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Parents' Perspectives on Their Relationship With Their Adolescent Children With Internet Addiction: Survey Study

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Abstract

Background: Parents of adolescents with internet addiction are confronted with their children's internet problems on a daily basis. Parents may notice that adolescents with addiction may also have emotional and behavioral problems, including impulsivity and violence. Parenting styles have been found to be related to internet addiction.

Objective: The purpose of this study is to investigate parents' perspectives on their parenting style, relationship with their child, and the degree of internet addiction and emotional and behavioral problems of their child.

Methods: A web survey was conducted with 600 parents of children between the ages of 12 and 17 years, from October 14 to 18, 2021, across Japan. Respondents were recruited by an internet research company and were asked to complete an anonymous online questionnaire. The survey was divided into two groups: 300 parents who answered "yes" to the question "Do you think your child is dependent on the internet?" and 300 parents who answered "no" to that question. Questionnaires were collected until each group had 300 participants. The questionnaire included (1) the Parent-Child Internet Addiction Test (PCIAT), (2) the daily time spent using the internet, (3) the Strengths and Difficulties Questionnaire (SDQ), (4) the Parenting Style and Dimensions Questionnaire (PSDQ), and (5) the Relationship Questionnaire (RQ) measuring self-report attachment style prototypes.

Results: Mean scores of the PCIAT and the daily time spent using the internet for the group with probable internet addiction were significantly higher than those of the group without probable internet addiction (50%; $P<.001$). The total difficulties score from the SDQ for the group with probable internet addiction (mean 10.87, SD 5.9) was significantly higher than that for the group without probable internet addiction (mean 8.23, SD 5.64; $P<.001$). The mean score for authoritarian parenting from the PSDQ for the group with probable internet addiction (mean 2.1, SD 0.58) was significantly higher than that for the group without probable internet addiction (mean 2.1, SD 0.58; $P<.001$). Regarding the RQ, there were no significant differences between the two groups.

Conclusions: Our findings suggest that parents who think their child is addicted to the internet may recognize emotional and behavioral problems of the child and have an authoritarian parenting style.

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KEYWORDS

internet addiction; mental health; parent-child relationship

Introduction

The internet is a highly convenient tool for the instantaneous and comprehensive exchange of large amounts of information with the world. It is no exaggeration to say that our lives are directly or indirectly supported by the internet, and it has enriched our lives through information accessibility, entertainment, communication, and trading. Over the past decade, internet use has increased dramatically and has become an integral part of everyday life. It has become especially central among adolescents and emerging adults, for whom technological literacy is important for both work and play. Recently, however, the negative aspects of the internet have been attracting attention, and in addition to fraud, crime, bullying, and wastage of time via the internet, the problem of internet dependence, the subject of this study, has been highlighted [1-4].

It was not until 1990 that reports of internet dependence began to appear sporadically. Overuse of the internet causes serious problems, such as poor grades, withdrawal to one's room, disordered eating habits, and lack of sleep. On the mental side, it causes depression, aggression, worsening of general mental symptoms, and a decline in self-esteem, which is undesirable for an individual's career path and social support [5]. The line between internet use and problematic internet use has been significantly overstepped. The concept of "addiction" has raised interest in the study of the internet. Problematic internet use comprises an important area of research as its negative effects have been found to affect daily functioning, interpersonal relationships, and emotional well-being [6-8]. In addition, its symptoms resemble those of substance-related addictions, including unpredictable behaviors and moods [9,10].

Due to this trend, the diagnostic criteria for internet gaming disorder (IGD) were included in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) in 2013 [11]. In addition, the International Classification of Diseases, 11th Revision, published by the World Health Organization in June 2018, also included diagnostic criteria for gaming disorder [12]. Pan et al [13] conducted a systematic review and meta-analysis of 113 studies that included 693,306 subjects. The 133 effect sizes included 53,184 subjects, and the authors reported that the weighted average prevalence for generalized internet addiction and IGD were 7.02 % and 2.47 %, respectively. A review of psychological intervention studies for internet addiction found the following interventions: cognitive behavior therapy, family therapy, reality training, cognitive bias modification, craving behavioral intervention, and integration of psychological treatments [14].

In recent years, various studies have been conducted on adolescents with internet addiction. It has been found that among junior high school students both attention-deficit/hyperactivity disorder (ADHD) and autism spectrum disorder (ASD), caused by developmental disabilities, are related to the risk of internet dependence.

We believe that parents' perspectives on their child's internet addiction are important because parenting a child with internet addiction as well as ASD, ADHD, or both can be a challenging and difficult experience. Simply scolding or punishing their children's internet addiction is a bad form of communication by parents and might exacerbate the internet addiction, leading to a vicious cycle. In such cases, we believe that helping parents with their children suffering from internet addiction through cognitive behavioral therapy [15,16], especially Community Reinforcement Approach and Family Training (CRAFT) [17,18], will be useful. Psychotherapy for the parent may improve the relationship between parent and child and stop the vicious cycle of internet addiction.

Based on this hypothesis, we are conducting a pilot randomized controlled trial of videoconference-based cognitive behavioral therapy for parents with children suffering from internet addiction between the ages of 12 and 20 years, separately from this study, which was approved by the Ethics Review Committee of Chiba University Hospital in 2018 (UMIN 000032483).

Direct parental factors, such as lack of affection from parents, increase children's online dependence. While a good parent-child relationship is negatively associated with online dependence, particularly among adolescents, there are reports that parents' discord is associated with increased online dependence among children [19,20].

The purpose of this quantitative study was to compare parents' perspectives on the degree of their child's internet addiction and emotional and behavioral problems, their parenting style, and the parent-child relationship between parents with children afflicted with internet addiction and those without, using an anonymous web-based survey across Japan.

Methods

Participants

We used an online research agency (Cross Marketing Inc, Tokyo) to oversee the web-based survey from October 14 to 18, 2021, across Japan. After understanding the purpose of the study and voluntarily agreeing to participate, 600 participants from Japan were recruited through the online research provider.

The participants were parents with children between the ages of 12 and 17 years, and they were asked to fill out an anonymous online questionnaire. Parents were instructed to complete the survey about only 1 child with internet addiction, no matter how many children they had.

We asked the parents, "Please think of your child who is addicted to the internet" and "Please tell us the birth order of that child."

The survey was divided into two groups: 300 parents who answered "yes" to the question "Do you think your child is dependent on the internet?" and 300 parents who answered "no" to that question. Questionnaires were collected until the number of parents in each group reached 300.

Items for Observation, Examination, Survey, and Reporting

Overview

Candidate respondents received brief text-based information about the study, including the purpose of the study, and informed

consent was obtained. The survey consisted of 2 parts. The first part asked for general information about the respondents (ie, age, gender, area of residence, and employment status of the parents, as well as age, gender, birth order, and hours of internet use per day of their children).

The second part of the survey asked respondents to selectively answer the 4 questionnaire items described in the following sections.

Parent-Child Internet Addiction Test

The items of the questionnaire pertaining to children's internet addiction from the parents' points of view were adapted from the Parent-Child Internet Addiction Test (PCIAT) [21-23], a 20-item inventory adapted from the Internet Addiction Test (IAT) developed by Young [24]. Items were rated on a 5-point Likert scale, ranging from 1 (not at all) to 5 (frequently), to indicate the degree to which internet use affected daily life, family relationships, social life, personal health, and state of mind. The minimum score was 20 and the maximum score was 100, with higher scores indicating greater problems caused by internet use. Young defines a score of 20 to 49 as an average user who has control over their use of the internet, a score of 50 to 79 as a dependent user who has occasional or frequent problems with their use of the internet, and a score of 80 to 100 as a dependent user who has major problems with their use of the internet.

Strengths and Difficulties Questionnaire

The Strengths and Difficulties Questionnaire (SDQ), developed by Goodman [25,26], is a comprehensive measure of children's adjustment and mental health status. It is a highly reliable screening method for assessing positive and negative aspects of children's behavior [27].

The SDQ consists of 25 items, with 5 subscales (ie, emotional symptoms, conduct problems, hyperactivity-inattention, peer problems, and prosocial behavior) and 5 items within each subscale. Each question was answered by selecting from 3 options: "yes" (2 points), "fairly true" (1 point), and "no" (0 points). The total score for each subscale was calculated, and the total difficulties score (TDS) was calculated from the total score of 4 of the 5 subscales: the prosocial behavior subscale was excluded.

In addition, by setting a cutoff point, the need for support in that area was classified into 3 categories: normal range, borderline range, and clinical range.

Parenting Style and Dimensions Questionnaire

The Parenting Style and Dimensions Questionnaire (PSDQ) by Robinson et al [28], which consists of subscales based on Baumrind's [29] classification of authoritative, authoritarian, and permissive parents, was used. It measures various characteristics of parents and children [30,31] and is an excellent scale for measuring parents' nurturing attitudes.

Self-Report Attachment Style Prototypes: Relationship Questionnaire

The Relationship Questionnaire (RQ), which measures 4 categories of attachment style, was used to measure the attachment styles of parents and children. Bartholomew et al's [32-34] RQ consists of a statement describing the characteristics of 4 attachment styles in relation to the "general other." Subjects were first asked to rate the degree to which each of the 4 sentences introduced as "types of feelings toward people" matched their own on a 7-point scale, ranging from 1 (not at all) to 7 (very much). Next, they were asked to choose 1 of the 4 styles that they thought was the most applicable to them. In the analysis, the attachment style chosen at the end was considered the subject's attachment style.

Statistical Analysis

A descriptive analysis (ie, numbers, frequencies, percentages, means, and SDs) of the 600 respondents was conducted. The responses of the 300 respondents in the "yes" group and the 300 respondents in the "no" group were compared for differences in items using a *t* test. Frequencies of gender, marital status, and birth order were analyzed using the chi-square test or the Fisher exact test. For the characteristics of the participants, *P* values were considered by applying a 2-tailed significance level of less than .05. For the SDQ, the PSDQ, and the RQ, we used the Bonferroni correction and set the *P* value threshold of .05/19=.0026 in order to avoid increasing the risk of a type I error by multiple comparisons. All data were analyzed with SPSS (version 22.0; IBM Corp).

Ethics Approval

This study was approved by the Ethical Review Committee of the Graduate School of Medicine, Chiba University, in September 2021 (M10095).

Results

Overview

The characteristics of the participants are shown in Table 1. The mean age of the parents was 49.24 (SD 5.67) years in the "yes" group and 49.07 (SD 5.06) years in the "no" group, with no significant difference between the two groups. Regarding marital status, about 95.1% (571/600) of the respondents in both groups were married; there was no significant difference between groups. There were significant differences in gender between the two groups. Female participants in the "yes" group constituted 45.0% (135/300) of the sample, whereas in the "no" group they constituted 36.0% (108/300) of the sample.

The average age of the participants' children was 15.01 (SD 1.59) years in the "yes" group and 14.95 (SD 1.58) years in the "no" group, with no significant difference between the groups. In terms of birth order, 58.7% (352/600) of the adolescents were the first child, 31.5% (189/600) were the second child, 8.0% (48/600) were the third child, and 1.8% (11/600) were in a different birth order position, with no significant difference (Table 1).

The total PCIAT score for the group that answered "yes" (mean 55.41, SD 15.78) was significantly higher than that for the group that answered "no" (mean 35.55, SD 11.64). As for the daily time spent on the internet, the children in the group that answered "yes" spent a mean of 4.0 (SD 2.06) hours on the internet, and those in the group that answered "no" spent a mean

of 1.7 (SD 1.06) hours on the internet, and there was a statistically significant difference between the two groups (P<.001).

Table 1. Characteristics of the participants.

Characteristics	Parents who thought their child was addicted to the internet (n=300)	Parents who did not think their child was addicted to the internet (n=300)	*P* value
Parent			
Age (years)			
Mean (SD)	49.24 (5.67)	49.07 (5.06)	.69
Range	35-65	33-64	N/A[a]
Gender, n (%)			.03[b]
Male	165 (55.0)	192 (64.0)	
Female	135 (45.0)	108 (36.0)	
Marital status, n (%)			>.99
Married	284 (94.7)	287 (95.7)	
Single	16 (5.3)	13 (4.3)	
Adolescent			
Age (years)			
Mean (SD)	15.01 (1.59)	14.95 (1.58)	.61
Range	12-17	12-17	N/A
Gender, n (%)			>.99
Male	165 (55.0)	165 (55.0)	
Female	134 (44.7)	134 (44.7)	
No answer	1 (0.3)	1 (0.3)	
Birth order, n (%)			>.99
1st child	180 (60.0)	172 (57.3)	
2nd child	93 (31.0)	96 (32.0)	
3rd child	23 (7.7)	25 (8.3)	
Other	4 (1.3)	7 (2.3)	
PCIAT[c] total score			
Mean (SD)	55.41 (15.78)	35.55 (11.64)	<.001
Range	21-98	21-74	N/A
Daily time spent using the internet (hours)			
Mean (SD)	4.0 (2.06)	1.7 (1.06)	<.001
Range	0-17	0-7	N/A

[a]*P* values were not calculated for range values.

[b]*P* values for a group are reported in the main row of the group.

[c]PCIAT: Parent-Child Internet Addiction Test; scores ranged from 20 to 100, with higher scores indicating greater problems caused by internet use.

Comparison of SDQ, PSDQ, and RQ Values From Both Groups

The results of the SDQ, the PSDQ, and the RQ are shown in Table 2. In the SDQ, the mean TDS score for the group that answered "yes" was significantly higher than for the group that answered "no" (P<.001). Regarding the subscale items, mean scores for emotional symptoms, conduct problems, and hyperactivity-inattention for the "yes" group were significantly higher than those for the "no" group (P<.001). There were no significant differences between groups regarding peer problems (P<.049) and prosocial behavior (P<.13).

