports)

Nightly Reports

Overall, participants answered approximately 40.00% (2555/6388) of the nightly messages (Figure 6). The average number of nightly reports per participant was 65.12 (SD 46.1, range 8-247). The overwhelming majority (88.00%, 2248/2555) of these reports were in the positive range with an average valence of 69.36 (SD 14.90) on the scale of 0 to 100 (50 and above is the positive range). The most frequently chosen valence was 50. Participants spent an average of 4.8 seconds (SD 4.03, range 1.36-18.26) making a nightly report.

Figure 6. Distribution of the number of nightly reports.

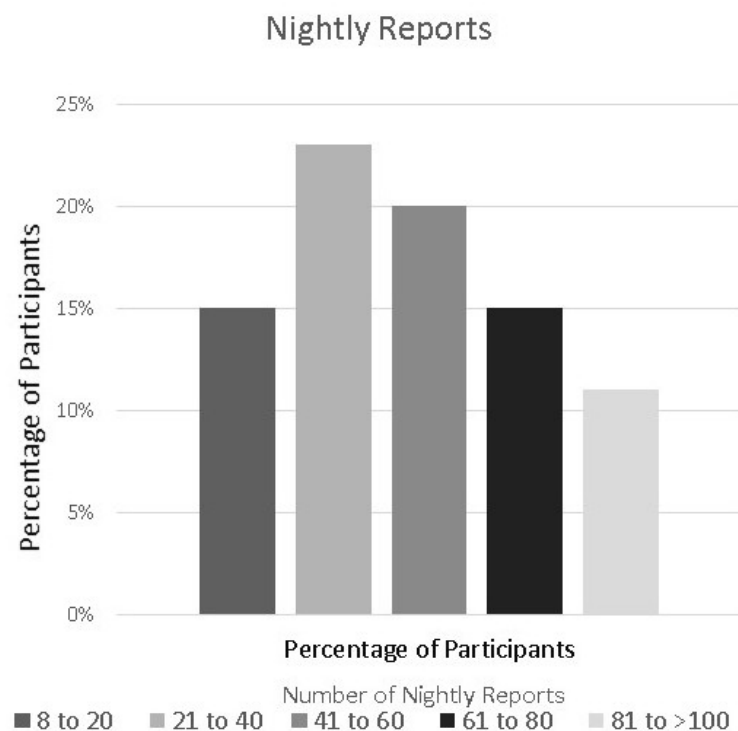
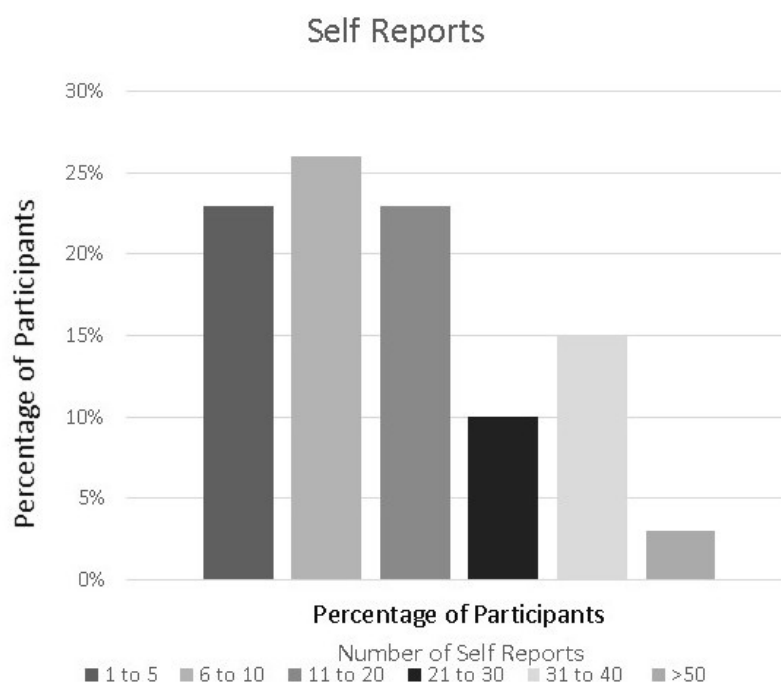


Figure 7. Distribution of the number of self reports.

Self-Reports

In total, participants made 609 self-reports with 97% (39/40) of participants making at least one self-report (mean 16.4 [SD 15.08], range 1-75). Approximately half of the participants made 10 or fewer self-reports and the other half made between 11 and 40 self-reports (Figure 7). The mean valence reported was 47.30 (SD 16.50, range 11.70-88.89). There were more positively (335, 55.0%) than negatively valenced (274) self-reports ($P=.01$). Participants spent an average of 3.07 min (SD 4.91, range 7.71 seconds to 25.32 min) making a self-report.

We examined the mean valence of the nightly reports versus the self-reports; the mean valence of the nightly reports was significantly higher than those of the self-reports ($t_{39}=2.94$, $P=.005$).

Sensorband Plus Mobile App

Of the 40 participants who received study phones, 7 participants left the TLP before they could receive the sensorband. Of these 33 participants, technical problems prevented 9 participants from using the band and 13 did not receive an alert. Therefore, only 11 out of the 33 (33%) participants who received a sensorband made one or more reports in response to sensorband alerts.

Sensorband Reports

Among these 11 participants, the number of reports varied between 1 and 71, with the vast majority (9/11, 77%) of participants making less than 20 reports. The average valence reported was slightly in the positive range (mean 57.23 [SD 11.2], range 43.95-81.43), with participants making significantly more positively valenced (192/218, 88.0%) than negatively valenced reports; however, the most frequently chosen valence was 50. Participants spent an average of 5.51 seconds (SD 9.4) making reports in response to sensorband alerts.

Quantitative Acceptability Data

The overall average rating on the acceptability scale was 3.55 on a 4-point scale, which ranged from 3.32 to 3.85 (Table 1). Specifically, 75% of participants ($N=40$) were “very” satisfied with the help they received from the blended intervention and 18% were somewhat satisfied. Participants reported using skills learned in the in-person sessions that were reinforced on the mobile app. Over 87% of participants reported using “cool thoughts and good moves” and over 82% used “Freeze, breathe, and choose,” “very,” or “somewhat” often. Over 94% and 92%, respectively, indicated that the sensorband and mobile app helped them manage their stress and deal with their child “very much” or “somewhat.”

Qualitative Results

Performance Expectancy

Performance expectancy refers to the degree to which an individual believes that the use of the technology will be helpful [51]. Within this construct, we identified 2 overall themes relating to the impact of the Calm Mom technology: (1) overall perceived benefits of the technology and (2) enhancing identification of emotions and emotion regulation strategies.

Overall Perceived Benefits of the Calm Mom Technology

Participants felt that the general content of the app was highly related to their lives as adolescents and new mothers. One noted that she liked the name “Calm Mom” because:

...it makes me want to use it because I want to be a calm mom. [P235]

Another explained:

...it was cool to just like connect with the phone...it'll put like, how are you feeling about your boyfriend or love-wise, school-wise, stuff like that. [P230]

Table 1. Acceptability questionnaire with a 4-point acceptability scale (N=40).

Survey item ^a	Mean (SD)
How satisfied are you with the help that you received from the Power Source Parenting program?	3.74 (0.60)
How well did Power Source Parenting program help you deal more effectively with parenting problems?	3.65 (0.63)
How much did you use the concept of Cool thoughts/good moves outside of group?	3.50 (0.77)
How much did you use the concept of freeze, breathe, and choose outside of group?	3.32 (0.94)
How well did the Power Source Parenting group help you deal with your stress?	3.33 (0.96)
How much did you like using the band and the smartphone?	3.85 (0.36)
How helpful was the band and smartphone in managing your stress?	3.57 (0.65)
How helpful was the band and smartphone to you for dealing with your child?	3.47 (0.65)

^aDerived from the client satisfaction questionnaire [50].

Relieving Feelings of Isolation and Obtaining Support and Guidance

A majority of participants noted that the app was very accessible, and several indicated that just having the technology made them feel less alone and genuinely cared for:

...well at least somebody is asking me about how my day went or how I feel today...It made me feel differently because it actually felt like, like somebody was listening and they at least give you feedback. [P249]

All participants commented that the affirmational messages and the skills-based “cool thoughts” and “good moves” messages were particularly helpful:

It would give me some advice, things like, you know, “just take one step at a time.” [P242]

Enhancing Identification of Emotions and Emotion Regulation Strategies

Participants believed that engaging with the technology supported their emotional regulatory skills at several points along the process, particularly in prompting self-monitoring, identifying and appraising their emotions, and encouraging self-reflection (Table 2). With one exception, all of the adolescent mothers characterized their interaction with the app as giving them an opportunity to pause for a moment, which assisted them in deploying their attention to their current feelings and subsequently, strategies for coping:

...I just liked that because it made me stop and really think and just calm down. [P231]

The messages also helped participants to adopt an attitude of mindfulness that, in turn, helped to bolster their mood or reduce their feelings of stress:

...like if I was having a bad day it was like...oh it's okay...this won't last forever. [P226]

Additionally, labeling and scaling their feelings on the app increased self-knowledge:

...just doing the little mirror helped me realize how stressed I really am...at what level of stress I was at... [P234]

For some, pausing to reflect on their feelings appeared to increase their motivation to regulate their emotions and use one of the skills taught in the in-person sessions:

Like it says, “freeze, breathe and choose” because you can actually stop what you are doing, think about it, and choose whether it is the right way or the wrong way to deal with it.