Regarding the PSDQ, the mean score for authoritarian parenting of the "yes" group was significantly higher than that of the "no" group (P<.001). There were no significant differences between authoritative parenting and permissive parenting. Regarding the RQ, there was no statistically significant difference between the "yes" and "no" groups of parents and children on the whole,

whether they had secure, dismissive, preoccupied, or fearful relationships.

Table 2. Comparison of Strengths and Difficulties Questionnaire (SDQ), Parenting Style and Dimensions Questionnaire (PSDQ), and Relationship Questionnaire (RQ) results between groups.

Scales and subscales	Parents who thought their child was addicted to the internet (n=300), mean (SD)	Parents who did not think their child was addicted to the internet (n=300), mean (SD)	*P* value
SDQ[a] score (25 items, including all 5 subscales)			
Total difficulties score (20 items, excluding prosocial behavior subscale)	10.87 (5.91)	8.23 (5.64)	<.001
Subscales (5 items each)			
Emotional symptoms	2.04 (2.18)	1.41 (1.83)	<.001
Conduct problems	2.26 (1.75)	1.51 (1.46)	<.001
Hyperactivity-inattention	3.70 (2.17)	2.73 (2.12)	<.001
Peer problem	2.87 (1.84)	2.58 (1.76)	.049
Prosocial behavior	4.81 (2.44)	5.11 (2.32)	.13
PSDQ[a] score (62 items)			
Authoritative subscale (27 items)	3.11 (0.61)	3.14 (0.67)	.65
Authoritarian subscale (20 items)	2.27 (0.61)	2.10 (0.58)	.001
Permissive subscale (15 items)	2.37 (0.44)	2.28 (0.46)	.02
RQ[a] score			
Parent			
Secure	3.83 (1.46)	3.85 (1.29)	.88
Dismissing	3.70 (1.38)	3.90 (1.36)	.07
Preoccupied	3.85 (1.31)	3.76 (1.35)	.41
Fearful	3.73 (1.47)	3.78 (1.41)	.71
Adolescent			
Secure	4.20 (1.32)	4.24 (1.22)	.70
Dismissing	3.70 (1.26)	3.60 (1.13)	.29
Preoccupied	3.97 (1.15)	3.87 (1.1)	.31
Fearful	3.52 (1.31)	3.27 (1.19)	.01

[a]For the SDQ, the PSDQ, and the RQ, we used the Bonferroni correction and set the *P* value threshold of .05/19=.0026 in order to avoid increasing the risk of a type I error by multiple comparisons.

Comparison of High Internet Users Versus Low Internet Users

From the 300 parents who answered "yes," we extracted those who scored 50 or higher on the PCIAT (190/300, 63.3%) to examine users who experienced occasional or frequent problems due to internet use. From the 300 parents who answered "no," 86.0% (258/300) had a PCIAT score of less than 50. The 2 sets were compared to each other. The results of the SDQ, the PSDQ, and the RQ are shown in Table 3.

The SDQ showed statistically significant differences in the TDS and in the subscales of emotional symptoms, conduct problems, hyperactivity-inattention, peer problems, and prosocial behavior (all *P*s<.001). The PSDQ showed a significant difference between authoritarian and permissive parents (*P*<.001) but not authoritative parents (authoritative subscale: *P*=.24; authoritarian subscale: *P*<.001; permissive subscale: *P*<.001).

Regarding the RQ, no statistically significant differences were found for parents under any of the items. Conversely, the children showed a significant difference only in the fearful type (*P*<.001).

We regrouped participants with a PCIAT cutoff value of 50, ignoring whether parents thought their child was addicted to the internet or not, conducted the analysis, and made a new table (Table 4).

The results showed that the group with a PCIAT score of 50 or higher (n=232) had a PCIAT mean score of 63.58 (SD 10.49). The group with a PCIAT score lower than 50 (n=368) had a PCIAT mean score of 34.07 (SD 8.19). The results of the SDQ, the PSDQ, and the RQ were compared between the two groups and were similar to those in Table 3.

Table 3. Comparison of parents who thought their child was addicted to the internet (Parent-Child Internet Addiction Test [PCIAT] score ≥50) and those who did not (PCIAT score <50).

Scales and subscales	Parents who thought their child was addicted to the internet (n=190), mean (SD)	Parents who did not think their child was addicted to the internet (n=258), mean (SD)	*P* value
PCIAT total score	64.91 (10.91)	31.96 (7.8)	<.001
SDQ[a,b] score (25 items, including all 5 subscales)			
Total difficulties score (20 items, excluding prosocial behavior subscale)	12.55 (5.65)	7.41 (4.96)	<.001
Subscales (5 items each)			
Emotional symptoms	2.44 (2.25)	1.17 (1.6)	<.001
Conduct problems	2.61 (1.81)	1.3 (1.25)	<.001
Hyperactivity-inattention	4.33 (2.09)	2.52 (2.02)	<.001
Peer problem	3.17 (1.88)	2.42 (1.68)	<.001
Prosocial behavior	4.36 (2.33)	5.15 (2.35)	<.001
PSDQ[b,c] score (62 items)			
Authoritative subscale (27 items)	3.09 (0.58)	3.16 (0.68)	.24
Authoritarian subscale (20 items)	2.39 (0.58)	2.04 (0.56)	<.001
Permissive subscale (15 items)	2.43 (0.4)	2.22 (0.45)	<.001
RQ[b,d] score			
Parent			
Secure	3.75 (1.43)	3.86 (1.33)	.38
Dismissing	3.59 (1.35)	3.88 (1.4)	.03
Preoccupied	3.95 (1.28)	3.73 (1.38)	.09
Fearful	3.79 (1.48)	3.74 (1.47)	.71
Adolescent			
Secure	4.08 (1.32)	4.26 (1.23)	.14
Dismissing	3.74 (1.27)	3.56 (1.14)	.12
Preoccupied	4.06 (1.21)	3.84 (1.13)	.046
Fearful	3.66 (1.34)	3.2 (1.22)	<.001

[a]SDQ: Strengths and Difficulties Questionnaire.

[b]For the SDQ, the PSDQ, and the RQ, we used the Bonferroni correction and set the *P* value threshold of .05/19=.0026 in order to avoid increasing the risk of a type I error by multiple comparisons.

[c]PSDQ: Parenting Style and Dimensions Questionnaire.

[d]RQ: Relationship Questionnaire.

Table 4. Comparison of 600 subjects classified according to Parent-Child Internet Addiction Test (PCIAT) cutoff values.

Scales and subscales	PCIAT score ≥50, (n=232)	PCIAT score <50 (n=368)	*P* value
PCIAT total score, mean (SD)	63.58 (10.49)	34.07 (8.19)	<.001
Parents who thought their child was addicted to the internet, n (%)	190 (81.9)	110 (29.9)	N/A[a]
Parents who did not think their child was addicted to the internet, n (%)	42 (18.1)	258 (70.1)	N/A
SDQ[b,c] score (25 items, including all 5 subscales), mean (SD)			
Total difficulties score (20 items, excluding prosocial behavior subscale)	12.67 (5.88)	7.58 (5.03)	<.001
Subscales (5 items each)			
Emotional symptoms	2.51 (2.28)	1.23 (1.68)	<.001
Conduct problems	2.64 (1.82)	1.4 (1.33)	<.001
Hyperactivity-inattention	4.27 (2.1)	2.55 (1.97)	<.001
Peer problem	3.24 (1.88)	2.39 (1.67)	<.001
Prosocial behavior	4.45 (2.29)	5.29 (2.38)	<.001
PSDQ[c,d] score (62 items), mean (SD)			
Authoritative subscale (27 items)	3.08 (0.58)	3.16 (0.67)	.12
Authoritarian subscale (20 items)	2.41 (0.57)	2.05 (0.58)	<.001
Permissive subscale (15 items)	2.47 (0.41)	2.23 (0.46)	<.001
RQ[c,e] score, mean (SD)			
Parent			
Secure	3.75 (1.36)	3.9 (1.38)	.19
Dismissing	3.68 (1.32)	3.88 (1.4)	.07
Preoccupied	3.95 (1.25)	3.72 (1.37)	.04
Fearful	3.83 (1.41)	3.71 (1.46)	.30
Adolescent			
Secure	4.09 (1.29)	4.31 (1.25)	.04
Dismissing	3.76 (1.23)	3.58 (1.17)	.09
Preoccupied	4.07 (1.15)	3.83 (1.1)	.01

[a]N/A: not applicable; a *P* value was not calculated for this item.

[b]SDQ: Strengths and Difficulties Questionnaire.

[c]For the SDQ, the PSDQ, and the RQ, we used the Bonferroni correction and set the *P* value threshold of .05/19=.0026 in order to avoid increasing the risk of a type I error by multiple comparisons.

[d]PSDQ: Parenting Style and Dimensions Questionnaire.

[e]RQ: Relationship Questionnaire.

Discussion

Principal Findings

In this study, we administered a questionnaire to investigate the relationship between parenting styles and adolescents' internet addiction and mental health problems. In recent years, various studies on adolescents have suggested that internet dependence is associated with developmental disorders; in addition, both ADHD and ASD have been found to be associated with the risk of internet dependence. Cakmak and Gul [35] reported that weekly internet usage among children with ADHD aged 12 to 16 years was higher than among children in the control group. Kawabe et al [36] reported that 25 out of 55 participants with ASD were classified as having internet addiction based on results from the IAT.

In this study, we did not take into account the diagnosis of ADHD, ASD, or both, but we did measure SDQ scores and found that the TDS of the SDQ in the group with internet addiction was significantly higher than that in the group without addiction. Baer et al [37] reported that the Computer/Gaming-station Addiction Scale score significantly correlated with the total SDQ score. Akdeniz et al [38] reported that the TDS of the SDQ was higher in the group with internet

addition compared to that of the group without internet addiction. Our findings were consistent with previous studies.

Previous research on the parent-child relationship between internet-dependent adolescents and their parents has largely been conducted from the perspective of the adolescents [39-41]. In this study, the perspective of the parents was the focus, and we investigated the parenting styles of those parents with internet-dependent adolescents. In a previous study from the parents' perspective, Dogan et al [42] investigated the perceptions of internet addiction and parenting styles among adolescents studying in secondary schools between the ages of 14 and 19 years. They used the Parental Attitude Scale by Kuzgun and Eldeleklioğlu [43] to measure parental attitude, and the results showed a negative relationship between internet addiction and a democratic parenting style. Results of that study also showed a negative relationship between a protective-demanding parenting style and an authoritarian parenting style, which was found to have a significant positive relationship with internet addiction. This study used the PSDQ, a parenting style scale created by Robinson et al [28]; the results from Robinson et al's study were consistent with the findings from our study, showing that parents in the group with internet-dependent children were found to have significantly higher authoritarian parenting tendencies than parents in the group with children who were not dependent on the internet.

Dogan et al [42] also found that a protective-demanding parenting style was a strong predictor of internet dependence, followed by an authoritarian parenting style. Although the 3 subscales of the PSDQ in this study and the 3 subscales of Kuzgun and Eldeleklioğlu's Parental Attitude Scale in the study by Dogan et al [42] are not comparable, the findings with regard to the relationship of authoritarian parenting style with internet addiction may be common.

Using structural equation modeling analyses of the data from 266 adolescents, Trumello et al [44] suggested that adolescents' mental health problems measured by the SDQ are an important mediator between parental care and youths' internet addiction. Our findings were in accordance with their report.

The research implications of this study are that parents who have children with internet addiction may be more aware of their children's emotional and behavioral problems, and their parenting style is more authoritarian. Clinicians may encourage parents to stop their authoritarian parenting style, to learn good communication skills, and to reward their children when they choose desirable behaviors. They may also encourage parents to engage children in treatment for internet abuse and emotional and behavioral problems using cognitive behavioral therapy, especially the CRAFT intervention, at the end of their discussion as their recommendation.

Limitations

As we suggested, although the online survey conducted in this study provided valuable information, it has several limitations. The first limitation was that we did not use the random sampling method. Originally, it would have been ideal to conduct random sampling, in which the probability of being selected for the sample would be equal for all individuals. In the future, an online survey using the random sampling method should be conducted.

The second limitation was that the children in this study were not diagnosed according to the DSM-5 diagnostic criteria for IGD. A structured diagnostic interview based on the online survey about internet addiction will be needed.

The third limitation was that no data were collected from the children in this survey. The parents' evaluations of their children were based on their assumptions. Considering that there are differences in the understanding of internet addiction between parents and children, future research should focus on collecting data from both parents and children.

Conclusions

ADHD and ASD are known to be related to the risk of internet addiction. Our findings suggest that parents who think their child is addicted to the internet may recognize emotional and behavioral problems in the child measured by the SDQ. In addition, parents with children who suffer from internet addiction may have an authoritarian parenting style. Clinicians may encourage parents to learn good communication skills instead of an authoritarian parenting style.

In the future, studies should conduct additional research on internet addiction in children and their families. Cross-sectional and longitudinal research on families, especially parents, is also needed.

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Conflicts of Interest

None declared.

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Abbreviations

ADHD: attention-deficit/hyperactivity disorder
ASD: autism spectrum disorder
CRAFT: Community Reinforcement Approach and Family Training
DSM-5: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
IAT: Internet Addiction Test
IGD: internet gaming disorder
PCIAT: Parent-Child Internet Addiction Test
PSDQ: Parenting Style and Dimensions Questionnaire
RQ: Relationship Questionnaire
SDQ: Strengths and Difficulties Questionnaire
TDS: total difficulties score

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Original Paper

Evaluation of Breastfeeding App Features: Content Analysis Study

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Abstract

Background: While a variety of health apps abound, less than half of adults in the United States report using a health app, despite the ubiquity of smartphones among users aged 18 to 49 years. Several studies have examined the use of breastfeeding apps; however, less is known about the types of features found on these apps and what factors might influence app ratings.

Objective: This paper seeks to characterize breastfeeding apps, assess whether apps with higher user ratings differ from apps with lower user ratings in their tracking and nontracking features, and analyze whether the type and number of features predict user star ratings and whether an app is higher- or lower-rated.