Individual Preferences

There were considerable individual preferences as some participants preferred the videos because they could relate to the character (“they were like girls who looked like they could be here,” P235), whereas others favored the written messages. Several participants commented that sometimes the messages were repetitive or not related to their current stressor, but P228 noted, “some of them weren't really on point but they had a lot to do with it.” P244 indicated that sometimes she gets a “perfect message and it really, really helps.”

The initial “bank” of messages for valences in the positive range was very small, and several adolescent mothers at the start of the study complained that these messages were very repetitive; therefore, midway through the study, we increased the number of messages that were provided when participants selected an emotional valence in the positive range.

Nightly Reports

Overall, the nightly “push-in” reports were the most frequent reports made by participants who used these to reflect on their mood after their children were asleep:

It was good because my kids were sleeping so I got to think about it...and take me out a little bit of my anger. [P249]

For P233, the regularity of the nightly reports helped to reinforce her ability to self-regulate:

Um just so you can have something to read every day, something to remind you to keep calm and think about what you do and breathe...

Table 2. Examples of Qualitative Responses of Emotion Regulation Strategies by Modes of Engagement with Calm Mom

Mode of Engagement and qualitative response	Emotional Regulation Strategies
Nightly report	
“reminded me everyday”	<ul style="list-style-type: none"> • Attentional deployment
“something to remind you to keep calm and think about what you do and breathe”	<ul style="list-style-type: none"> • Attentional deployment • Cognitive change • Response modulation
“I liked waiting for the motivational message to come in...help me just be relaxed and calm”	<ul style="list-style-type: none"> • Attentional deployment • Cognitive change • Response modulation
“it was good so sometimes you don’t go to bed angry or upset”	<ul style="list-style-type: none"> • Attentional deployment • Cognitive change • Response modulation
Self-report	
“gave me a moment that I could use for myself”	<ul style="list-style-type: none"> • Situation selection
“if you are having a bad day, you can be like, ‘I need a Calm Mom’”	<ul style="list-style-type: none"> • Situation modification
“I could just sit down and take time to do the report”	<ul style="list-style-type: none"> • Attentional deployment
“would make me feel better about myself so I did not have to be upset the whole day”	<ul style="list-style-type: none"> • Cognitive change • Response modulation
“gave me self-control ’cause I could basically get them whenever I wanted”	<ul style="list-style-type: none"> • Situation selection • Situation modification
“gave me a moment I could think”	<ul style="list-style-type: none"> • Attentional deployment
“helped me notice feelings”	<ul style="list-style-type: none"> • Attentional deployment
“I stopped and thought before I would say anything”	<ul style="list-style-type: none"> • Attentional deployment
“helped me control the situation without yelling or other stuff, there were alternatives”	<ul style="list-style-type: none"> • Cognitive change • Response modulation
Sensor Band Report	
“it does not put you in a chaotic situation like you would if you didn’t really think about it”	<ul style="list-style-type: none"> • Situation modification
“helps you stop, think, and breathe”	<ul style="list-style-type: none"> • Attentional deployment • Cognitive change • Response modulation
“I was yelling but then I went upstairs and calmed down and then came back down to apologize”	<ul style="list-style-type: none"> • Situation modification • Attentional deployment • Cognitive change • Response modulation
“so I chilled out and didn’t talk to him for like three days and that was good”	<ul style="list-style-type: none"> • Situation modification
“so I flip out...and it sent a thing to my phone about your baby feeling what you feel and made me realize that it is not about me anymore”	<ul style="list-style-type: none"> • Attentional deployment • Cognitive change
“made me meditate to calm down”	<ul style="list-style-type: none"> • Response modification
“even with no one being there I still felt like someone was there”	<ul style="list-style-type: none"> • Cognitive change
“I paused for a second...read what it said to me...and I was like, ‘look, you are right, let’s just leave it at that’”	<ul style="list-style-type: none"> • Attentional deployment • Cognitive change • Response modulation

On the other hand, P228 noted that although the nightly reports were helpful when she was angry, they were not useful when her mood was positive:

When I'm just chill and it popped up, it got kind of annoying...it wasn't really relevant to anything but when I was actually mad and it popped up, it was a good reminder.

Several participants reflected on the nightly reports in relation to putting their children to bed, a typically challenging time for parents of young children.

P234: And sometimes it would be rough for him to fall asleep. Or he would be cranky...so if my phone started buzzing for the evening report I would put in...I was feeling bad because the baby was cranky and...um...it would say something to calm me so I would take a deep breath and then just relax and ignore. It's not really so much ignore the fact that he was cranky but ignore it enough for him to calm down and fall asleep.

Interviewer: Do you think that changed the situation?

P234: If I hadn't gotten the report I would've probably been a little bit more stressed...I think it kind of like calmed him down a bit because he realized that he wasn't getting a reaction from me as he was being so cranky and he just ended up falling asleep. 'Cause usually...like I will take him out of the bed and let him stay up longer...

In this instance, the app supported the participant's ability to engage in more mindful parenting as it drew her attention away from her son's "crankiness" to an awareness of her own feelings in the moment. This mindful attending then allowed her to momentarily accept and tolerate her son's mood and refrain from taking him out of the crib, enabling him to fall asleep faster. She also keenly observed that the nightly report aided both her and her son.

Self-Reports

Many of the themes evidenced in the nightly reports were echoed in participants' experiences engaging in self-reports. The main difference was that instead of a "push-in" reminder, self-reporting was purely volitional where participants could actively select to engage with the app.

It just gave me a moment that I could use for myself. [P236]

...it gave me self-control because I could basically get them whenever I wanted to and had access to them all the time. [P235]

Moreover, mothers were able to hold a mental representation of the app and its benefits when cued by stressful situations.

...because if you are having a bad day you can be like, "I need a Calm Mom." [P230]

She describes a particular instance when the app helped her relieve the tension associated with the many demands on her as a mother:

Yeah, because I had to go to my doctor's appointment, got my eyes checked...and then had to come home and get him [child] to eat, and then go back for his doctor's appointment, and then come back, and then put him to bed and so that was a stressful long day and I was like, let me make a report.

Self-reporting was often cited by participants as a self-caring activity as participants engaged in self-reporting when they were feeling, "alone," "down," or "bored." Additionally, the self-report was useful during challenging situations with children, family members, peers, or romantic partners. P233 recounted how after completing a self-report she was able to use self-talk to plan a more adaptive behavior in the midst of having a disagreement with another resident:

It's helpful because I don't want to get myself in trouble or come at somebody the wrong way because I'm because I'm angry...but if I read it I would be like...maybe I should calm down and talk to them maturely and not yell.

Finally, self-reporting was also used as a strategy to engage in more effective parenting:

P249: And I would just make a self-report if my son wasn't cooperating with me or my daughter was being, you know, disrespectful.

Interviewer: And did it change how you responded to your child?

P249: Yeah, it did, I stopped and thought before I would say anything or...responded to what they did. It helped me basically control the situation without yelling or other stuff; there were alternatives.

Sensorband

As a result of technical challenges with the sensorband, fewer participants received notifications on their smartphones in response to heightened levels of EDA. However, for participants who received the alerts, many reported that the notification caused them to stop and pay attention to their actions.

...it would send those messages to my phone and some of the time it did help because um, I don't know, sometimes when I get stressed out I really don't think about what I'm doing so it's like having those little reminders it really helped sometimes. [P228]

A few participants expressed surprise that the sensorband could detect that they were feeling stressed.

I was wearing this sensorband that was feeling [my] mood, just like, you know, having a stressful day...it actually chimed, it actually knows. [P230]

Additionally, P242 explained that the alerting made her feel cared for:

...even with no one being there, I still felt like someone was there...

A number of participants related that alerting of increased EDA often occurred when they were involved in an argument. For P231, the alert confirmed the intensity of her feelings and assisted in modifying her response:

And as soon as the argument was getting to a point where I was actually getting mad...it just started going off and that's when, you know, I paused for a second while she just kept running her mouth screaming and I looked towards my phone, read what it said to me, and I just froze and I was like, "look, you're right...let's just leave it at that." And I just walked away and did what I needed to do for the day. I wasn't really thinking about my actions until I saw it, like I felt it and that's when I was like...alright...and it actually calmed me down.

Alerts in response to escalating EDA also assisted participants to attend to and reappraise their stress and allow them to engage in situation selection by using parenting skills learned in the intervention. P230 describes a time when she missed her bus and would get home late to cook dinner for her son:

...at that time I was stressful, like on the bus I was just like, "Oh my goodness, am I going to make it? He is going to come home angry...there's no food..." And then after it beeped I just thought about it and was like, okay, just do what I have to do now for A [son]...let me just get started. Let me give him something to do, or do something with him while I'm cooking.

At times, the sensorband alert alone acted as a cue to draw participants' attention to their emotion and modulate their response without engaging with the app. P243 explained that she tended to disregard the content of the app but engaged in self-talk after hearing the alert that her EDA had risen:

I just paid more attention to you know when the phone going off...notice that I was feeling angry and then I would know, "alright, I need to calm down."

She also indicated that at other times the alert was not helpful because:

All it did was told me which I already knew...that I was getting upset.

Effort Expectancy

Effort expectancy refers to the degree of ease of using the technology. All participants found the app easy to use and navigate. By comparison, participants had mixed experiences with the sensorband.

Functionality of the Sensorband

The greatest challenge reported by participants involved difficulty knowing when the band was charged and working properly ("I thought it was charging but it would just die," P233). Additionally, some participants felt as if the band was too sensitive ("I felt as if I was getting Calm Mom assessments every 5 minutes," P228). Several participants expressed disappointment that they did not receive an alert at times when they were stressed:

I just want to know when I'm stressing and when I'm not. [P233]

Moreover, wearing the sensorband and not knowing if it was working diminished participants' enthusiasm for using it.

Facilitating Conditions

Facilitating conditions refers to the compatibility between individuals' lives and the use of the technology. We include comfort and fit of the sensor band in this construct.

Challenges Integrating Use of the Sensorband Into Their Daily Routines

Although most participants used the study smartphone as their main phone, managing 2 devices was challenging:

I don't have any time. I'm always like, doing something and then when I get home I'm always doing something, for my son or like my boyfriend or something... [P228]

The transient lifestyle of some adolescent mothers also presented a challenge:

I didn't wear the band as much as I should have because I was moving from shelter to shelter and I did, at one point, misplace the band. [P236]

Comfort, Fit, and Appearance

Participants were mixed about the level of comfort, although some found it comfortable and often forgot they were wearing it:

Once I put it on in the morning, I didn't really notice it. [P235]

Others found it "bulky," "itchy," or "too big."

Social Issues

Several participants indicated that they were asked if the sensorband was a legal monitoring or probation bracelet when they wore it outside of the TLP, which was described as bothersome and sometimes "embarrassing." Others described that wearing the sensorband generated questions from others:

Um, they thought it was interesting and kind of...a few people wanted to participate in it...and others were like...oh, that's pretty cool... [P231]

Discussion

Principal Findings

We found a high degree of acceptability among homeless adolescent mothers for the technology components of a blended intervention designed to increase emotional regulation. Using both the quantitative and qualitative data, we found that participants highly valued the accessibility of the Calm Mom app both alone and in combination with the sensorband. For many adolescent mothers, the app became an integral part of the ways in which they dealt with heightened emotions in stress-inducing situations. Qualitative findings indicated that engagement with Calm Mom elements increased adolescent mothers' ability to increase their mindful attention to their experiences in the present moment, which is an integral aspect of the ability to adaptively regulate emotions and a primary goal of the parenting intervention.

The Calm Mom technology assisted adolescent mothers to effectively regulate their emotions in theoretically meaningful

ways and marks a meaningful contribution to the mHealth literature, which has been somewhat limited in the application of behavioral theory to technological interventions [54]. Adolescent mothers reported that use of the app—and for a smaller proportion of participants, in combination with the sensorband—increased their identification and understanding of their emotions in a variety of stressful situations with their children, peers, and family, which in turn helped them engage in more adaptive emotion regulation and behavioral strategies.

Independent of the sensorband, we observed high response rates to both the “push-in” nightly reports and the “pull” self-reports, and there was a considerable range of the number of nightly and self-reports. As expected, and in line with other research [55,56], there were fewer self-reports relative to the nightly “push-in” reports, which prompted adolescent mothers at the same time every evening and involved a very brief, low-demand response along with a well-liked affirmational message. Additionally, the average screen time for the nightly reports was shorter than the self-reports, which involved more content. As detailed in the qualitative data, for many adolescent mothers, the nightly reports arrived at an opportune time when they had a quiet moment to reflect on their day or, in some cases, when putting their child to bed. Regarding the self-reports, qualitative analysis revealed that adolescent mothers were able to maintain a mental representation of the app as a tool for helping them cope with their many daily stressors, an important facilitator of engagement with the app. In this way, the technology served as a “virtual holding environment” [57], thereby scaffolding adolescent mothers’ attempts at regulating their emotions. Yet, the fact that many of the adolescent mothers reported relying on the app for comfort and to ease their loneliness highlights the acute vulnerability of this population of young mothers who are homeless and struggling to meet numerous demands.

Surprisingly, for all elements of the Calm Mom technology, the average valence selected on the feeling scale was in the positive range. This may be due to the design of the “How are you feeling” screen where the default choice on the slide bar was “50” and considered in the positive range. In future research, we will use other ways of eliciting emotion such as the circumplex model [58].

Although we encountered considerable technology challenges with the sensorband, the smaller number of participants who experienced the full capability of the Calm Mom technology (app plus sensorband) reported high levels of acceptability and notably experienced benefits consonant with the theoretical model of the intervention. Importantly, participants who received alerts via the sensorband expressed that they were typically emotionally aroused when they received the alert. Although previous research of wearable sensors for the measurement of EDA has been limited to small, proof-of-concept studies [26,27,59], this is one of the few studies to deliver “just-in-time” behavioral intervention strategies over an extended period of time to capture real-life stressful situations among a highly vulnerable population of adolescent mothers.

A comprehensive understanding of the needs, challenges, and life circumstances of the target population is vital for designing any behavioral intervention and may be particularly important

for mHealth interventions as participants receive the intervention during the course of their daily lives [60], outside of their interaction with intervention facilitators. mHealth technology can be experienced as demanding [59,61], and we did not want Calm Mom to distract adolescent mothers from their children or tax the cognitive and emotional capacity of these highly overburdened young mothers. Thus, providing adolescent mothers with a variety of ways to engage with the technology and varying the content of the app emerged as strengths of our design and helped to meet individual preferences for engagement [62].

In this acceptability study, we did not aim for “compliance” per se; rather, we sought to understand adolescent mothers’ receptivity to the technology with respect to the frequency, timing, mode (nightly or self-reports or sensorband alerts), media (eg, video vs text), and content, particularly the reinforcement of skills taught in the in-person intervention [63]. Our findings underscore the need to design mHealth interventions that use more refined algorithmic tailoring over time based on participants’ responses and levels of stress and preferences [17]. For instance, for some participants, receiving an alert in a stressful moment was opportune, whereas for others, it was perceived as irritating. Thus, in future studies, we plan to refine decision rules that adapt to individuals’ dynamically changing states and preferences to enhance personalization and capitalize on both states of vulnerability and opportunity [17]. For example, alerts provided when stress levels are just beginning to increase may be a more ideal window of time for some participants. Importantly, the provision of support must augment rather than disrupt individuals’ existing, autonomous effective coping strategies.

The EPMER was extremely useful for understanding the theoretically derived mechanisms by which adolescent mothers used the technology and the ways the technology was able to augment in-person, provider-delivered sessions. The qualitative interviews revealed that many adolescent mothers valued the way specific skills learned in the in-person sessions were translated onto the app, helping to bridge their experience of the in-person sessions in their daily life. In future research, we will focus on specifying the exact mechanisms by which the in-person and technology components complement one another.

Limitations and Future Directions

The primary limitation of the study was the small number of participants who were able to use the sensorband due to technological challenges that are typical when new technologies are tested in the field. Similar to other mHealth studies that have collected affective data using objective, longitudinal methods [64], we encountered operating system problems as well as issues related to the form and functioning of the sensorband. Although we piloted the sensorband over a short period of time with a small number of participants from the target population [48], over the course of the study, major upgrades occurred in the operating systems of both Android and Bluetooth, which resulted in the loss of connectivity for a number of participants. Furthermore, participants may not have always worn the sensorband correctly, which prevented transmission of EDA; therefore, in future research, utilizing a “run-in” period with the

sensorband may be warranted. Although these issues will be addressed in future studies, the current limitations of the technology may impede scalability. However, sensor technology is advancing at a rapid pace, and the reliability and design of devices for measuring ambulatory EDA and other physiological measure of stress continue to improve [65-68]. Future studies will benefit from these advances coupled with the increasing popularity of wearable activity trackers and smart watches, which will help to reduce social issues some participants

encountered when wearing the sensorband. Finally, determining the correct “dose” regarding the timing and duration of technological support in conjunction with provider-delivered intervention is an important avenue of future research.

Despite the challenges we encountered, our findings suggest a high level of enthusiasm and acceptability for the Calm Mom technology and patterns of use consistent with the underlying theoretical model, all of which will be harnessed in future studies as the technology improves.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Study flowchart.

[[JPG File, 46KB - pediatrics_v1i1e1_app1.jpg](#)]

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Abbreviations

- CBT:** cognitive behavioral therapy
EDA: electrodermal activity
EPMER: extended process model of emotion regulation
IRB: institutional review board
mHealth: mobile health
TLP: transitional living program
UTAUT: unified theory of use and acceptance of technology

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Original Paper

Maternal and Child Acceptability of a Proposed Guided Imagery Therapy Mobile App Designed to Treat Functional Abdominal Pain Disorders in Children: Mixed-Methods Predevelopment Formative Research

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Abstract

Background: Functional abdominal pain disorders are chronic abdominal pain conditions, which affect up to 20% of children worldwide. Of the various functional abdominal pain disorder treatment modalities, psychological therapies such as guided imagery therapy appear most effective. However, there are significant barriers to receiving psychological therapies, including access to trained therapists. Alternatively, remotely delivered psychological therapies for functional abdominal pain disorders have been efficacious.