Methods: Using a cross-sectional design, a convenience sample of breastfeeding apps was culled from the Apple App Store (iOS) and Google Play Store (Android). Content analysis of the apps (N=82) was conducted using a schema of 87 items, which was then compiled into 9 topical indices for breastfeeding, bottle feeding, solid foods, infant health, infant care, technical characteristics, informatics, informational characteristics, and interactivity. Analysis consisted of descriptive statistics, the Mann-Whitney *U* test, and Spearman rank correlations. Linear regression and binary logistic regression analyses were conducted to determine which features predicted user star ratings.

Results: On average, users rated breastfeeding apps 4.4 of 5 stars. Two-thirds of apps (n=54) were higher rated (≥4.5 stars), and one-third (n=28) were lower rated (<4.5 stars). Higher-rated apps offered more tracking features for breastfeeding, bottle feeding, solid foods, infant health, and infant care than lower-rated apps. The breastfeeding, solid-food, and technical indices explained 17% of user star ratings. For each additional breastfeeding and solid-food feature, we can expect to see a 27% and 35% increase, respectively, in user star ratings. Additionally, as the number of solid-food features increased, the odds that the app is higher rated increased 1.58 times.

Conclusions: Our findings suggest user ratings are driven in part by tracking features, specifically those related to breastfeeding and solid foods. The proliferation of mobile health apps offers opportunities for parents and caregivers to track behaviors associated with infant feeding and other health metrics in a dynamic, detailed, and comprehensive manner. Hence, breastfeeding apps have the potential to promote and support breastfeeding among users.

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KEYWORDS

breastfeeding; breastmilk expression; bottle feeding; infant food; infant health; infant care; consumer health informatics; mobile apps; smartphone; cross-sectional study

Introduction

Human milk is the gold standard for infant nutrition, and it is associated with improved maternal and infant health outcomes [1]. Many national and international health authorities recommend that infants be fed only human milk during the first 6 months of life, with continued breastfeeding alongside appropriate complementary foods for 1 year or longer [2-4]. Yet in the United States, only 1 in 4 infants born in 2018 were exclusively breastfed through 6 months, and about 1 in 3 were still breastfed at 12 months [5]. The reasons for early supplementation and breastfeeding cessation include inadequate knowledge; perceived inconvenience or embarrassment; medical conditions or lactation issues; lack of professional, family, and social support; early return to work; marketing of human milk substitutes; and societal norms and policies [6-8].

Mobile health (mHealth) technologies can address some barriers to breastfeeding by offering tracking features, data on user behavior, and information. The use of e-technologies has been associated with higher rates of breastfeeding initiation, exclusive breastfeeding at 4 weeks and 6 months, breastfeeding attitudes, and breastfeeding knowledge [9]. mHealth—the "medical and public health practice supported by mobile devices including mobile phones, patient monitoring devices, personal digital assistants...and other wireless devices" [10]—is on the rise due to the growth in smartphone ownership. In 2021, 85% of Americans owned a smartphone, up from just 35% in 2011. Rates are even higher among adults aged 18 to 29 years (96%) and 30 to 49 years (95%) [11].

Given the ubiquity of smartphone ownership, mHealth apps have become increasingly popular. By 2019, more than 45,000 [12] and 43,000 [13] mHealth apps were available in the Apple App Store and Google Play Store, respectively. An mHealth study by Krebs and Duncan [14] suggested individuals with more education, higher income, younger age, and Latino ethnicity were more likely to have downloaded a health app to track physical activity or dietary intake, help with weight loss, or learn exercises. Recent consumer data, however, show less than half of US adults have used or purchased health apps, and among individuals who report using a health app, more than half are upper or middle income [15].

The average childbearing age in the US is 26 years [16], which corresponds to a high rate of smartphone ownership. With limited formal structures for parental leave in the US, half of infants born in 2018 were breastfed for between 6 and 7 months. However, half of infants born in 2018 were exclusively breastfed for only 2 to 3 months [17]. Approximately one-third of infants receive human milk substitutes before 3 months of age [5]. Breastfeeding tends to be more heavily concentrated among certain racial and ethnic groups (ie, non-Hispanic Asian, non-Hispanic white, and Hispanic) and among college educated, higher income, and married women. Within the US, infants living in rural areas are less likely to have ever been breastfed than those living in urban areas, and infants living in the Southeast are less likely to be breastfed at 6 months than those living in other areas of the country [5].

In this nascent area of research, several studies have focused on one or more characteristics of infant-feeding smartphone apps. Mieso et al [18] performed a scoping review that addressed app development, user experience, and app effectiveness on breastfeeding outcomes. Studies of app development have reported the feasibility and need for smartphone apps to provide education, peer and professional support, and tracking features. User experience appears more positive than negative; apps were mostly helpful and reassuring, though some study participants noted apps were time-consuming, anxiety-provoking, burdensome, technically difficult, or provided questionable information. Only 3 studies examined app effectiveness, suggesting that apps are useful for capturing data and may help support exclusive breastfeeding and continuation of breastfeeding for 6 months [18].

Other studies have characterized the quality and content of infant-feeding smartphone apps available from the Apple App Store and Google Play Store. Cheng et al [19] evaluated 47 infant-feeding and activity apps in Australia, concluding the overall quality of information was poor, though apps were generally of moderate quality with regard to engagement, functionality, and aesthetics. Schindler-Ruwisch et al [20] similarly identified 50 breastfeeding apps in the US. The main interactive app features varied, and most apps only provided informational support (versus emotional, instrumental, or appraisal support). A plurality of apps included troubleshooting information related to breastfeeding and related issues, followed by information about breastfeeding in public [20]. Likewise, Sidhu et al [21] scored 41 US iPhone apps based on their features and content. Most apps (85%) offered features that assisted with promoting, tracking, or interpreting milk production. Among these, apps ranked in the top 200 in their respective categories within the Apple App Store received a significantly higher feature score compared to unranked apps. Finally, about one-third of apps in the sample contained educational content related to milk production; however, their content and diversity scores were low [21].

While previous scholarship has examined breastfeeding apps, little is known about the availability and comprehensiveness of features offered and their influence on user ratings. Because user ratings tend to drive downloads, these ratings potentially influence app adoption [22]. The aims of this study are to (1) provide descriptive statistics characterizing commercial breastfeeding apps in terms of their ratings, development, and other app details; (2) assess whether apps with higher and lower user star ratings differ in their tracking and nontracking features; and (3) determine whether the type and number of features predict user star ratings and whether an app is higher or lower rated.

Methods

Research Design

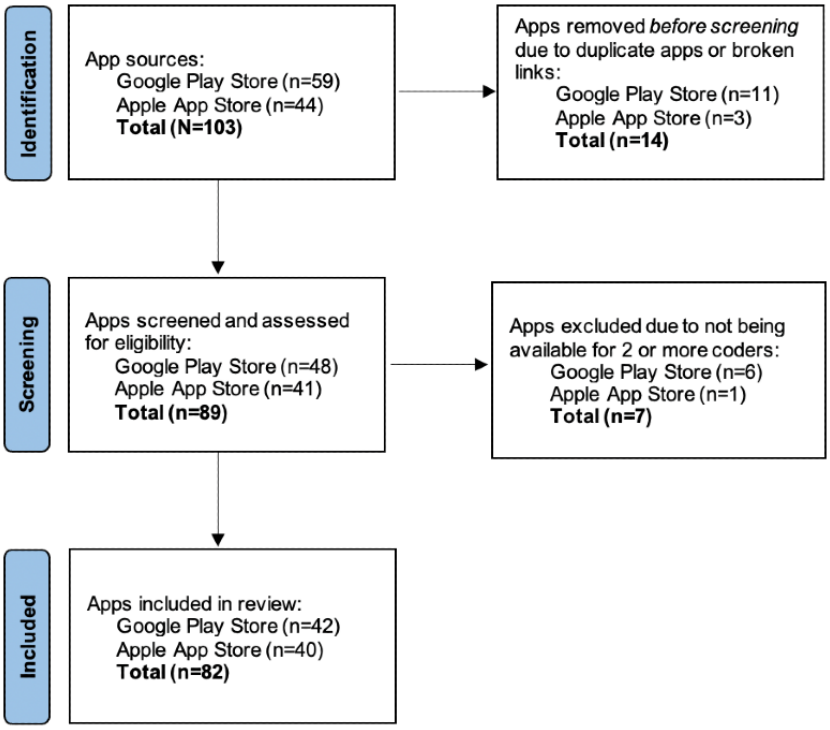
To best address the study aims, we chose a cross-sectional research design using content analysis. Given that apps are updated with new features over time, a longitudinal design was not appropriate. Our methods were informed by previous studies of infant-feeding apps [20,23] and other health apps [24-26].

This study was exempt from Institutional Review Board approval.

Sample

To compile a convenience sample of breastfeeding apps, a graduate student in the US conducted a keyword search in the Apple App Store (iOS) and Google Play Store (Android) in fall 2018. A combination of keywords was used to search for English-language breastfeeding apps, including "breastfeeding" and "breastfeeding applications." In January 2019, another graduate student created a sample in the same manner and cross-referenced it with the fall 2018 sample, increasing the sample size while also removing duplicates and dead links; the sample was finalized in February 2019. All relevant apps were included regardless of their cost. All apps were free except for 9; these 9 paid apps were downloaded for a combined cost of US $31.92 ($18.95 for 5 iPhone apps and $12.97 for 4 Android apps). A total of 40 iPhone and 42 Android apps were included in the final sample (N=82) of which 80 were free to users; only 2 paid iPhone apps remained in the final sample (Figure 1). The final sample is comparable to those of previous infant-feeding app studies, which included 41 to 77 apps [18,20,21].

Figure 1. Smartphone breastfeeding app selection process.



Measurement

To analyze the apps, a coding schema was created a priori based on existing studies of apps [20,24,27] and 2 breastfeeding textbooks [28,29]. The schema contained 87 distinct app characteristics and features. We defined features according to Sidhu et al [21] as any "opportunity for user interaction with the app (e.g., a button)."

Descriptive characteristics were derived from the app's download page and included the name of the app, website link, download date, version number, date of last update, developer or seller name and affiliation (ie, commercial, government, nongovernment organization, university, unknown, or other), whether and which experts or end users were involved in the app development process, user rating (ie, number of stars out of 5), number of user reviews, app category (ie, medical, lifestyle, health and fitness, parenting, or other), language options, cost of basic and premium app versions, and age rating (not unlike a movie rating, each platform recommends the minimum maturity level of app content for end users by age, ie, >0, >4, >12, or >17).

Features were observed by navigating the downloaded app. Tracking features monitored breastfeeding, bottle feeding, solid foods, pumping and human milk expression, diapering, bathing, sleeping, infant growth and development, medication and vitamin use, vaccinations, temperature, illnesses, and well-child visits. Nontracking features included the ability to add notes, information, pictures, or videos; connect to a breast pump; print or export data; sync data with another program or device; use the app for more than one child or for multiple caregivers to use the app; customize features; receive static information (ie, articles, guidance, tips, checklists, product recommendations, frequently asked questions, pregnancy information, maps, graphs, or charts); share data with others (ie, other caregivers, health care providers, or social media); and interact with peers, lactation professionals, or others (Table 1).

Table 1. App features grouped by tracking and nontracking indices. Each variable was coded 0 (no), 1 (yes), or 2 (do not know). These summative indices only indicate the presence of a feature.

Indices	Features
Tracking indices (range)	
Breastfeeding index (0-8)	• Tracks start and stop times of a breastfeeding session • Tracks time nursing per breast (left vs right) • Tracks total time of a full breastfeeding session • Tracks which breast (left vs right) was last nursed from • Tracks number of pumping or milk-expression sessions • Tracks amount of time per pumping or milk-expression session • Tracks volume of milk per pumping or milk-expression session • Tracks which breast (left vs right) was last pumped
Bottle-feeding index (0-3)	• Tracks number of bottle feeds • Tracks time of bottle feeds • Tracks volume of bottle feeds
Solid-food index (0-4)	• Tracks number of solid-food meals • Tracks time of solid-food meals • Tracks types of solid foods given • Tracks amount of solid foods given
Infant-health index (0-10)	• Tracks infant's weight over time • Tracks infant's length over time • Tracks infant's head circumference over time • Compares infant's growth to standards and averages • Tracks milestones in physical development (eg, first tooth and first step) • Tracks medication and vitamin use • Tracks vaccines • Tracks infant's temperature • Tracks infant's illnesses • Tracks infant's well-child visits
Infant-care index (0-7)	• Tracks number of diaper changes • Tracks time of diaper changes • Tracks type of dirty diaper (urine vs feces) • Tracks color of feces • Tracks number of baths • Tracks bath schedule • Tracks nap and sleep schedule
Nontracking indices (range)	
Technical index (0-15)	• Ability to add notes to tracked data • Ability to connect to breast pump • Ability to add pictures or videos • Ability to set notifications, alarms, or reminders • Ability to print directly from app • Ability to export data as email, text, pdf, spreadsheet, or eBook • Ability to sync with cloud-based programs (eg, iCloud or Dropbox) • Ability to copy data or sync to another device • Ability to personalize app with infant's picture, name, or date of birth • Ability to use the app for more than one child at a time • Ability for multiple caregivers to use the app and enter data • Different themes for day and night • Customizable features (eg, sound and content notifications) • Audio content • Video content
Informatics index (0-3)	• Provides maps or locations for where to feed or change an infant • Provides graphs and charts • Reports that support graphs and charts

Indices	Features
Informational index (0-5)	• Provides articles, guidance, or tips • Provides checklists • Provides recommendations for products • Provides frequently asked questions • Provides pregnancy information
Interactivity index (0-5)	• Ability to share data with other caregivers or health care providers • Ability to share with social media (eg, Facebook or Twitter) • Peer support • Ability to contact a lactation consultant or counselor • Question and answer interface

Data Collection

All apps were downloaded to a donated iPhone (iPhone 5S, iOS version 12.1.4; Apple Inc) or Android smartphone (Samsung Galaxy Note 2, Android version 4.4.2, or Samsung Galaxy S8, Android version 7.0; Samsung Electronics Co Ltd). Coders primarily used the shared iPhone and Android phones, aside from 1 student who used a personal iPhone to expedite coding. Coding of the apps began in March 2019 and was completed in December 2019. Two graduate students and 1 undergraduate honors student (with no prior involvement in the study) from different academic departments (including food and nutrition, law and governance, and political science and law) coded the apps.