Objective: The objective of our study was to assess acceptability of a proposed guided imagery therapy app designed to treat functional abdominal pain disorders through remote delivery of prerecorded audio sessions and to evaluate user preferences for using such an app.

Methods: Using a mixed-methods approach, we conducted a predevelopment formative study among children aged 7 to 12 years with a functional abdominal pain disorder and their parents. The parents completed our modified Technology Acceptance Model (TAM) questionnaire, which quantified behavioral intention and related factors for using a guided imagery therapy app. Dyads participated in separate in-person semistructured interviews to assess their attitudes toward and preferences for a guided imagery therapy app. Questionnaire and interview findings were collected concurrently, analyzed separately, and then integrated through methods triangulation.

Results: Among the 15 participating parent-child dyads, 5 (33%) children were Hispanic and 11 (73%) had irritable bowel syndrome. They had diverse socioeconomic status. All parent participants were mothers. The TAM questionnaire indicated that mothers scored favorably on behavioral intention to use a guided imagery therapy app (mean score 12.0, SD 2.6, possible range 3-15). Scores for the TAM factors perceived usefulness, perceived ease of use, hedonic motivation, compatibility, and habit also were favorable. Maternal interviews confirmed positive attitudes toward the proposed app. They advocated a visual component

to hold their child's attention during the guided imagery therapy sessions; recommended incorporating background sounds into the sessions; favored session reminder notifications from the app; and thought the best time for their child to listen to the sessions would be in the evening or before bed. The child interviews also confirmed positive attitudes toward the proposed app. They suggested guided imagery therapy session topics such as sports and adventures; listening to sessions in their bedroom; and the need for parental supervision to install the app on their mobile device. Integration of the quantitative and qualitative methods findings complimented one another on acceptability. The favorable behavioral intention TAM score aligned well with expressed positive maternal and child attitudes toward the app and can be explained by the desire to avoid medications. The questionnaire and interviews also confirmed therapeutic benefit as an intrinsic motivator to promote routine use.

Conclusions: A guided imagery therapy app designed to treat pediatric patients with functional abdominal pain disorders appears to be acceptable to both mothers and children. Incorporating parent and child preferences into a guided imagery therapy app could promote therapeutic compliance and increase access to optimal care.

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KEYWORDS

functional abdominal pain disorders; guided imagery therapy; mixed methods; mobile applications; pediatrics; parents; Technology Acceptance Model; imagery (psychotherapy)

Introduction

Functional abdominal pain disorders (FAPDs; eg, irritable bowel syndrome, functional abdominal pain, and functional dyspepsia) are chronic abdominal pain conditions that cannot be ascribed to a particular biochemical or anatomical abnormality [1]. These disorders affect about 20% of school-aged children and adolescents worldwide and are associated with psychological distress, such as anxiety and depression [2-10]. Affected children often have a decreased quality of life to a greater degree than those with organic diseases such as gastroesophageal reflux disease and inflammatory bowel disease [6,11,12].

Mainstay treatment options for FAPDs include conservative medications, alternative medications, diet modification, and psychological therapy [1,13,14]. Recently published Cochrane reviews support psychological therapies over medications for treating FAPDs in children [15,16]. Cognitive behavioral therapies and related therapies such as guided imagery therapy (GIT) appear to be the most efficacious psychological treatments for pediatric patients. GIT is based on a cognitive-behavioral framework that uses the imagination to reduce anxiety and stress [17,18]. A traditional in-person GIT session involves an alert person relaxing and following a practitioner's audio commands to imagine various sensory images, which in turn serve as a mental representation of a concept such as abdominal pain. Afterward, the patient is able to modulate their pain using this mindfulness technique [19-21]. The three principles of GIT are mental imagery, an altered state as induced by trance, and a locus of control that enables a person to control their situation [22]. This therapy is often used for psychological and chronic pain disorders such as anxiety and fibromyalgia [23-25].

Access to psychological approaches such as GIT is hindered by various systemic barriers such as lack of trained practitioners, limited insurance coverage for mental health services, and the need for repeated visits [26,27]. To overcome these barriers, researchers have studied whether psychological therapies delivered remotely can decrease abdominal pain symptoms related to FAPDs. Both gut-directed hypnotherapy and GIT delivered via compact disc have been shown to decrease pain symptoms in children with FAPDs [28-30]. Thus, psychological

therapies delivered remotely have the potential to overcome these systemic barriers affecting access to optimal care for affected children.

The World Health Organization defines mHealth as "medical and public health practice supported by mobile devices" [31]. Given the ubiquity of electronic mobile devices in our contemporary society, translating the remote delivery of prerecorded psychological therapy sessions to a mobile app would create a ubiquitous mHealth clinical tool that could improve health outcomes of many children with FAPDs [32,33]. This mobile therapy approach has been used successfully for adult psychological disorders, including anxiety, depression, and mood disorders [34,35]. Furthermore, mobile apps for anxiety and depression have been developed for children [36,37]. Considering the preliminary success of remotely delivered GIT for FAPDs, a GIT mobile app could transform our paradigm for treating children with FAPDs if our target population would find this clinical tool acceptable.

Technology acceptance of a clinical tool depends on several factors, including satisfaction and perceived appropriateness [38]. The literature and experts at the Institute of Medicine and Robert Wood Johnson Foundation in the United States, and the National Health Service in the United Kingdom, recommend integrating the preferences of stakeholders, including the target population, into the mobile health app and other electronic interventions and recommend conducting formative research to capture this information prior to app design and development [39-41]. These studies and organizations also support the utility of formative research to capture stakeholders' preferences for an electronic mHealth clinical intervention. Unfortunately, the vast majority of health apps, including psychological mobile apps, have not followed these recommendations and, indeed, commonly lack evidence of efficacy [34-37]. Thus, our long-term goal is develop an efficacious GIT mobile app following the guidelines outlined above.

Modi et al [42] conceptualized a framework for self-management in the pediatric population and outlined multiple behavioral influences on pediatric health, including individual, family, and community influences, which is similarly

summarized in the social ecological model [42,43]. Furthermore, pediatric obesity studies have shown that parents are key agents of change for weight loss and behavior change to promote weight loss [44]. Based on these studies, our formative research study also aimed to capture important environmental and family influences that could affect the sustained use of a GIT mobile app designed for children with FAPDs.

Given the above background, the purpose of our formative study was to assess the acceptability and appropriateness of using a GIT mobile app among children with FAPDs and their parents. We also evaluated whether specific preferences or barriers to use would affect the therapeutic compliance of such a clinical tool.

Methods

Participants

This study recruited pediatric patients aged 7 to 12 years with a FAPD and their parents through volunteer sampling. We selected this age range because these children are old enough to have thoughts that are developmentally logical and organized enough to participate in therapy, but they have not yet reached the stage of autonomy seen in adolescents, who characteristically have poor self-management health behaviors [42,45]. We excluded participants who had other comorbidities associated with chronic abdominal pain, including abdominal surgery and other diagnoses (eg, diabetes mellitus, cystic fibrosis) [46,47].

Patients were recruited in three ways from a large metropolitan ambulatory health care system in Houston, Texas, USA. The first method entailed recruiting patients from another noninterventive clinical study conducted within our research group. The second method involved posting flyers in 52 ambulatory primary care clinics affiliated with a tertiary pediatric health care system in which interested families could contact our research team for possible enrollment. The final method involved sending letters directly to families who had recently visited one of our primary care clinics for abdominal pain, with the approval of their treating primary care physician. If the families did not respond to the letters, we attempted to contact them by phone. This study was approved by the Baylor College of Medicine Institutional Review Board (H-37308).

Interested families completed the pediatric Rome III questionnaire to ensure that the patient met the criteria for a FAPD. The Rome III questionnaire is a validated instrument that assesses abdominal pain and stooling patterns in children and determines whether a FAPD is present and, if so, its respective classification (eg, irritable bowel syndrome) [48,49]. Potential participants also agreed to have the child's medical record screened for additional inclusion and exclusion criteria. Once a parent agreed to participate, written parental informed consent of study participation and child assent were obtained at the start of the research visit.

Data Collection

Mixed-Methods Study Design

This mixed-methods study used a complementary design consisting of a parental quantitative questionnaire and separate

parent and child in-person interviews [50,51]. Both quantitative and qualitative phases contributed equally to the final study results [51]. Experts cite the purpose of a mixed-methods approach as 2-fold: to verify that recorded data from two different methods can be corroborated, and that the overall data captured are robust and comprehensive [52,53]. We used methods triangulation of both a quantitative questionnaire and qualitative interviews for both of these purposes [54]. For this study, we integrated the results of our quantitative questionnaire and qualitative interview findings and assessed whether the results were complimentary or discordant to one another, and also determined whether our qualitative interviews could further explain the quantitative questionnaire findings.