Interrater reliability (IRR) was measured among the 3 coders with 3 possible outcomes. Agreement between all 3 coders was labeled as “complete agreement.” Agreement between 2 of 3 was considered “partial agreement.” When all 3 coders disagreed, we deemed this “no agreement.” In 7 apps, only 2 coders completed the coding; thus, the IRR was determined as “complete agreement” or “no agreement.” This might have occurred because one of the students used their personal phone or used a phone that was incompatible with a particular app version. The authors reviewed coder agreement on variables with partial or no agreement to determine the final coding decision. For continuous variables (eg, the number of languages, user ratings out of 5 stars, and number of user ratings) we used the most recent version of the app.

Data Analysis

To address aim 1—characteristics of breastfeeding apps—descriptive statistics were used to characterize the sample and are reported as frequencies and percentages. Apps rated ≥4.5 stars were defined as higher-rated apps, while those rated <4.5 stars were considered lower-rated apps. Prior studies have used a cutoff of ≥4 stars [18,20]; however, the present sample had a skewed rating distribution, whereby only 16% (13 of 82) of apps were rated under 4 stars. Therefore, the 4.5-star cutoff was chosen to maximize variability in both groups. Nine summative indices were created by grouping like features by topic (Table 1). For aim 2—comparison of higher- and lower-rated apps—we used the Shapiro-Wilk test to assess the normality of the data and found that the indices were not normally distributed. We conducted Mann-Whitney *U* tests, which are appropriate for nonnormally distributed independent groups, to assess whether higher- and lower-rated apps differed by index.

To address aim 3—predictive relationships between user ratings and indices—we determined the Spearman rank correlation between the indices, user star ratings, and whether the app was higher rated or lower rated. All indices that were significantly correlated with the user star ratings were included in the linear regression model, except for bottle feeding, which was highly correlated (r=0.693) with the breastfeeding index. The same indices were entered into a binary logistic regression model to examine their ability to predict whether an app was higher or lower rated. Logistic regression results are reported as odds ratios (ORs) with 95% CIs. For all statistical tests, significance was defined at P<.05.

Results

Aim 1: Characteristics of Breastfeeding Apps

The sample was composed of 82 breastfeeding apps, including 40 iPhone and 42 Android apps (Table 2). On average, users rated breastfeeding apps 4.4 of 5 stars. Of the 82 apps reviewed, two-thirds (54) were higher rated and one-third (28) were lower rated. The number of user ratings per app ranged from 4 to 81,800.

Table 2. Descriptive characteristics of breastfeeding apps, overall and for apps with higher user star ratings and lower user star ratings.

Characteristics	Total (N=82), n (%)	Higher user star ratings[a] (N=54), n (%)	Lower user star ratings[b] (N=28), n (%)
Platform			
iPhone	40 (49)	31 (57)	9 (32)
Android	42 (51)	23 (43)	19 (68)
Affiliations			
Commercial	61 (74)	37 (69)	24 (86)
Nongovernmental organization	1 (1)	1 (2)	0 (0)
Unknown	16 (20)	13 (24)	3 (11)
Experts or end users involved in the development process			
Yes	21 (26)	16 (30)	5 (18)
No	37 (45)	20 (37)	17 (61)
Do not know	24 (29)	18 (33)	6 (21)
Experts or end users involved			
Mothers	8 (10)	6 (11)	2 (7)
Parents	6 (7)	5 (9)	1 (4)
Neonatal intensive care unit staff	2 (2)	2 (4)	0 (0)
Fathers	1 (1)	1 (2)	0 (0)
Breast pump manufacturers	2 (2)	1 (2)	1 (4)
Other	2 (2)	1 (2)	1 (4)
Category			
Medical	36 (44)	27 (50)	9 (32)
Lifestyle	3 (4)	1 (2)	2 (7)
Health/fitness	15 (18)	4 (7)	11 (39)
Parenting	26 (32)	21 (39)	5 (18)
Productivity	1 (1)	1 (2)	0 (0)
Tools	1 (1)	0 (0)	1 (4)
Available languages			
English	82 (100)	54 (100)	28 (100)
Spanish	18 (22)	17 (32)	1 (4)
Chinese	13 (16)	13 (24)	0 (0)
Cost of basic version			
US $0	80 (98)	53 (98)	27 (96)
US $3.99	1 (1)	1 (2)	0 (0)
US $4.99	1 (1)	0 (0)	1 (4)
Age rating[c] (minimum maturity level of end users)			
>0 years	41 (50)	23 (43)	18 (64)
>4 years	31 (38)	24 (44)	7 (25)
>12 years	8 (10)	6 (11)	2 (7)
>17 years	2 (2)	1 (2)	1 (4)

[a]Apps with higher user star ratings are those with ≥4.5 stars.

[b]Apps with lower user star ratings are those with <4.5 stars.

[c]Age ratings differed by platform.

Aim 2: Comparison of Higher- and Lower-Rated Apps

Mann-Whitney *U* tests were performed (Table 3) to determine differences between higher- and lower-rated apps. All indices were significant, and the mean ranks for all indices except the informatics, informational, and interactivity indices were greater among higher-rated apps than lower-rated apps. The breastfeeding and solid-food indices yielded the most notable differences in median scores between higher- and lower-rated apps.

Table 3. Mann-Whitney *U* test comparing apps with higher and lower user star ratings by index (N=82).

Indices	Higher user star ratings[a] (n=54), median (range)	Lower user star ratings[b] (n=28), median (range)	*U* statistic	*z* score	*P* value
Tracking indices					
Breastfeeding index	7.0 (0-8)	4.0 (0-8)	483.500	–2.724	.006
Bottle-feeding index	3.0 (0-3)	3.0 (0-3)	592.000	–1.768	.001
Solid-food index	3.0 (0-4)	0.0 (0-3)	402.000	–3.699	.004
Infant-health index	3.5 (0-10)	4.0 (0-7)	579.500	–1.765	.004
Infant-care index	4.0 (0-7)	4.0 (0-7)	586.500	–1.712	.004
Nontracking indices					
Technical index	6.0 (0-12)	4.0 (1-10)	510.000	–2.418	.004
Informatics index	1.0 (0-1)	1.0 (0-2)	727.000	–0.326	.004
Informational index	0.0 (0-4)	0.5 (0-4)	611.000	–1.626	.004
Interactivity index	0.0 (0-4)	0.0 (0-2)	722.000	–0.494	.004

[a]Apps with higher user star ratings are those with ≥4.5 stars.

[b]Apps with lower user star ratings are those with <4.5 stars.

Aim 3: Predictive Relationships Between User Ratings and Indices

Table 4 illustrates the Spearman rank correlations between user star ratings, whether an app was higher versus lower rated, and the indices. The correlation between user star ratings and the solid-food index was positive and strong, while the correlations for breastfeeding, bottle-feeding, and technical indices were positive and moderate. The correlation between an app being higher rated and the solid-food index was positive and strong, while the correlations with the breastfeeding index were positive and moderate. Finally, the correlations between an app being higher rated and the bottle-feeding and technical indices were positive and weak.

A linear regression analysis was performed to determine whether breastfeeding, solid-food, and technical features predicted user star ratings (Table 5). The independent variables explained 17% of user star ratings (adjusted R^2=0.172). The breastfeeding and solid-food indices were significant. For each additional breastfeeding feature, we can expect to see a 27% (β=.265, *P*=.047) increase in the user star rating, while each additional solid-food feature increases the user star rating by 35% (β=.354, *P*=.009).

A binary logistic regression analysis was performed to determine whether tracking features or nontracking features predicted higher user star ratings (Table 6). In the unadjusted bivariate analysis, there was a significant association between the breastfeeding, bottle-feeding, solid-food, and technical indices and the dependent variable. In addition, the odds of an app receiving a higher rating increased by 28% (OR 1.284, 95% CI 1.064-1.550) for each additional breastfeeding feature. Similarly, the unadjusted odds of an app receiving a higher rating increased by 68% for each additional bottle feeding (OR 1.683, 95% CI 1.112-2.548) and solid-food (OR 1.685, 95% CI 1.236-2.297) feature. The technical index also increased the odds that an app was higher rated. In the adjusted model, only the solid-food index remained significant. The odds of an app receiving a higher user star rating increased by 58% (OR 1.579, 95% CI 1.074-2.321) for each additional solid-food feature.

Table 4. Spearman rank correlations between user star ratings, higher versus lower user star ratings, and indices for the apps (N=82).

Indices	User star ratings (1-5), ρ	*P* value	Higher versus lower user star ratings[a], ρ	*P* value
Tracking indices				
Breastfeeding index	0.391	<.001	0.303	.006
Bottle-feeding index	0.334	.002	0.242	.03
Solid-food index	0.422	<.001	0.411	<.001
Infant-health index	0.255	.02	0.196	.08
Infant-care index	0.252	.02	0.190	.09
Nontracking indices				
Technical index	0.343	.002	0.269	.02
Informatics index	0.104	.35	–0.036	.75
Informational index	–0.186	.09	–0.181	.10
Interactivity index	–0.077	.49	–0.055	.62

[a]Apps with higher user star ratings are those with ≥4.5 stars; apps with lower user star ratings are those with <4.5 stars.

Table 5. Indices influencing user star ratings for the apps (N=82). Note: R=.451, R^2=.203, adjusted R^2=.172, and F_3=6.625 (P<.001).

Variables	B	SE	β	*t* test[b] (*df*)	*P* value	95% CI
Constant	4.025	0.136	N/A[a]	29.603 (78)	.001	3.754 to 4.295
Breastfeeding index	0.056	0.028	.265	2.023 (78)	.047	0.001 to 0.112
Solid-food index	0.109	0.041	.354	2.662 (78)	.009	0.027 to 0.190
Technical index	–0.025	0.027	–.136	–0.934 (78)	.35	–0.078 to 0.028

[a]N/A: not applicable.

[b]The *t* test was 2-tailed.

Table 6. Odds of indices predicting higher user star ratings for the apps (N=82). Note: Cox and Snell R^2=.159, Nagelkerke R^2=.219, and χ^2_3=14.168 (P=.003). The dependent variable was higher user star ratings (≥4.5 stars) set at 1, lower user star ratings (<4.5 stars) set at 0, and 1 set as the reference category.

Indices	Higher user star ratings			
	Unadjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value
Breastfeeding index	1.284 (1.064-1.550)	.009	1.142 (0.890-1.466)	.30
Bottle-feeding index	1.683 (1.112-2.548)	.01	N/A[a]	
Solid-food index	1.685 (1.236-2.297)	<.001	1.579 (1.074-2.321)	.02
Infant-health index	1.163 (0.997-1.357)	.06	N/A	
Infant-care index	1.218 (0.980-1.514)	.08	N/A	
Technical index	1.234 (1.041-1.463)	.02	0.977 (0.762-1.253)	.85
Informatics index	0.788 (0.337-1.846)	.58	N/A	
Informational index	0.724 (0.482-1.088)	.12	N/A	
Interactivity index	0.984 (0.516-1.877)	.96	N/A	
Constant	N/A		0.549	.30

[a]N/A: not applicable.

Discussion

Principal Findings

Our study builds on previous research of breastfeeding apps while expanding our understanding of what these apps offer by evaluating their features. Our sample is slightly larger than that of Mieso et al [18] and includes a greater percentage of free apps than earlier studies [18,20,21]. Similar to Schindler-Ruwisch et al [20], the sample draws upon a range of app categories, including medical, health and fitness, and parenting. Our cross-sectional review of apps occurred within a specified timeframe, akin to earlier studies [20,21].

Many characteristics of our sample reflect earlier studies of breastfeeding apps. For example, breastfeeding apps tend to be highly rated. Both Mieso et al [18] and Schindler-Ruwisch et al [20] found that nearly 70% of apps received user ratings >4 stars, and Mieso et al [18] showed that the average rating for breastfeeding apps was 4.3 of 5 stars. This is consistent with our findings. Similar to Mieso et al [18], the number of user reviews in our sample displayed a wide range.

Unsurprisingly, higher-rated apps offered more tracking features on all indices. In their qualitative analysis of maternal and infant health app user reviews, Biviji et al [30] found that across positive reviews, many users mentioned tracking features, including feeding, pumping, diapering, and sleep—akin to one-stop shopping. Conversely, there were complaints about apps with limited data-tracking abilities [30]. According to Mendiola et al [31], factors that predicted user ratings of health apps include usability, data export, and tracking. While the tracking component was negatively associated with user ratings, it was positively correlated with export and usability, both of which were positively associated with user ratings [31]. An alternative explanation as to why more features might appear in higher-rated apps is the release of new app versions that include new or updated features. Future studies should consider how tracking features correspond to other usability features and critically analyze the tracking features to determine their appropriateness to support infant-feeding goals. While informatics, informational, and interactivity features were not correlated with user star ratings, lower-rated apps had higher scores for these indices. Though few apps appeared to have these features, future studies might consider investigating their utility, since the study by Biviji et al [30] suggests that users desire these features.

In the regression models, the breastfeeding index predicted user star ratings; however, it did not predict whether an app was higher or lower rated. The former finding is to be expected, since breastfeeding tracking is the primary purpose of the apps. This is supported by Sidhu et al [21], who found that apps often had features that assisted with human milk tracking. However, we are unable to explain the latter finding, though it may be related to how we defined higher-rated apps.

Across both regression models, the solid-food index was significant. Solid food–tracking features allow users to continue with a familiar app that contains other tracking data (such as human milk or human milk–substitute consumption, diaper changing, or vaccinations) by carefully monitoring the introduction of new foods, which typically occurs on a weekly basis. This prolongs the usefulness of an app beyond a limited timeframe, again tapping into one-stop shopping [30]. Biviji et al [30] reported that positive app reviews emphasized tracking, highlighting feeding in particular. The authors demonstrated how users provided additional feedback on exporting data, additional tracking options, and data visualization, which might be incorporated into updated app versions [30]. Alternatively, the solid-food index might be a proxy for a feature not included in our study. Since our model only explains a small portion of the variance, we recommend an overall assessment of an app's interface. For example, how seamless are the features? What are the advantages offered by one app over another? We also recommend a qualitative study of breastfeeding app users to gain greater insight into the reasons behind app adoption and features utilized.

Limitations

While this study provides an overview of breastfeeding apps, there are several limitations. First, this was a convenience sample gathered between November 2018 and December 2019. We conducted a manual search with keywords, which may have resulted in missing some apps. Second, since new apps are frequently introduced to the market, this research only provides a snapshot in time; however, with a total of 82 apps, it still offers a comprehensive overview. Third, this research is limited to English-language apps in the US. Future studies should consider apps in other languages and in countries with higher rates of breastfeeding. Fourth, this study does not examine the apps' clinical or scientific merits, but instead assesses features. Breastfeeding apps might contain content that is contrary to medical advice, and apps might not conform to national guidelines on infant feeding [19,23]; nevertheless, this was beyond the scope of this study.

Conclusions

This study of breastfeeding apps demonstrates that user ratings are partially driven by tracking features, specifically those related to breastfeeding and solid foods. Nontracking features appear to be less important with regard to how users rate apps, though why this is the case remains unclear. Researchers should consider investigating this in the future. More importantly, the proliferation of mHealth offers opportunities for parents and caregivers to track behaviors associated with infant feeding and other health metrics in a dynamic, detailed, and comprehensive manner. In this way, breastfeeding apps have the potential to promote and support breastfeeding among users.

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Conflicts of Interest

None declared.

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Abbreviations

IRR: interrater reliability
mHealth: mobile health
OR: odds ratio

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Original Paper

Data Completeness and Concordance in the FeverApp Registry: Comparative Study

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Abstract

Background: The FeverApp registry uses ecological momentary assessment (EMA) to collect parental data on pediatric fever for scientific research. The mobile app FeverApp educates parents on safe fever management and serves as a fever diary.

Objective: The focus of this study was to evaluate the completeness and concordance of the EMA-based FeverApp registry with regard to its data quality from a multilevel perspective.

Methods: Structured descriptions of fever episodes by health care professionals from an office were used as reference. The number of children, their sociodemographic data, and agreement of fever episodes, with maximum temperature, intake of antipyretics and antibiotics, and physician visits, were compared with the entries in the corresponding physician's reference records. The data quality indicators for completeness, meaning the extent to which the necessary data for the registry has actually been submitted, and concordance, which is the correspondence of the value of a data element with a reference source, were chosen to analyze whether EMA may be a suitable method for this kind of registry.

Results: In both data sources, 1012 children were available for comparison over 16 months. The completeness of gender (1012/1012, 100%) and date of birth (1004/1012, 99.2%) information was high, and the mismatches were 0.69% (7/1012) and 1.19% (12/1012), respectively, between the sources. Of these 1012 children, 668 (66%) registered fever episodes in FeverApp. They relate to 534 families with 953 fever episodes in the reference records and 1452 episodes in the FeverApp registry. Of the 534 families, 183 (34.3%) refrained from visiting the office during fever episodes but nevertheless documented them in FeverApp. Largest part (766/1452, 52.75%) episodes were recorded exclusively in the FeverApp registry by 371 (371/534, 69.5%) families. The remaining 686 (47.2%) episodes of 391 (58.5%) children from 351 (65.7%) families were comparable with the reference data source in terms of physician visits, medication, and temperature. The completeness ranged, depending on the kind of variable, from 11.5% to 65% in the registry and from 7.6% to 42.6% in the office. The 953 fever episodes reported by the reference office consisted of 681 (71.5%) acute and 272 (28.5%) past episodes. In FeverApp, most past (262/272, 96.3%) but less acute (424/681, 62.3%) episodes have been entered. The concordance rates were varied: 90.2% for antibiotic use, 66.6% for antipyretic use, 61.7% for physician visits, and 16% for the highest temperature during the fever episode.

Conclusions: Both sources delivered only partial data, and the rates of completeness and concordance depended on the kind of variable. However, the FeverApp registry showed higher documentation and precision rates than professional records for all considered variables. Therefore, EMA may play a unique supplement for research in ambulatory care. FeverApp could support pediatric offices, especially during the pandemic.

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KEYWORDS

registry; data quality; completeness; concordance; ecological momentary assessment

Introduction

Background

Modern technologies enable registry studies via mobile phone apps through ecological momentary assessment (EMA) [1,2]. On the one hand, this is beneficial because of straightforward data collection: the study participants enter the data themselves, saving time and costs for study personnel. In sudden symptoms, for example, fever, ecological observation during long periods is more applicable in contrast to paper-based protocols [3] in other study situations. On the other hand, the quality of the entered data is not controlled separately. Transfer errors in paper-based documentation are reduced, and immediate plausibility checks are possible. It has yet to be proven to what extent they are comparable with the data from medical personnel, a common standard in registries. Especially, if the real-time data of nonprofessionals are used as registry data, their comparability and difference should be monitored specifically, at least in samples.

On-site monitoring and source data verification are important methods to improve data quality not only in clinical studies, but also in other medical research contexts. In an app-based, real-time registry, there are usually no further sources. Medical registries often rely on medical professionals. This is useful for diseases, but symptoms such as fever are often acknowledged or recorded by nonprofessionals. A further challenge is that health care routine data are often not appropriately structured. Comparable structured data from health care professionals are needed to verify the quality of app-based registry data generated by parents. An example of such a registry that relies on parental real-time EMA is the FeverApp registry.

FeverApp Registry

The Federal Ministry of Education and Research in Germany has funded 6 model registries in 2019 [4]. They should provide exemplary features of registries, such as the consideration of observing (parent using an app) and observed (children) units at suddenly occurring events (fever episodes) [5]. The registry protocol was published [1] and registered in the German Clinical Trials Register with the registration number DRKS00016591.

In general, FeverApp could be used completely anonymously if no identifying entries are made. There are currently no mandatory fields that force identification. The app is freely accessible, but users need an access code from a pediatric office that generates a random family code. This random pseudonym could nevertheless identify if it is made public. Hence, the family code gives the opportunity to share access to further family members. This procedure ensures the acknowledgment of the treating physician, even if no reference records with direct recording of the family code were made by the participating offices.

The FeverApp registry collects data via parental EMA of the child's febrile episodes since September 2019. Recruitment was started in a large pediatric reference office. Since July 2020, FeverApp has spread on a larger scale to multiple pediatric offices. Until now, pediatric offices have solely granted access to parents.

FeverApp is a mobile app in which parents and caregivers can record, track, and manage children's fever episodes and symptoms. By providing scientific information based on current guidelines [6], FeverApp helps parents to understand fever better and manage it safely and comfortably. The goal of FeverApp is to establish a model registry through the self-documentation of fever management by families, thereby drawing conclusions about the implementation of the guidelines. It aims to inform parents that fever is not a disease but rather a symptom of the immune defense system fighting the underlying causes [7-9]. To strengthen the immune system, the intake of antipyretics and antibiotics should be restrained. It also educates parents that the use of health care resources depends on the child's age, emphasizing that these are not mandatory unless specific warning signs are observed. In this case, a physician's visit should be considered. Therefore, in case of solely high temperature, an immediate visit to a physician or medication is not recommended.

The submitted entries and interactions between different pages of the app are stored locally in the app within an open-source JavaScript database, PouchDB 7.3.0, which synchronizes it with Apache CouchDB 2.3.1 when connected to the internet. The latter database is centrally located on the University of Witten/Herdecke servers, and the documents of CouchDB are transformed and transferred daily to MongoDB. Several relational data tables are exported in CSV format, extracted on demand through SQL scripts, and processed in SPSS (version 27; IBM Corp). These data represent the FeverApp registry [5].

There are specific access codes for test purposes to ensure that, routinely, only real observation data are collected. To consider a high standard of data correctness and security, all decentral data deleted from the app are also deleted from the central registry. If a parent deletes any data on their mobile phone, this deletion is synchronized with the central CoachDB, and the data are no longer available for export. Therefore, wrong entries can be reduced.

The aforementioned 6 registries agreed to compare their data quality but could not agree on a common understanding of completeness because of the different scope of each registry. Furthermore, the funding reviewer questioned whether reliable data could be collected via a parental app.

Aim of the Study

Therefore, this study aimed to evaluate 2 important indicators for trueness: completeness and concordance. It especially takes

into account the multilevel or clustered structure of the collected EMA-based data.

Methods

Conception of Data Quality

There are different approaches to conceptualize data quality. Weiskopf and Weng [10] categorized 5 dimensions of data quality in their review of the clinical research literature discussing data quality assessment methodology for electronic health record (EHR) data. These are completeness, correctness, concordance, plausibility, and currency. The approaches used for data quality assessment are summarized as follows: comparison with gold standards, data element agreement, data source agreement, distribution comparison, validity checks, log review, and element presence. The authors conclude that there is little consistency or potential generalizability in the methods used to assess data quality in EHRs, and they demand for systematic methods of EHR data quality assessment.

Kahn et al [11] proposed a conceptual model for data quality assessment in EHR data that can improve data utility over time. The framework was created especially for clinical research. This concept is followed by the approaches of Weiskopf et al [12] and Lee et al [13]. All authors underline that quality assessment should be customized for every single study. This statement raises the question of how the data quality of EMA-based registry studies should be realized.

This gap is closed by the concept of adaptive management of data quality: *The Technology and Methodology Platform for Networked Methodological Medical Research* (TMF) published an approach for the independent assessment of data quality and its improvement in 2006. The manual *Guidelines for the Adaptive Management of Data Quality for Cohort Studies and Registers* (GAMOQ) [14] enables the evaluation of the quality of data concerning different aspects. The novel approach of these guidelines is the distinction of the data quality conception into 3 dimensions. It allows assessing data quality in a structured manner and has become a standard approach in Germany [15-18]. It is crucial to ensure that the collected data in an app-based registry are of high quality in terms of their structures, processes, and outcomes (to aspects of health data quality).

According to the recommendations of the GAMOQ, data quality assessment can be divided into 3 dimensions: data integrity, data organization, and data trueness. These correspond to the approaches developed by Donabedian [19] for the assessment of the quality of medical data: structure (ie, integrity of data), process (ie, organization of data), and outcome quality (ie, trueness of data). Each of these data quality aspects can be described with specific data quality indicators (DQIs). The GAMOQ includes a total of 51 DQIs. The choice of suitable DQIs for the quality assessment of data integrity, organization, and correctness depends on the specific study situation. Thus, the GAMOQ offers a flexible tool for the systematic evaluation of the quality of registry data. Defined threshold values for DQIs are a prerequisite for calculating the overall score for data quality from the individual indicator values.

An important quality indicator for external validity or representativeness is the completeness (confer in the GAMOQ as TMF-1042) of the collected data elements. This quality indicator describes the trueness of data. Concordance (confer in the GAMOQ as TMF-1002) is one of the DQIs that is used for the description of the integrity of data [14].

Completeness

The DQI *completeness* is defined as the extent to which the necessary data that could be included in the registry have been submitted. Other registries or patient records in medical offices are possible data sources for determining the necessary data, which could be included in the registry. Nonnemacher et al [14] underlined that an examination of the data quality in registries is mostly done by comparison with other data sources.

In this innovative parent-based and app-based registry, technical and informative mandatory fields have to be distinguished. FeverApp keeps nearly all fields as technical voluntary fields, although they are informative mandatory. Therefore, if a technical voluntary field would not be understood as being incomplete, then no field could become informative incomplete. As FeverApp is a model registry, we apply DQIs as informative mandatory fields, although they are technical voluntary. This is a special feature of this model registry. Completeness is analyzed as informative mandatory.

Concordance

Concordance is defined as the correspondence of the value of a data element with a reference source. Concordance is usually used as a DQI for data structure [14], but it can also be regarded as a DQI for the completeness of data [20]. As an alternative for *completeness*, it would be possible to use the DQI *concordance* under awareness that the physician's registry could be seen as the gold standard for the data quality of EMA. It is common that fever events are recorded in pediatrician offices. However, it is usually not done in a structured way, as we have done it. In this pediatric office, each patient was asked regarding fever. In the app-based registry, this was a voluntary commitment. Hence, these structured office records may be seen as the gold standard.

Usually, the threshold value for the concordance rate and completeness rate is defined as 95% for registries by medical professionals [14]. Thresholds are not scientifically validated and can be changed with justification [16].