Demographic and Clinical Characteristics Questionnaires

Parents completed self-report questionnaires that assessed parent and child demographic characteristics and household members' access to electronic devices; they also completed the pediatric Rome III questionnaire, which captured the affected child's FAPD [47]. We obtained the annual median household income based on the family's zip code [47,55]; using 2015 salary estimates [55], we averaged the sample's median annual household income as a proxy measure for socioeconomic status [56].

Guided Imagery Therapy Demonstration

Parent and child dyads were separated for semistructured interviews. The first portion of each interview involved explaining that the research team was interested in using a mobile app that played GIT sessions on an electronic mobile device to treat children with FAPDs. The interviewer then showed the participant an electronic tablet with mobile app icons on its home screen to demonstrate the platform envisioned by the research team. Afterward, the interviewer played a 2-minute GIT session audio excerpt on the electronic tablet, which was derived from a track previously demonstrated to be efficacious in a pediatric clinical study (excerpt provided by MALvT) [28].

Modified Technology Acceptance Model Questionnaire for a Guided Imagery Therapy Mobile App

After the audio demonstration, parents were asked to complete a survey containing questions related to their child's demographics, family technology use at home, and a modified version of the Technology Acceptance Model (TAM) questionnaire. The TAM was developed based on the theory of reasoned action/theory of planned behavior and is tailored to assess users' acceptance and use of modern technologies [57,58]. Central tenants of these models are the multiple factors that influence behavioral intention to do a specific task. The Institute of Medicine defines behavioral intention as the "subjective probability that he or she will engage in a given behavior" [59]. The theory of reasoned action/theory of planned behavior posit that the behavioral intention to engage in a particular health behavior is highly associated with an actual health behavior [57,58]. The original TAM model included the domains of perceived usefulness (the degree to which a person believes that using a technology would enhance his or her performance),

perceived ease of use (the degree to which a person believes that using a technology would be free of effort), and attitude (how much a person likes the object of thought and their related beliefs about the thought), all acting on behavioral intention to use a technology [57,60,61]. Over time, the model expanded to include the domains of compatibility (the extent in which the technology fits a person’s experiences or activities), habit (a perceived link between a goal and a specific behavior), social influence (the person’s perception of a referent other’s opinion about the person’s use of a technology), and hedonic motivation (the intrinsic drive to use a technology) [62-65].

For this study, we adapted the original TAM questionnaire to assess how parents in this sample rated various TAM factors and behavioral intention to use a proposed GIT mobile app to treat their child’s FAPD. Our questionnaire was based on questionnaires used in 5 other TAM studies [66-70]. The final modified TAM questionnaire consisted of 33 questions that assessed the factors of perceived usefulness, perceived ease of use, attitude, compatibility, habit, and behavioral intention to use a GIT mobile app for FAPDs. Questionnaire items were scored on a 5-point Likert scale: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree (Multimedia Appendix 1). Figure 1 shows an adapted version of the modified TAM summarizing the factors that influence people’s use of a modern technology [66-70].

Interviews

Separate semistructured interviews were conducted for parents after the surveys and after the GIT demonstration for the children. Interviews were conducted by trained interviewers following a script (see Multimedia Appendix 2 for the parent interview script and Multimedia Appendix 3 for the child interview script). Script questions were guided by the social ecological model and the theory of planned behavior/theory of reasoned action [58,71]. The parent script contained 12 questions, while the child script consisted of 15 questions. Although the scripts contained similar questions, the child script

used simpler terminology and captured less information regarding app logistics for use; the different script questions also reflected the different roles that parents (agent of change) and children (user) would be expected to assume. Probes and prompts were used as needed to expand and clarify responses. Interviews were designed to last no longer than 1 hour. All interviews were digitally recorded.

Data Analysis

Modified Technology Acceptance Model Questionnaire Analysis

We computed the modified TAM questionnaire factors and behavioral intention scores by summing each possible item(s) response for each factor and each participant, and then averaging the summed item response(s). The number of questions for a particular factor varied from 1 to 7 questions (Table 1). For those factors with more than 1 question, we assessed the internal consistency by calculating each factor’s Cronbach alpha. Internal consistency and other statistical testing was conducted in IBM SPSS Statistics for Windows, version 25 (IBM Corporation).

Qualitative Analyses

Verbatim transcripts were generated from the digital recordings and compared with the original recordings to check for accuracy prior to analysis; modifications were made as needed. The child and parent transcripts were systemically analyzed by 2 independent trained analysts using applied thematic analysis [72]. A priori structured codes, guided by the social ecological model and the theory of reasoned action/theory of planned behavior, were supplemented with emergent codes during the analyses. Coders met routinely to discuss application of the codes and emergent codes. Coding differences were discussed and resolved (JMH and AOV). All codes and definitions were recorded in a codebook maintained by the coding team. Child and parent transcripts were coded and analyzed separately. Coding was conducted using NVivo 10 for Windows (QSR International).

Figure 1. Modified Technology Acceptance Model.

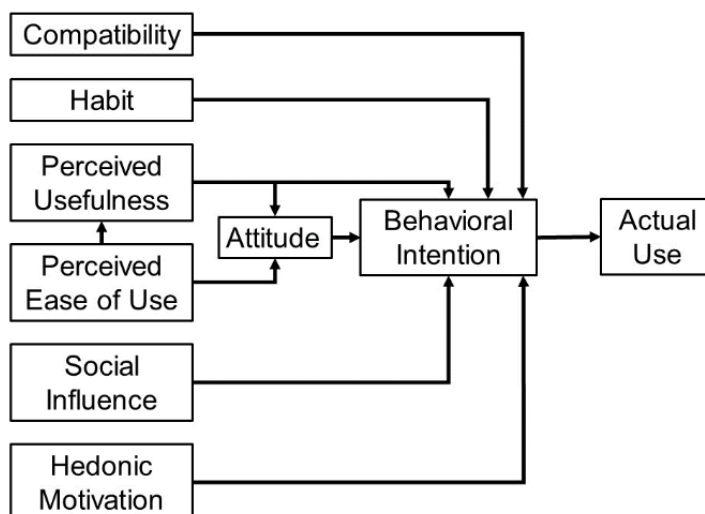


Table 1. Measured items of the modified Technology Acceptance Model theoretical factors.

Factors	Factor question(s)	Sample item
Perceived ease of use	1, 2, 3, 6, 7	Using the guided imagery mobile app appears easy to learn.
Hedonic motivation	4, 5	Using the guided imagery mobile app appears fun.
Perceived usefulness	8, 9, 10, 11, 13, 14, 16	The guided imagery mobile app appears to be useful in helping to treat abdominal pain easier.
Compatibility	12	Using the guided imagery mobile app matches well with all aspects of my everyday life.
Habit	18	I would feel comfortable when using guided imagery mobile app.
Social influence	19, 20	People who are important to me think I should use the guided imagery mobile app.
Attitude	15, 17, 24	Overall, my attitude toward the guided imagery mobile app is favorable.
Behavioral intention	21, 22, 23	I would plan to use the guided imagery mobile app frequently.

Integration of the Questionnaire and Interview Findings Through Triangulation

As described above, we used mixed methods (both a quantitative questionnaire and qualitative parent and child interviews) to assess acceptability, preferences, and barriers to using a GIT mobile app for treating FAPDs. As described by Creswell and Plano Clark, a mixed-methods approach is a concurrent research design that uses both qualitative and quantitative methods to explore a research question. Multiple research methods also permit comparison of the research findings through triangulation [51]. Triangulation is a process in which investigators seek convergence or collaboration between findings of various methods, including quantitative and qualitative methods [73]. We used methodological triangulation to determine whether the qualitative findings and quantitative results, when weighted equally, corroborated one another [74].

Results

Participant Characteristics

We enrolled a total of 15 parent-child dyads, which we deemed likely sufficient to attain theoretical saturation (ie, the point at

which no new information emerges from the qualitative interviews; details outlined below) [75]. We attained sample saturation after 12 parent and child interviews; we conducted an additional 3 interviews to confirm saturation. Figure 2 outlines the outcome of our recruitment efforts.

Table 2 summarizes the child and parent demographic characteristics. All parents were mothers of the child participants. The mean (SD) maternal and child ages were 36.9 (SD 6.6) and 9.3 (SD 1.6) years, respectively. The median annual household incomes ranged from US \$17,602 to US \$95,137. The sample was diverse in regard to race/ethnicity, and most of the children has a diagnosis of irritable bowel syndrome (11/15, 73%; Table 2).

All mothers and most children had access to a mobile phone or electronic mobile device (Table 3). Most also had internet access through Wi-Fi or mobile cellular data. Children’s access to a computer or laptop was the same as that of their mothers, and access to a tablet among children was slightly lower than that of their mothers. More children reported using their tablets every day than a laptop or computer, or a mobile phone. Most mothers reported being comfortable using mobile phones, tablets, and laptop or desktop computers (Table 3).

Figure 2. Study recruitment flow diagram. FAPD: functional abdominal pain disorder.

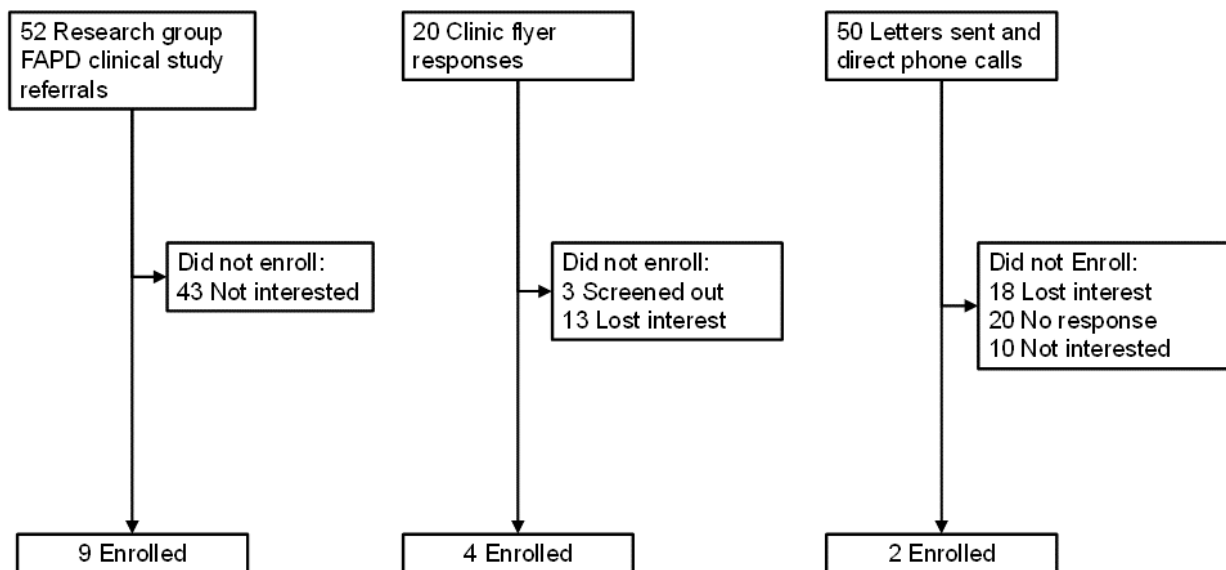


Table 2. Child and parent demographics (N=15 mother-child dyads).

Characteristics	Sample proportion, n (%)
Child participants	
Age range (years)	
7-8	5 (33)
9-10	7 (47)
11-12	3 (20)
Sex	
Female	8 (53)
Male	7 (47)
Race/ethnicity	
Asian non-Hispanic	1 (7)
Black non-Hispanic	3 (20)
White Hispanic	5 (33)
White non-Hispanic	6 (40)
Functional abdominal pain disorder type	
Irritable bowel syndrome	11 (73)
Functional dyspepsia	2 (13)
Functional abdominal pain	2 (13)
Parent participants	
Age range (years)	
25-30	4 (27)
31-35	2 (13)
36-40	4 (27)
41-45	2 (13)
46-50	3 (20)
Sex	
Female	15 (100)
Male	0 (0)
Race/ethnicity	
Asian non-Hispanic	1 (7)
Black non-Hispanic	3 (20)
White Hispanic	5 (33)
White non-Hispanic	6 (40)
Median household income by zip code (US \$)	
10,000-30,000	3 (20)
30,001-50,000	4 (27)
50,001-70,000	2 (13)
70,001-90,000	4 (27)
90,001-110,000	2 (13)

Table 3. Household technology ownership characteristics (N=15 mothers).

Questions	Positive responses, n (%)				
	Mobile phone	Laptop or desktop	Tablet	Wi-Fi	Mobile data
I have access to the following	14 (93)	14 (93)	15 (100)	14 (93)	12 (80)
My child has access to the following	8 (53)	14 (93)	13 (87)	13 (87)	9 (60)
I use the following on an everyday basis	14 (93)	8 (53)	10 (67)	9 (60)	10 (67)
My child uses the following on an everyday basis	4 (27)	6 (40)	11 (73)	7 (47)	4 (27)
I am comfortable with using the following	14 (93)	13 (87)	15 (100)	12 (80)	10 (67)
I feel confident when using the following	15 (100)	14 (93)	15 (100)	13 (87)	10 (67)

Table 4. Descriptive sample statistics of the modified Technology Acceptance Model (N=15 mothers)

Technology Acceptance Model factors	Factor response score range (minimum-maximum) ^a	Factor response score, mean (SD) ^b	Cronbach alpha
Perceived ease of use	5-25	23.1 (2.2)	.86
Hedonic motivation	2-10	7.5 (1.4)	.81
Perceived usefulness	7-35	27.5 (3.5)	.69
Compatibility	1-5	3.8 (0.8)	N/A ^c
Habit	1-5	4.5 (0.6)	N/A
Social influence	2-10	6.6 (2.0)	.84
Attitude	3-15	12.7 (1.5)	.31
Behavioral intention	3-15	12.0 (2.6)	.95

^aQuestionnaire responses were rated on a 5-point Likert scale of 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree).

^bFactor response scores are the average of the summed item response values for each participant.

^cN/A: not applicable.

Modified Technology Acceptance Model Guided Imagery Therapy Mobile App Quantitative Questionnaire

Mothers completed all questions of the modified TAM questionnaire. Table 4 summarizes the results. The Cronbach alpha of the TAM factors with more than 1 item response ranged from .31 to .95 (Table 4). The perceived usefulness (.69) and attitude factors (.31) had the lowest Cronbach alphas, which indicate a moderate and poor strength of association of the factor item responses, respectively (Table 4) [76]. Given the limited sample size and use of an adapted questionnaire, we retained all factors, including perceived usefulness and attitude, for this analysis. The mothers reported favorable behavioral intention for using a GIT mobile app to treat their affected child if such a technology were available (Table 4). In addition, all of the modified TAM factors that influence behavioral intention were highly favorable (ie, perceived ease of use, hedonic motivation, perceived usefulness, compatibility, habit, and attitude; Table 4).

Interview Findings

Mothers

The maternal interviews ranged from 45 to 60 minutes. Figure 3 outlines the thematic network for the maternal interviews.

Attitudes Toward a Guided Imagery Therapy Mobile App

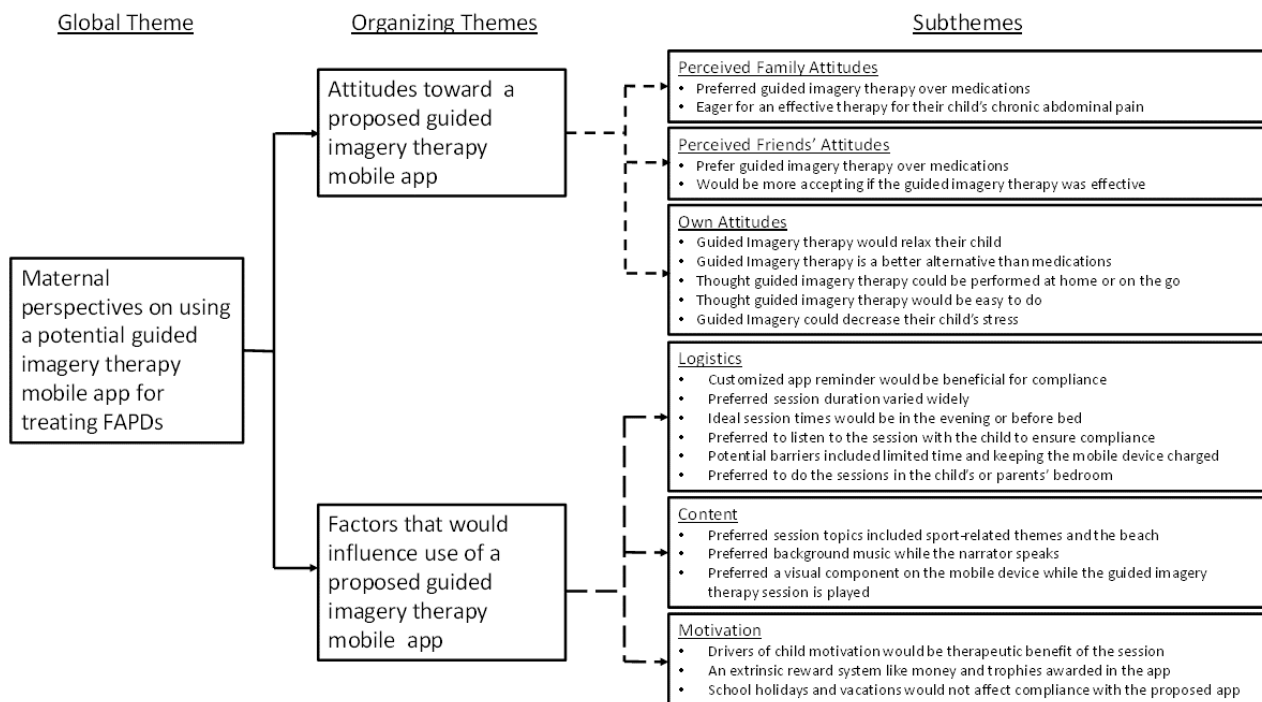
The attitudes toward the proposed app contained 3 subthemes: perceived family attitudes, perceived friends' attitudes, and one's own attitudes. Most mothers thought their family would be supportive of GIT, because they would prefer GIT over medications. Furthermore, they were eager to find a remedy for their child's chronic abdominal pain.