Multilevel Perspective

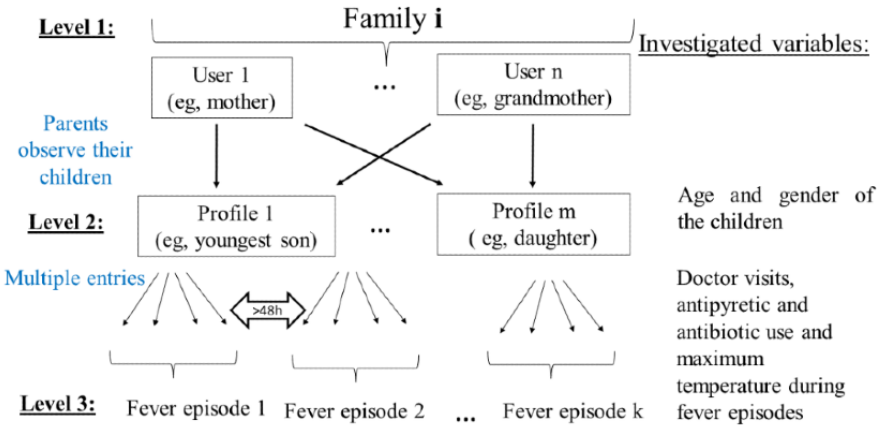
FeverApp is a tool for parents to observe the fever episodes of their children. A fever episode is defined by a series of multiple entries without cessation for >48 hours. It always relates to a child profile, which belongs to a family, so this can be considered a cluster. If several users install FeverApp with the same family code, they will share the same profiles of their children. Hence, a family is the major observation unit of the registry. This contrasts with the reference records of a pediatric office, where a child and an adolescent is the observation unit and not the total family. However, the main point of interest is the fever rather than the family or children. For children, who we label as profiles, we can consider some sociodemographic

data (date of birth and gender) for comparison. Because each child within a family can have several fever episodes, each consisting of multiple entries and different variables during a period, these could be considered as a further level. Owing to these circumstances, any reporting of quality indicators, such as completeness or concordance, depends on the considered observation object. We have illustrated this structure in Figure 1.

The collected EMA data rely on event-based sampling at the family level and on time-based sampling at the fever-episode level: children have fever occasionally, but researchers intend to monitor how body temperature and other indicators, such as parental confidence and children's well-being, vary over time during a fever episode. The EMA design was combined [21] owing to the multidimensionality of the data.

We are aware that with additional offices, further levels such as physicians' offices and regions or countries could be integrated above the family level, and pointing downward, single entries and the aspects of fever episodes may be considered separately. The schematic figure (Figure 1) depicts the data structure of the central FeverApp registry where "i" denotes an arbitrary number of the family (the possible app user values are from 1 to n, profile values from 1 to m, and fever episodes from 1 to k, wherein n, m, and k are any natural numbers). Participating pediatric offices in the country (currently only German-speaking countries) distribute an access code for the app to several families with children that are interested in using FeverApp. The access code of the pediatric office generates a random family code, which can be shared with other family members to access the same profiles of the children. The random family code is an 8-character lowercase combination and uniquely defines the participating family.

Figure 1. Multilevel observation units of the FeverApp registry.



Hence, participating families (level 1) are the observation units, defined by a family code and related to a pediatric office. In each family, there can be several users, that is, app installations with the same family code, who observe the same children (profiles). Therefore, ≥1 users of a family document ≥1 profiles (level 2) with ≥1 entries in FeverApp. These entries document ≥1 fever episodes (level 3), which are currently defined until a child is marked as *healthy*. Some long fever episodes may have been recorded erroneously when the users forgot to click the *child healthy* button, which naturally defines the end of an episode. Therefore, episodes were redefined using the definition of fever duration. If no entry was made for at least 2 days (>48 h), the next entry is regarded as a new fever episode. The time of the entries is recorded, but if the entries are made retrospectively, for example, after the end of a night, the user is called to enter the time of real occurrence to be used for calculations. As fever occurs especially at an early age, the project primarily intends to collect data about children who are yet to reach adulthood. Since October 2020 (app version 1.7), it is possible to enter a separate physician's office for each profile. In this case, the pediatric office can differ between profiles and from the distribution office for each family [5,22].

As part of this model registry, we established structured reference records regarding fever in a pediatric physician's office, which may be considered as true to assess the quality indicator completeness.

Physician's Reference Records

One large pediatric office in Bochum (North Rhine-Westphalia, Germany) has participated in the FeverApp registry study since it was established in September 2019. This reference office very accurately documents several fever-related questions [Multimedia Appendix 1] for each child in the physician's reference records with separate fields in the EHR system Medistar from the CompuGroup. Each family participated with a written informed consent for the comparison of registry data with the reference records of their children. The main purpose of this effort was to validate the parental FeverApp registry data. From the EHR system, these data were extracted using an SQL export. These reference record data from the physician's office could be considered a second registry to validate the parental FeverApp registry.

The records in the pediatric office contain the following information about a patient's fever episodes: date of the visit, past and acute fever episodes, fever duration, maximum temperature level, and medication. A past fever episode is fever that is only reported to the physician when they asked regarding any fever episode since the last visit. An acute fever episode is defined as any visit to the physician with a child having acute fever. It was noted whether children received any antipyretics

and antibiotics including their names. The FeverApp access code that families have received is registered in the EHR and serves as an identifier. These parents should also answer whether they actually used FeverApp during the reported fever episodes. As sociodemographic information, only the date of birth and gender were considered for each patient.

Statistics

Data analysis was performed using the statistical software R 3.6.3 [23], and data visualization was performed with the R-package ggplot2 [24]. The ratios for concordance are calculated with the number of matches in relation to the number of possible matches. Whereas Nonnemacher et al [14] defined concordance as nonmatching in relation to all the evaluated variables. The exact 95% CIs for the ratios were derived using quantiles of the *F* distribution (Clopper-Pearson intervals) [25].

We analyzed the quality of the information concerning the number of children in the family, number of episodes and agreement of episodes at the family level, and sociodemographic data (gender and date of birth) at the profile level as well as provided information about physician visits, antipyretics, antibiotics, and maximum temperature during the fever episode in the FeverApp registry in comparison with the entries in the physician's reference records at the level of fever episodes.

Ethics Approval

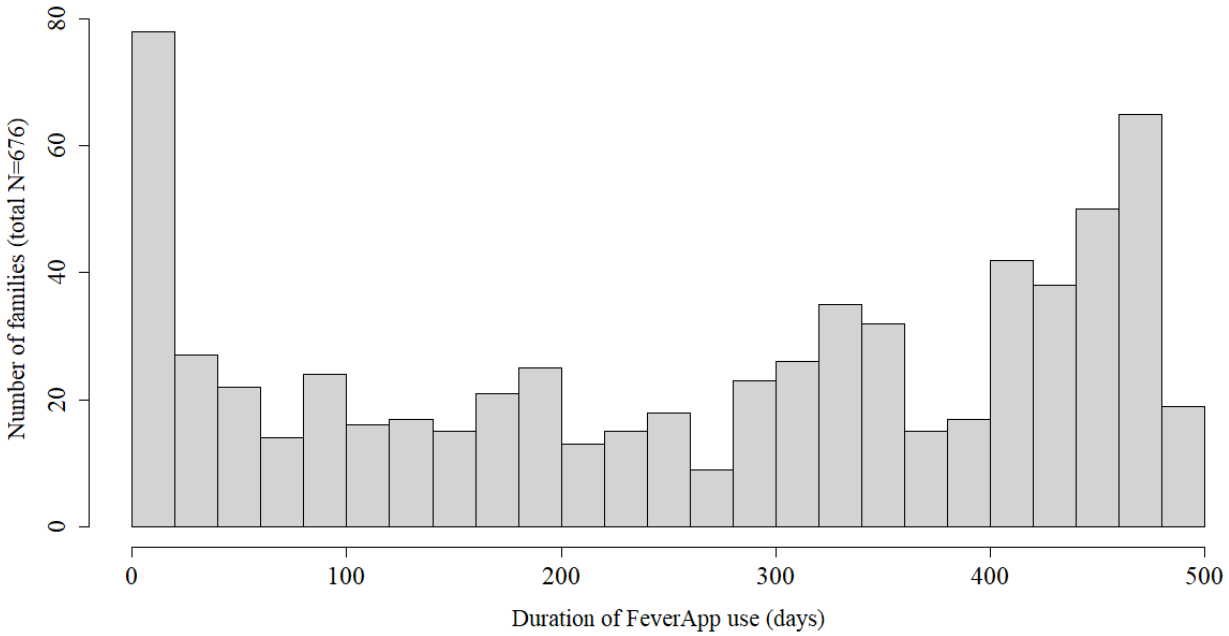
The study was conducted in accordance with the guidelines of the Declaration of Helsinki, approved by the Ethics Committee of the University of Witten/Herdecke (protocol code 139/2018 on December 13, 2018) on pseudonymized data collection using an app, and received a positive vote by the data protection service.

Results

Overview

The results are considered level by level. Naturally, the focus of the analysis is on the level of the fever episodes, which already aggregates several variables over a period. This study considered consecutive enrollment in the 16-month period between September 2019 and December 2020. For each participating family, the duration of FeverApp use varied depending on both the registration date and the need because of fever phases. The median (IQR) time of use of FeverApp by families was 302 (105-423) days, as shown in the histogram (Figure 2).

Figure 2. Duration of FeverApp use by 676 participating families.



Family and Children's Numbers in Reference Records and in the FeverApp Registry

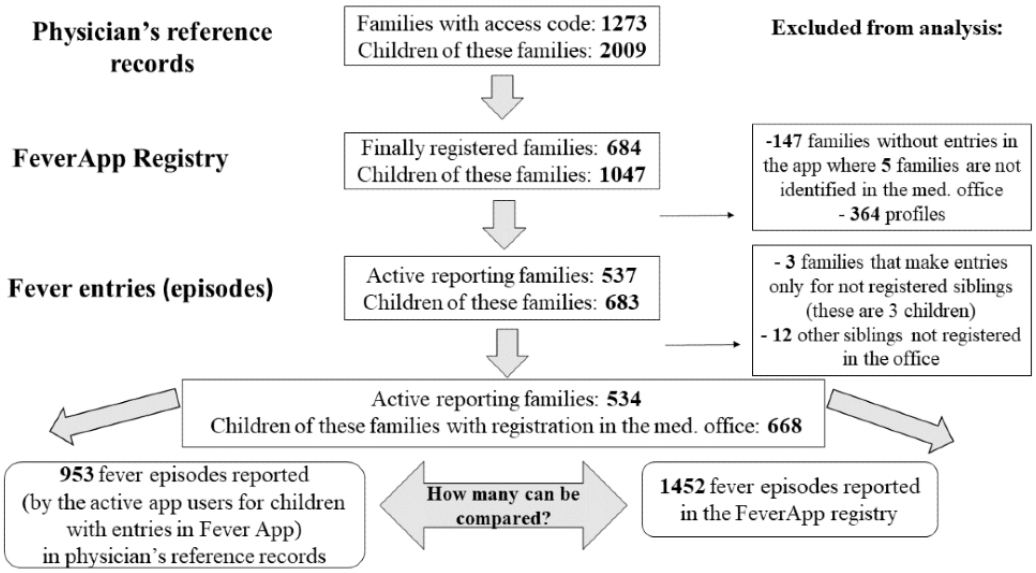
Consideration of the family level shows that 1273 families with 2009 children signed the participation agreement and received an access code to use the app. In total, there were 3579 patients in the pediatric office during the observation period of 16 months. Therefore, the physician's office invited 56.13% (2009/3579) of their patients to the FeverApp registry during this time. In comparison, the app-based registry showed that 684 (684/1273, 53.73%) families, with a total of 1047 (1047/2009, 52.12%) profiles, completed the registration process for the app registry during the same period. However, 5 of these families with a total of 6 children could not be identified in the physician's reference records, probably because of errors in processing the exported EHR comparison data. In addition, 3 registered families did not register any profiles for their children but installed the app. Their profiles in the office records cannot be compared with those in the app-based registry.

Only 24 (24/676, 3.6%) of the remaining 676 (676/684, 98.8%), respectively 679 (679/684, 99.3%) registered families registered more profiles in the app-based registry than in the pediatric office. Of the 676 families, 50 (50/676, 7.4%) did not register all their children in the FeverApp registry. Of the registered families, 602 (89%) registered all their children in FeverApp.

A close look shows that 24 (2.31%) of the remaining 1041 profiles from 676 families belong to persons who are not patients in the office (22 siblings and 2 mothers). Moreover, 5 children have double (synonymous) profiles (confer in the GAMOQ as TMF-1029): this can occur if 2 parents register their children on 2 mobile phones simultaneously due to the time lag of synchronization with the server. Therefore, a comparison of 1012 registry profiles with the records in the pediatric office was possible for a total of 676 families. The word "profiles" in this analysis refers to the profiles of children because all adult profiles (parents) were excluded. There were 3 (3/684, 0.4%) families who installed the app without any profile. Thus, there were 679 families, of which only 676 had a profile.

The 679 families that installed the app reported 1171 fever episodes in the pediatric office. Not all have used FeverApp as a fever diary during the observation period: only 537 (537/684, 78.5%) participating families with 683 children documented 1481 fever episodes in the FeverApp registry. They reported 1038 fever episodes at the same time in the pediatric office. If we exclude 29 episodes of siblings that have no registration in the office's registry, then 534 families (3 families make entries only for nonregistered children) and 668 children remain with 1452 episodes. In contrast, there were 953 reported episodes for these children in the pediatric office. The flowchart (Figure 3) depicts the process of participation in the FeverApp registry study at all 3 levels and reports the fever episodes that could be used for comparison.

Figure 3. Units of observation at all 3 levels in both data sources.



Recorded Number of Fever Episodes at Family and Child Levels

In the following part of this study, we will look closer at the number of finally comparable episodes, which depends on the observation unit definition. As mentioned, each child in each family can have multiple fever episodes. In Figure 4, the numbers and percentages of registered families (cornflower blue) and registered profiles of children (yellow) with differences in the number of fever episodes between the app-based registry and reference records can be seen on the axis of abscissae. In the axis of ordinates, the absolute and relative frequency of the 1012 children's profiles from the app, corresponding to 679 registered families, could be seen.

Positive differences indicate that the number of episodes in the app-based registry is greater than the number of episodes in the reference records. Zero indicates that the number of episodes in both sources is equal. It is worth mentioning that 30.2% (205/679) of the families and 31.02% (314/1012) of the children had an equal number of episodes in the app's and physician's registries or even had more fever episodes in the app (546/1012, 53.95% children and 289/679, 42.6% families). Therefore, most users do not always contact the physician during the fever episodes of their children.