My parents [the child's grandparents] would be all for it, only because they hate taking medicine. They're just like, "Oh, your medicine, in the long run, it's gonna damage something else." My parents would definitely be all for it [GIT sessions]. [Participant 15]

Mothers thought friends would be supportive of GIT and would also prefer this treatment approach over medications. In addition, mothers believed that their friends would be accepting of GIT if it improved their child's abdominal pain.

I think they would just be really open to "Wow, you don't have to medicate her? This will work, and you don't have to give her medicine? This is fantastic." I think that's how they would go. That's what they'd say." [Participant 4]

Figure 3. Thematic network of maternal perspectives on a proposed guided imagery therapy mobile app designed to treat functional abdominal pain disorders (FAPDs).



Mothers expressed positive self-attitudes toward the proposed app and thought the GIT sessions would relax their child. They also thought this therapy was a better option than medications to treat their child's chronic abdominal pain. Most mothers liked the idea of having their child go to a peaceful and soothing place in their mind by listening to these sessions. Mothers also thought the GIT sessions had the potential to decrease stress for their child.

Because it's not like experimental drugs that they would have to put in their bodies. It's just something that they will have to listen to. [Participant 2]

I'm always looking for [a] way to not use medicine or things like that [for child's abdominal pain]. So, if it's something that we can do, yeah I would [use GIT]. [Participant 5]

Maternal Factors Influencing Use of a Guided Imagery Therapy Mobile App

The theme of factors influencing use of a proposed GIT mobile app comprised 3 subthemes: logistics, content, and motivation.

Logistics

The first theme encompassed logistics for using the app. This referred to ideal characteristics and conditions for its use. Mothers thought reminders to encourage their child to use the app would be helpful; however, there were varying opinions on the format for the reminders (eg, text messages, emails). There were also varying suggestions for the ideal time to receive a reminder. A customizable reminder option in which they could set a reminder alarm was suggested. Despite the customization of the reminder, the mothers thought a once-a-day reminder would be sufficient.

I think it [an app reminder] would be very helpful because you get—I tend to forget homework, band,

and everything that goes into your daily activities or your daily life is just—I would definitely say a reminder would be very helpful. [Participant 14]

In regard to the timing of the sessions, the mothers thought the evening or before bed would be the ideal time to listen to GIT sessions. They also stated that their child would listen to the session in their own or the parent's bedroom. The suggested session duration was no longer than 15 minutes due to concerns that the child may not be able to pay attention for a longer duration. The mothers also preferred to listen to the sessions with the child to ensure therapeutic compliance.

But in the morning, I feel like they have enough trouble getting up, getting themselves ready to go, so maybe not necessarily in the morning. [Participant 10]

Because I think that if it [GIT sessions] went a lot longer than [15 minutes] she would get bored and she wouldn't want to do it anymore. [Participant 2]

The mothers identified potential problems that could arise during use of the app. They were concerned that their busy lifestyle could interfere with listening to the sessions consistently. The mothers also were concerned that the child's mobile device may not be charged as needed to conduct the sessions.

To really stay on it [listening to the GIT sessions], to do it, to make sure we're doing it. Just 'cause the day is wacky busy sometimes, and things happen. You're not at home when you thought you were gonna be, or the morning just gets crazy, and you don't have that time to pull away. [Participant 4]

Content of Guided Imagery Therapy Sessions

We defined the content theme as opinions about the ideal information to include or not include in GIT sessions. The

mothers thought that sports-related themes such as soccer and a beach location would be ideal topics for the GIT sessions. They also stated that they would prefer background music to go along with the narration. They also thought that a visual image on the mobile device would be ideal to accompany the GIT sessions. The recommended on-screen visuals varied among the mothers but ranged from a static related picture of the concurrent GIT session to changing colors and mazes.

He likes basketball, soccer. Imagine if you are playing soccer and you're in a soccer field and you don't do this and you don't do this, or you do this, your stomach pain is not gonna come, something like that, or how well you should exercise or bicycle and it can cure your stomach pain, and it will make your legs feel better. These things are the activities that these kids do. [Participant 13]

So, I'd like soothing music. So there's no background. And so if we're trying to relax, often times, and kids, often times, they play soothing music in the background. I mean what are some of the things you do to get a baby to sleep? Sometimes they have the light noise, the soothing backgrounds. [Participant 9]

Maybe have a picture that they can see if they open their eyes and they can see a picture of a swing or someone swinging, just to help them out a little bit. Because like I said, I'm a visual person. I like to see things so that helps me comprehend a little bit more. [Participant 5]

Motivation

The final theme for the maternal interviews was motivation. We defined this theme as mothers' perspectives on factors that

may affect their child's willingness to use the app. The mothers thought their child would be motivated to listen to the sessions if the sessions led to therapeutic benefit for their FAPD-related abdominal pain. They also thought that a reward system based on compliance using the GIT sessions would be ideal. Their responses about specific types of rewards varied but included candy, money, a game on the mobile device, and even trophies within the proposed app. Mothers thought their child's motivation to use such a mobile app would not change during holiday breaks or summer vacations.

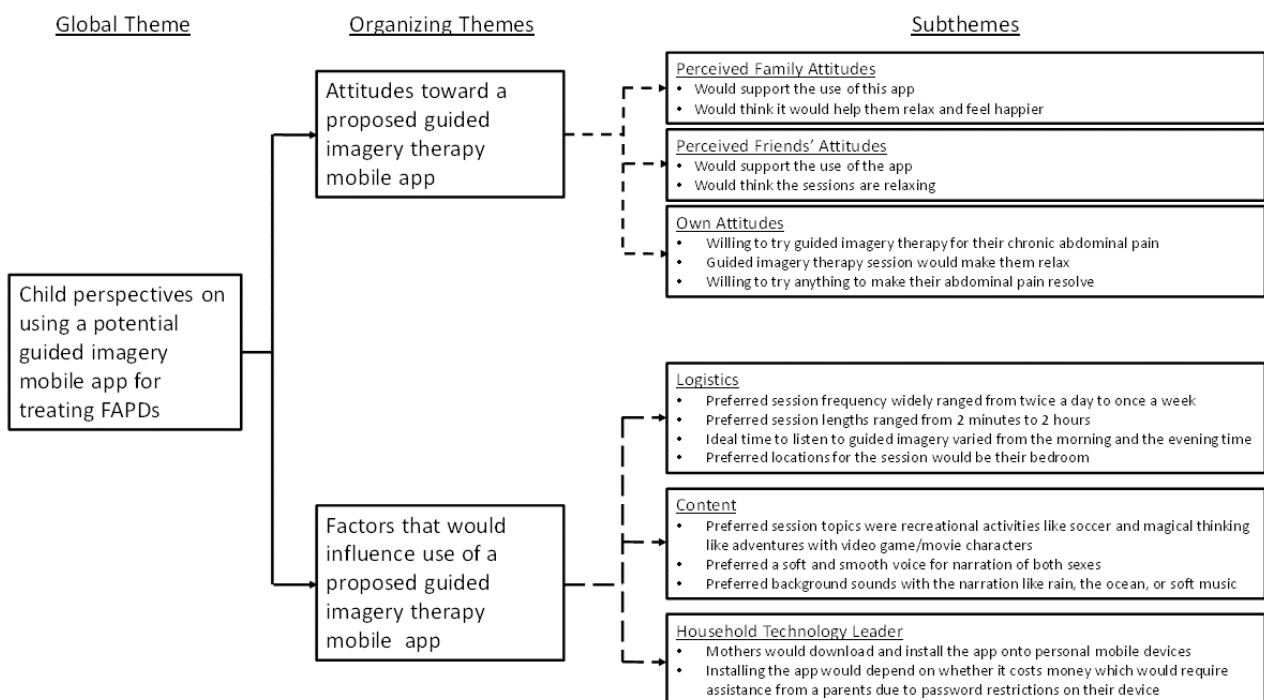
I know that if it [the proposed GIT mobile app] really does get rid of her abdominal pain, she would do it. She's to the point where if it worked, she would do it. I think that if it worked, I wouldn't have to say today we're gonna do—she would remind me. "Mom, we didn't do what we were supposed to do." She would be motivated, I think, to do it, if it really did work for her. [Participant 4]

But yeah, I mean he does school, they're not apps, but they're school websites that you go to where you actually have little math sessions. And when you complete a certain level of math session, then you get a trophy or get a star or whatever it is. And you elevate to different levels, that kind of thing. [Participant 7]

Children

The child interviews lasted from 15 to 40 minutes. Figure 4 outlines the thematic network for the child interviews.

Figure 4. Thematic network of child perspectives on a guided imagery therapy mobile app designed to treat functional abdominal pain disorders (FAPDs).



Attitudes Toward a Guided Imagery Therapy Mobile App

The attitudes theme reflected thoughts on a GIT mobile app that treats abdominal pain related to their FAPD. Similar to the previous analysis, this theme had 3 subthemes: perceived family, perceived friends', and one's own attitudes. The children thought their family would support listening to these sessions as treatment for their abdominal pain. The children also thought that their friends would either be indifferent to or supportive of their using such an app. In regard to self-attitude toward the proposed app, the children liked the GIT session excerpt and wanted to try out these sessions to help with their abdominal pain. They thought the session excerpt was relaxing and these sessions would change their mood in a positive sense.