Comparison of Children's Sociodemographic Data

First, completeness and concordance at the second level (Figure 1) were analyzed. In contrast to the app-based parental registry, the EHRs of physicians' offices consider only patients (profiles) and not complete families. The assignment of persons for comparison is difficult because the identification numbers are different for each data source (sequential number in the reference records in the pediatric office and randomly generated combinations of numbers and letters in the FeverApp registry). Therefore, the family code of FeverApp and children's gender and date of birth were used to identify comparable profiles. In the following sections, all comparisons are made at the profile level (level 2 according to Figure 1) and not at the family level.

A comparison of entries for gender and date of birth demonstrated that the FeverApp data includes 22 siblings without registration in the office registry and 2 parents. We compared the remaining 1012 (1012/1036, 97.68%) profiles of 676 families (without the 5 synonymous profiles mentioned earlier) based on demographic information. They include 8 nonstatements of the date of birth, 18 errors in the date of birth (n=11, 1.09%), gender (n=6, 0.59%), or both (n=1, 0.10%). The presence of different options for answers for the variable gender (3 in the FeverApp registry and 2 in the physician's registry) is also a potential cause for disagreements. Most errors in gender

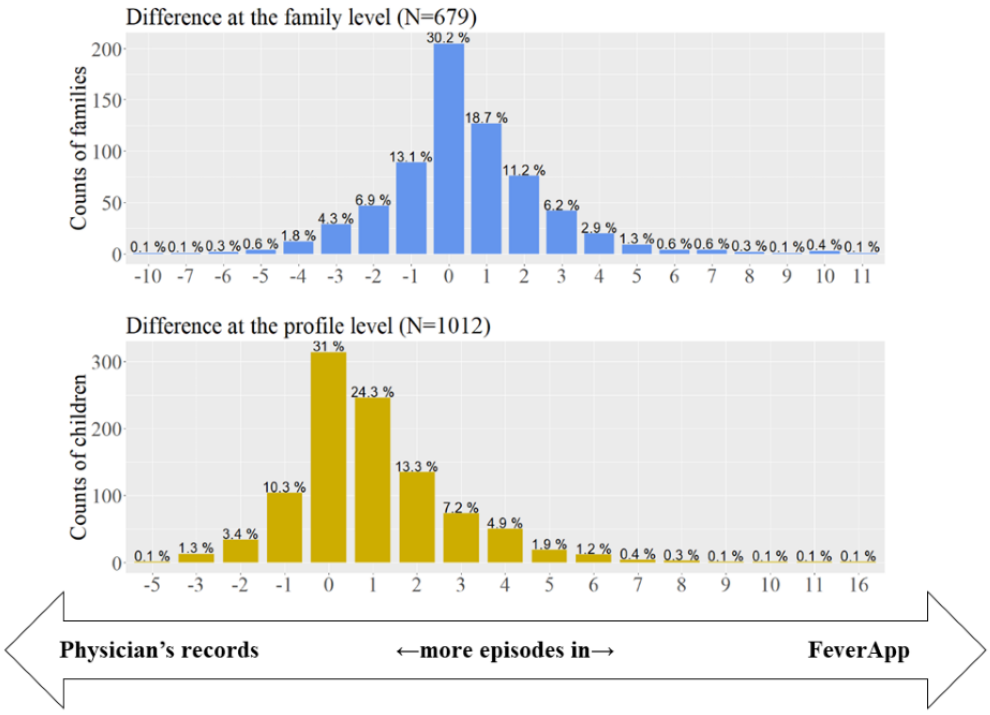
(5/6, 83%) occurred in the physician's registry, and all 19 errors in date of birth occurred in FeverApp, where only month and year of birth are recorded. According to the names in the registered profiles, it can be decided which registry includes incorrect values for gender. There were only 0.69% (7/1012, gender) and 1.19% (12/1012, date of birth) of mismatches between the sources. Therefore, the concordance rates were 99.31% and 98.81%, respectively.

Completeness for gender and date of birth, as expected, reached 100% in the reference records but only 99.2% in the app-based registry for date of birth. This could be because the submission of the month and year of birth was not mandatory in earlier versions of FeverApp.

Comparison of Fever Episodes

Because of differences in the number of recorded fever episodes at the family and child levels (Figure 4), the analyses of concordance and completeness at the episode level (level 3 according to Figure 1) was more challenging. As stated in Figure 3, there were only 953 reported fever episodes of finally participating families in the FeverApp registry being recorded in physician's office reference records, whereas approximately 50% (1452/953) more fever episodes were entered by parents in the EMA-based FeverApp registry.

Figure 4. Difference in episode numbers between the app-based registry and reference records.



Comparable Data

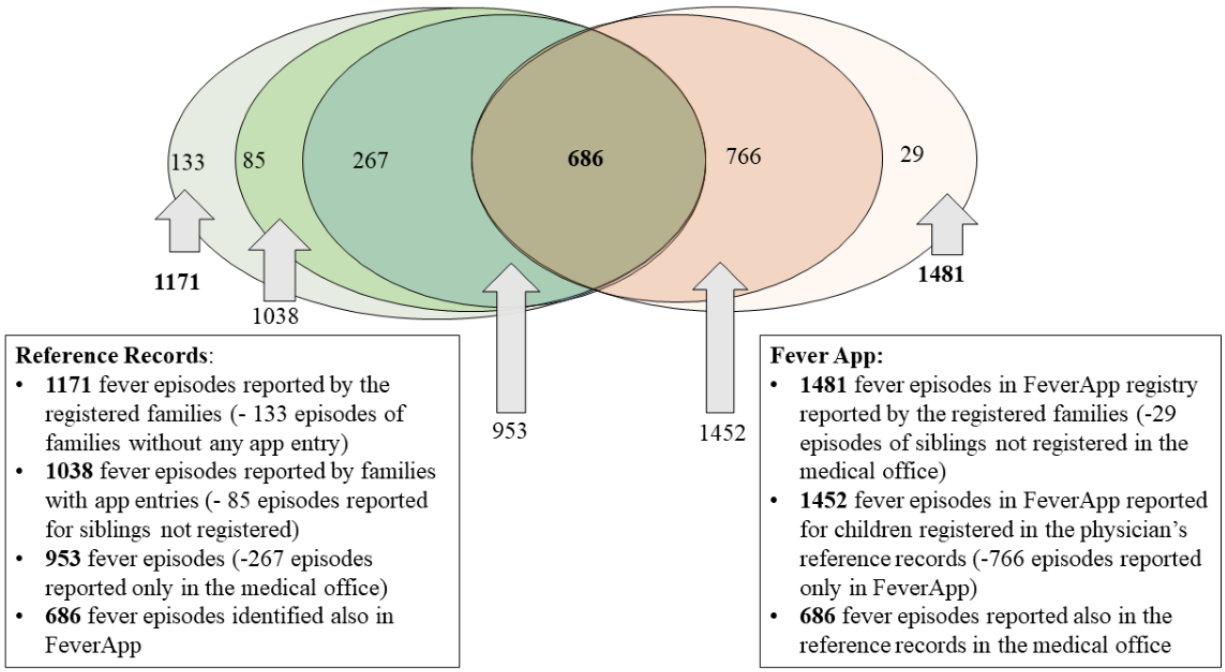
To depict comparable fever episodes (on level 2 according to Figure 1) from these 2 sources, a Venn diagram (Figure 5) illustrates the sets of fever episodes in both the reference records in the physician's office and the central FeverApp registry.

In Figure 5, the 3 green ovals on the left side represent the episodes from the physician's records as reference. In total, 1171 fever episodes were reported by families with registration in the app; that is, they not only signed the informed consent but also installed the app. Of the 1171 episodes in the office, 133 (11.362%) originated from families without any episode entry in the app. Families with app entries reported the remaining 1038 (88.64%) episodes in the office. As mentioned earlier, 50 (50/537, 9.3%) families did not register all their children, such that 85 (85/1038, 8.19%) fever episodes recorded at the office were from children without profiles in FeverApp. The remaining 953 episodes in the reference records originated from children with profiles in the app. They can be distinguished as 681 (71.5%) acute and 272 (28.5%) past episodes.

The 2 orange ovals on the right side represent the fever episodes from the app-based registry. In total, these were 1481 episodes, with 29 episodes from children who could not be identified in the physician's records. The remaining 1452 fever episodes from the app registry were from children who could be identified in the physician's records.

Only 686 episodes in the olive intersection were comparable, where children with profiles and fever episodes in FeverApp also visited the physician's office after the parents signed the consent to participate. These are 71.9% (686/953) fever episodes from the physician's records, which originate from children with profiles in the app and 47.25% (686/1452) of fever episodes in the app registry from children who could be identified in the physician's records. In total, 424 fever episodes in FeverApp were reported as acute and 262 as past in the physician's reference records. Therefore, 96.3% (262/272) of the past episodes and 62.3% (424/681) of the acute episodes noted in the medical office were also recorded in FeverApp.

Figure 5. The Venn diagram of fever episodes in the reference records and app-based registry.



Of the 351 families that visited the office owing to an acute fever episode, 37.7% (257/681) of acute episodes were not documented additionally in the registry. Of the 534 families with entries in the app, a similar percentage (183/534, 34.3%) of families refrained from visiting the office during fever episodes but nevertheless documented 338 (338/1452, 23.28%) episodes in FeverApp. These families seem to feel safe using solely FeverApp as support. Additionally, 188 (188/351, 54.4%) families visited the office, but partially refrained to report their episodes (428/1452, 29.48%) in physician's office.

To calculate the concordance rates, it is sensible to use only the information that can be found in both data sources. Therefore, we compared 686 episodes of 351 families in terms of physician visits, medication, and maximum temperature during the fever episodes.

Completeness of Fever Episodes

The completeness of data concerning maximum temperature, physician visits, and medication during fever episodes was analyzed at the level of fever episodes (level 3 according to Figure 1).

Table 1 presents the median, IQR, and total range for the maximum temperature (in ˚C) during a fever episode for records from the app registry and for past and acute episodes from the reference records separately.

Table 1. Characteristics of the maximum temperature of a fever episode in °C.

	Value, median (IQR)	Total range
FeverApp registry	38.9 (38.3-39.5)	36.2-41.6
Past episodes in the reference records	39.2 (38.9-39.7)	38.0-41.0
Acute episodes in the reference records	39.4 (39.0-39.9)	38.0-42.4

Table 2 summarizes the agreement in FeverApp and reference records. In the analysis, it was assumed that missing answers concerning physician visits and medicaments were equal to negation. In medication, we considered antipyretics and antibiotics separately and no other drugs. The results for FeverApp are presented in the first row: only in 27.55% (400/1452) of the records, parents admitted visiting the physician's office, and in 30.99% (450/1452) and 3.17% (46/1452) of the episodes, they gave antipyretics and antibiotics, respectively, to their feverish child. In 97.45% (1415/1452) of the episodes, the question about body temperature was answered. The second row presents the answers concerning physician visits, medication, and maximum temperature per fever episode provided in the reference records of the physicians' office.

The third row presents the subset of all the 1452 episodes entered in FeverApp: 686 fever episodes in the app, which can also be identified in reference records (Figure 5). The fourth row presents 686 fever episodes of the 953 office-registered episodes that can also be identified in the app registry (Figure 5). The comparison of the third and fourths rows shows that the answers concerning medication, physician visits, and maximum temperature per fever episode given in the app and office often differ.

The number of agreements for each of the 4 data elements is shown in the fifth row. The agreement was the lowest regarding the reported maximum temperature and differed between acute (90/424, 21.2% of possible agreements) and past (20/262, 7.6% of possible agreements) reported episodes in the reference records (χ^2_1=21.225; *P*<.001).

Table 3 summarizes completeness rates with corresponding 95% CIs for both data sources: the rates are much lower as the usually used DQI benchmark of 95% in both sources, although they are higher in the app-based registry.

Completeness ranges from 11.5% to 65% for the app registry and from 7.6% to 42.6% for the reference source, as shown in the 2 rows in Table 3.

Table 2. Response and agreement for submitted physician visits, antipyretics, antibiotics, and temperature in both sources.

	Physician visits		Antipyretics		Antibiotics		Maximum temperature per episode	
	Yes	No	Yes	No	Yes	No	Answered	Not answered
Episodes in FeverApp (N=1452) and reference records (N=953)								
FeverApp episodes, n (%)	400 (27.55)	1052 (72.45)	450 (30.99)	1002 (69.01)	46 (3.17)	1406 (96.83)	1415 (97.45)	37 (2.55)
Reference records, n (%)	744 (78.1)	209 (21.9)	552 (57.9)	402 (42.1)	90 (9.4)	863 (90.6)	931 (97.7)	22 (2.3)
Corresponding episodes (n=686)								
FeverApp, n (%)	279 (40.7)	407 (59.3)	274 (39.9)	412 (60.1)	32 (4.7)	654 (95.3)	675 (98.4)	11 (1.6)
Reference records, n (%)	474 (69.1)	212 (30.9)	418 (60.9)	268 (30.1)	61 (8.9)	625 (91.1)	576 (84.0)	110 (16.0)
Agreements between the FeverApp and reference source, n (%)	245 (35.7)	178 (25.9)	234 (34.1)	223 (32.5)	13 (1.9)	606 (88.3)	110 (16.0)	N/A[a]

[a]N/A: not applicable; it is not possible to compare not submitted answers.

Table 3. Completeness rates for submitted physician visits, antipyretics, antibiotics, and temperature with corresponding 95% CI.