Well, they'd [participant's family would] be fine because it's trying to help me feel better. [Participant 7]

Because I don't know it [guided imagery therapy session excerpt] makes me feel—because most of the time I get dizzy and stuff because I'm very stressed out and I just don't wanna have to think about school and everything I have to do. And I will try this out because, I don't know, it would get those things off my mind at the moment so I could just kind of—I don't know like relax. [Participant 6]

Factors Influencing Use of a Guided Imagery Therapy Mobile App

This theme reflected how the children would use the app. Subthemes that emerged were logistics, content, and household technology leader.

Logistics

Logistics referred to ideal characteristics and conditions for using a GIT app. The children had no consensus on the suggested duration or frequency of a GIT session. The duration and frequency responses ranged from 2 minutes to 2 hours and once a week to twice daily, respectively. The ideal time to listen to the sessions would be in the morning or evening. Affected children stated that they would prefer to listen to the sessions in their bedroom.

Because when you wake up because your scared. What if you're going to school, if there's gonna be a test and your stomach might hurt in the mornings. [Participant 4]

Up in my bedroom. You literally can't hear anyone downstairs besides if they shout up. [Participant 3]

Content of Guided Imagery Therapy Sessions

We defined the content theme as opinions about the ideal information to include or not include in guided imagery sessions for a mobile app. The child participants stated that they would prefer to listen to guided imagery sessions focused on various recreational or sporting activities and magical thinking. These session topics included sports themes (eg, lacrosse and soccer), animals, video game characters and related adventures, and food. A soft and smooth voice for GIT narration was preferred. They also preferred background sounds with the session

narration. The children liked background sounds such as rain, the ocean, and soft music.

I'd really like to hear imagine you're in a place with a bunch of kitty cats. And then they would have kitty cat sounds in the background... [Participant 12]

I love lacrosse, so I scored the winning goal or something and that would probably help me. [Participant 8]

Household Technology Leader

We defined this theme as the persons responsible for downloading and installing the app onto household electronic mobile devices. Children stated that their parent would be the person to download and install the app. They also stated that downloading the app to their device would depend on whether the app costs money and, if so, this process would definitely require a parent to complete the app installation.

Triangulation

Acceptability of the proposed GIT mobile app was addressed in both the quantitative questionnaire and qualitative interviews. The questionnaire demonstrated a favorable behavioral intention score to use the app and attitude score toward the app. The interviews also addressed this issue through the positive maternal and child attitude themes. In this case, the questionnaire results were corroborated by the qualitative rich data. Both mothers and affected children supported the app because they did not like giving or taking medications for FAPD-related abdominal pain, they were eager for another modality for treatment, and the sessions could make affected children feel good.

The concept of motivation was addressed in both quantitative and qualitative methods. Hedonic motivation examines the intrinsic motivation to use a technology. The maternal and child interviews both addressed intrinsic motivation as a subtheme in the theme of influencing factors. Integration of these methods findings also showed corroboration between the methods and further insight into why there was a favorable hedonic motivation score in the questionnaire. The mothers insisted that the therapeutic benefit of such an app would drive their affected children to use the app. These data suggest that the mothers expected a GIT mobile device to be therapeutic if it were available.

Perceived ease of use seemed to be congruent between both the quantitative questionnaire and the qualitative interviews. The TAM questionnaire revealed a favorable perceived ease-of-use score regarding the proposed app. Parental interviews supported this same finding because the parents were familiar with reminder alerts on mobile devices and text messages. Furthermore, the child interviews mentioned that their parents would be responsible for manipulating their mobile device to install such an app. The mothers and their children were familiar with mobile devices; hence, perceived ease of use of a proposed GIT mobile app is plausible.

Discussion

The use of psychological therapies for FAPDs is recommended by experts, as they have been shown to be effective [15,77]. Unfortunately, accessing such therapies is problematic due to limited access to trained specialists and restricted insurance coverage for such therapies [26,27]. The utility of remotely delivered psychological therapies for FAPDs (eg, delivered by compact disc or telephone) appears highly promising [26,28-30,78]. However, these methods also have drawbacks (eg, compact disc use is unpopular). As a solution, the ubiquity of personal electronic mobile devices could permit low-cost, large-scale distribution of prerecorded audio GIT sessions to children with FAPDs.

Principal Findings

This study is the first, to our knowledge, to examine the perspectives of children with FAPDs and their parents on a proposed mobile app to remotely deliver GIT sessions. We successfully recruited and captured the thoughts of a diverse representative patient sample and their mothers, and they both demonstrated support for this technology-based treatment approach through a quantitative questionnaire and qualitative interviews. Our modified TAM questionnaire was completed by affected children's mothers, and this instrument discovered favorable behavioral intention to use such a device, along with other factors that affect use of health technology. The maternal and child interviews confirmed their interest and provided explicit detail for supporting such a technology. Furthermore, the participants provided key information about their preferences for the app and how they would use the health technology tool in their everyday lives. Integration of our quantitative questionnaire and qualitative interview findings also demonstrated favorable motivation and perceived ease of use for such an app.

The study questionnaire affirmed that affected children and their mothers typically had access to electronic mobile devices and internet access, and this finding aligns with other US national studies [79,80]. Beyond possession of these technologies, mothers and their children exhibited features of proficiency with these devices, as they were familiar with app reminders, text messages, and calendar reminders on their mobile devices. Our results align with a previous study reporting that parents saw value in a reminder feature for medication compliance [56]. The children also confirmed that they would have to give their mobile device to their parent download and install apps. This patient population and their families appeared to have the required hardware and technical proficiency to use a GIT mobile app.

The qualitative analyses of the maternal and child interviews had similar organizing themes of attitudes toward a proposed GIT app and factors that would affect use of such an app. This is likely an artifact of the purpose of the study (to determine acceptability and appropriateness of using a GIT to treat FAPDs) and closely related maternal and child interview scripts. Despite the similarities in the maternal and child thematic networks, the mothers and children provided unique responses (eg, mothers thought a beach location would be ideal for GIT session topic

content, but the children endorsed other topics such as animals, adventures, and food as topic content of interest). Such differences will need to be further explored during the app development phase in the future.

Our mixed-methods approach confirmed acceptability of a proposed GIT mobile app to treat FAPDs in children. Both mothers and their affected children did not like giving or taking medications, especially when they did not seem to help the children's abdominal pain. We suspect that parents are willing to accept this technology because parents already feel comfortable using electronic mobile devices to calm and distract young children [81]. Our findings are congruent with a qualitative focus group study of adolescents with chronic pain who confirmed the utility of various methods to treat their pain, including psychological approaches [82]. Our results suggest that external factors, such as family members and friends, do not seem to be a barrier to using this proposed clinical tool.

Motivation to use the app appeared favorable among affected children and their parents. The intrinsic motivation of the app's therapeutic effects would drive its use. The study also identified extrinsic motivation through external rewards such as money and app-based trophies. Further studies are needed to evaluate the value of intrinsic benefit versus extrinsic reward and how long extrinsic awards should be maintained or even if they should be started.

There is a growing body of literature that supports a user-centered approach for mobile health app development, and our study findings suggest why this is important. Our qualitative interviews revealed important features that will need to be incorporated in app development to increase therapeutic compliance among pediatric patients (eg, specific GIT session topics and app reminders). Zhao et al suggested adding features to mobile health apps to improve their effectiveness, including those that offer less time consumption, user-friendly design, real-time feedback, individualized elements, detailed information, and health professional involvement [83]. Incorporating these key study results should optimize compliance and encourage pediatric patient motivation.

Limitations

The generalizability of this study is restricted, as we characterized 15 mother-child dyads for our study's conclusion. However, the demographics of our sample aligned with the patient population within our pediatric health care system, which is in the most racially and ethnically diverse large city in the United States. In addition, we used thematic saturation to minimize bias. Our limited study sample did not allow us to determine which specific factors of the modified TAM or other unforeseen factors were most influential in predicting behavioral intention for using the proposed GIT mobile app.

Conclusion

Based on the results of our study, a GIT mobile app designed to treat pediatric patients with FAPDs has the potential to be a well-received, evidence-based clinical tool similar to other mobile apps designed to treat anxiety or depression [36,37,84]. This study identified key features to incorporate into the design of the mobile app (eg, reminder features, ideal session topics,

and background music in addition to narration) to increase compliance. These findings provide a strong foundation to develop and deploy a GIT mobile app into clinical practice and establish a new paradigm for treating FAPDs in the pediatric population.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Modified Technology Acceptance Model questionnaire for a guided imagery mobile app.

[\[PDF File \(Adobe PDF File\), 25KB - pediatrics_v1i1e6_app1.pdf\]](#)

Multimedia Appendix 2

Parent interview script.

[\[PDF File \(Adobe PDF File\), 20KB - pediatrics_v1i1e6_app2.pdf\]](#)

Multimedia Appendix 3

Child interview script.

[\[PDF File \(Adobe PDF File\), 18KB - pediatrics_v1i1e6_app3.pdf\]](#)

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Abbreviations

- FAPD:** functional abdominal pain disorder
GIT: guided imagery therapy

TAM: Technology Acceptance Model

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