	Physician visits	Antipyretics	Antibiotics	Maximum temperature in 0.1°C resolution
Completeness rate of app registry in relation to 953 reference records, n/N (%; 95% CI)	423/953 (44.4; 41.2-47.6)	457/953 (48; 44.7-51.2)	619/953 (65; 61.8-68.0)	110/953 (11.5; 9.6-13.7)
Completeness rate of reference records in relation to N=1452 in app registry, n/N (%; 95% CI)	423/1452 (29.13; 26.8-31.5)	457/1452 (31.47; 29.1-33.9)	619/1452 (42.63; 40.1-45.2)	110/1452 (7.58; 6.3-9.1)

Concordance of Fever Episodes

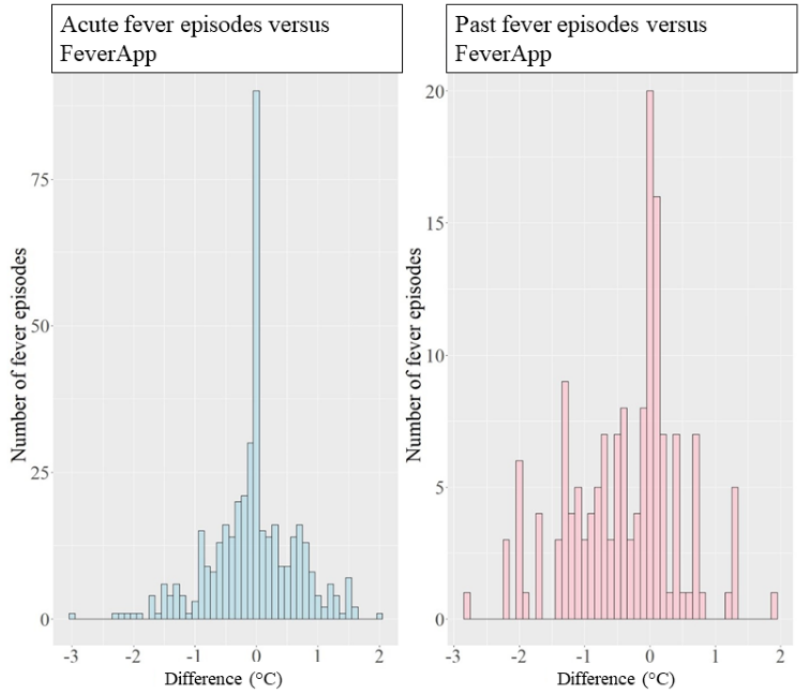
Table 4 summarizes all concordance values with corresponding 95% CI and frequencies of agreement at the episode level (level 3 according to Figure 1). The concordance rates were varied: 90.2% in terms of antibiotics, 66.6% in terms of antipyretics, 61.7% in terms of physician visits, and 16% in terms of maximum temperature. The lowest rate of agreement was observed for the maximum temperature per episode. This depends on the resolution of the metric measure at a temperature of 0.1 °C. With less subtle resolution, higher agreement rates are possible. Therefore, in Figure 6, we present the histograms of the temperature differences between acute and past fever episodes. Differences between the values from the FeverApp records and those from the reference office records were in the range of −2 °C to 3 °C. Positive differences indicated that the submitted maximum temperature per fever episode in the app records was higher than that in the reference records. The IQR for acute fever episodes lies within the range of −0.3 °C to 0.4 °C. The IQR is wider for past fever episodes: from −0.1 °C to 0.9 °C (Figure 6). The Mann-Whitney test showed a significant difference between acute and past fever episodes (*W*=38,854; *P*<.001).

Table 4. Concordance rates of comparable data elements.

	Physician visits (N=686)	Antipyretics (N=686)	Antibiotics (N=686)	Maximum temperature in 0.1 °C resolution (N=686)
Agreement, n	423	457	619	110[a]
Concordance rate (%)	61.7	66.6	90.2	16.0
95% CI	57.9-65.3	63.0-70.0	85.7-90.6	13.4-19.0

[a]Expecting exact agreement, see Figure 6.

Figure 6. Differences in the maximum temperature between reference records and the app-based registry for 424 acute and 262 past fever episodes.



Discussion

Principal Findings

As part of a publicly funded model registry initiative [4], 6 registries aim to implement several DQIs for drawing comparison between very different registries. The 2 presented DQIs, completeness and concordance, cover 2 of the 5 dimensions according to Weiskopf and Weng [10]. In contrast, according to the GAMOQ [14], these 2 DQIs (concordance and completeness) belong to the dimension of trueness. These dimensions seem to be diversely understood in the comparison of different registries, resulting in interpretation difficulties [26]. Therefore, because it is especially important for an EMA-based registry, we herewith contribute to shedding light on an example with a multiple clustered observation unit.

This study has provided several new insights into research on the possibilities in ambulatory pediatric care and demonstrates the use of DQIs. First, it demonstrates that in all analyses of clustered observation units, the cluster level must be mentioned and considered in separate analyses. Second, although the cooperating pediatricians purposefully and systematically collected data to create a reference for the FeverApp registry, with a high motivation to assure high quality of gathered office data, the records in the pediatric office were less complete than the parental recordings in FeverApp. This finding was surprising to the authors and reversed their perspective: in many situations, such as the present example of comparing FeverApp to office records or even to extra office-based febrile history records, app-based EMA is of higher quality. Therefore, medical practice records should not be seen as the gold standard in comparison with the app-based approach.

The data element gender was the most complete, with only few disagreements due to mistakes. The question about date of birth was not mandatory until the release of version 1.7.2 of the app in October 2020. The data on gender and date of birth in the FeverApp profiles, together with the physician's records, shows high concordance (>98%) and even perfect completeness because of the obligation to fill the selection fields of gender and date of birth.

A comparison of the number of children and the number of episodes at the family level (679 families) between both data sources gives only a limited view on complete values. Although families are seen as observation units in the FeverApp registry, it is essential to analyze data quality at lower levels. To avoid biases, result profiles and even single fever episodes must be considered. A comparison of these levels seems to be much more informative concerning the real quality of data. For example, registered families can use the app for siblings who are not patients of the pediatrician's office. Hence, a simple

comparison of the number of fever episodes per family seems to differ strongly, without clarity as to whether they belong to the same patient. The number of episodes per family may be higher than the number of fever episodes in the reference records for children registered without their siblings. Alternatively, the information does not differ at all; for example, the number of fever episodes seems to be equal between both sources because it is not guaranteed that parents submit information about the same child or the same episode. Therefore, it is essential to compare the fever episodes of each registered child based on the information available in both sources: the date of physician visit, medication with antipyretics and antibiotics, and maximum temperature.

We observed a descent of concordance values for nonmandatory elements: parents often do not submit information concerning physician visits in the app during an acute fever episode. The relatively high grade of agreement for antibiotics could be caused by the rare prescription of antibiotics in this pediatric office during the observation period. In addition, information about typical antipyretic medications may not be submitted to the app-based registry or to the physician's office. Without mandatory entries, high completeness rates of 95% are quite illusory. Hence, thresholds depend on the circumstances of data collection and cannot be generalized. High DQI values may be easily produced through the analysis of accumulated data level. A low level could occur because of families that do not consider the documentation of medication as important and, hence, mandatory. Therefore, neither complete nor concordant data capture should be expected. On the other hand, temperature is very often only roughly recorded in physicians' offices.

In contrast to clinical research, there are fewer mandatory fields in public health research, and the kinds and levels of these variables are much more diverse. To overcome this issue other view in public health or even EMA as a possible solution. If research circumstances allow, we suggest that each person collecting data define their own mandatory fields according to their needs.

In app research, a short duration of use is often expected and may produce some kind of proinnovation bias; that is, in the beginning, the app may be used more often. Figure 2 depicts clearly that the duration of use was not skewed, and a remarkable period of app use was confirmed.

Limitations

The approach of using reference records for comparison, regarding completeness and concordance, has limitations. This comparison is only possible for the observation period between informed consent and last attendance at the pediatric office. This may be a reason for the approximately 50% higher number of episodes in the FeverApp registry than that in the reference records. The extent may be even greater because of the pandemic [5]. However, children have mandatory office consultations because of vaccinations and examinations; therefore, we assumed no influence on the total number of fever events. Nevertheless, the number of acute and past fever events may differ and may shift the numbers in Figure 5. However, without a nonpandemic observation period, further conclusions were impossible.

Nevertheless, the achieved EMA quality in direct comparison with that of professionally acquired data is extraordinary. For some discrepancies, it was not possible to verify which of the data sources was correct. Theoretically, it is possible that both data sources may contain errors in the same direction, which would render such errors unnoticeable during comparison.

We validated the data for 1 office with the highest number of participants and very accurate documentation by the medical personnel in the office, and it is possible that the pediatrician in the office has a positive motivational influence on the users of the app. The extension of the study to other participating offices is desirable and would increase the significance of the study but is difficult to implement because of the high effort required from the medical personnel in the offices.

Of course, data quality analyses can be extended in various directions; for example, extension to further dimensions in structure and integrity according to Donabedian [19]. Data quality statements and investigations are still a stepchild in research, and the well-known FAIR (Findable, Accessible, Interoperable, Reusable) principles on data could be extended by their quality, as could FAIR-Q (Findable, Accessible, Interoperable, Reusable and Quality) [26].

Comparison With Other Studies

According to other studies, users show a common behavior: participating parents kept fever diaries on paper [3] or used a mobile app [2] during a certain period, and many parents stopped filling out the diaries after their child recovered [3] or forgot to answer the questions because of different external factors (eg, stress) [2].

The data quality of mandatory data elements in FeverApp is comparable with a study from 1993 [27], where entries were done by medical personnel. The results of Kenny et al [28] show that the input of date of birth has a high potential for mistakes; therefore, the quality of this data element should be assured.

Data quality in clinical registers is reported as generally high [29,30]. There are many possibilities to assess the completeness of data in clinical registries: source data verification, comparison of established epidemiological measures such as incidence rates, cumulative incidence curves, and incidence mortality ratios with external databases [15]. However, these methods are not appropriate for the app-based registry FeverApp because of the lack of a data source owing to momentary assessment. In addition, epidemiological measures for fever are not available because it is only a symptom of heterogeneous diseases. Therefore, lower thresholds for existing DQIs are required in this case.

Recently, Schmidt et al [18] presented a set of DQIs developed specifically for the assessment of data quality in health research. A possible step forward could be a complete evaluation of the data sets from the FeverApp with this extension of the GAMOQ framework. Furthermore, Kapsner et al [31] developed a tool for EHR data quality assessment in clinical research, which can be used for multidimensional data and may be also used for the data from the FeverApp registry.

Kenny et al [28] suggested a possibility to avoid comparison with other sources. This technique suggests validation relaxation for data collected via mobile devices: this is the intentional omission of electronic data validation features for selected questions to allow for data recording errors to be committed, detected, and monitored.

Doherty et al [32] mentioned the data quality issue of EMA data in their work. Review studies [33,34] show in their analyses that compliance and completeness rates of EMA studies are under a desirable level of 80%, but they provide no uniform conclusion regarding the reason for this. Ono et al [34] concluded that the duration of the study influences the completeness rates of the EMA data, whereas Jones et al [33] and Wen et al [35] did not find any significant influence of duration. Nevertheless, Yang et al [36] showed that completeness rates in the daily EMA study decreased after 5 days of use.

Concordance is seldom a major focus in EMA studies with mobile phones. Our values of concordance are comparable with that of Olson et al [2] but lower than those in the study by Hopper et al [37] from 2006, where the investigation of the completeness and concordance of the ActiWatch device data was a part of an EMA study concerning drug intake.

Nowadays, public health researchers must deal more and more with not only EMA data but also EHRs in general, which are in itself limited in completeness, as shown recently by Weiskopf et al [38]. This study explains this issue in detail for 2 very important DQIs as part of an elaborate framework.

Conclusions

Despite purposeful and systematic data collection by pediatricians, the parental real-time recordings in the FeverApp registry were more complete. Public health data, especially parental EMA data, cannot be easily compared with the same thresholds of clinical registries. Especially data completeness depends on the obligation to answer. For the comparison of quality, the indicator's obligation, source, level, and kind of variable have to be considered carefully.

Data completeness in registries based on optional self-documentation is not comparable with that in clinical registries by medical professionals (eg, for cancer), where all data elements are mandatory. A further conclusion is that although families are the main observation units, it is necessary to analyze more specific levels (profiles and fever episodes) to avoid incorrect conclusions concerning data quality aspects such as completeness. Test entries or omissions of data in this app-based registry were not seen as shortcomings because of its educational approach. Educated parents may use the app less frequently over time and visit the pediatrician only if necessary. This behavior must be taken into account during assessing and improving the data quality of app-based registries.

In direct comparison with a highly motivated professional office, the EMA-based registry shows how much data, and hence the quality indicators, depend on the acquisition method. It has been shown that EMA by parents can supplement ambulatory care, especially during the pandemic. This study is particularly interesting in light of the fact that mobile apps will have a much greater presence in patient care in the future.

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Data Availability

The data presented in this study are available in SPSS formats as supplementary material Multimedia Appendix 2.

Authors' Contributions

EJ and LR conceptualized the study; EJ and LR established the methodology; DM and EJ contributed to the software; LR and EJ contributed to validation; LR conducted the formal analysis; EJ, DM, SS, LR, MG, SHK, and IF conducted investigations; DM and IF contributed to resource acquisition; LR and EJ curated the data; LR and EJ wrote the original draft of the manuscript; DM reviewed and edited the manuscript; SS contributed to project administration; and DM and EJ contributed to funding acquisition. All authors have read and agreed with the published version of the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Fever variables in doctor's office reference records.
[DOCX File , 25 KB - pediatrics_v5i4e35510_app1.docx]

Multimedia Appendix 2
Data files in SPSS format.

[ZIP File (Zip Archive), 94 KB - pediatrics_v5i4e35510_app2.zip]

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Abbreviations

DQI: data quality indicator
EHR: electronic health record
EMA: ecological momentary assessment
FAIR: Findable, Accessible, Interoperable, Reusable
FAIR-Q: Findable, Accessible, Interoperable, Reusable and Quality
GAMOQ: Guidelines for the Adaptive Management of Data Quality for Cohort Studies and Registers
TMF: The Technology and Methodology Platform for Networked Methodological Medical Research

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Original Paper

Quality of Mobile Apps for Child Development Support: Search in App Stores and Content Analysis

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Abstract

Background: Following increases in smartphone access, more parents seek parenting advice through internet sources, including blogs, web-based forums, or mobile apps. However, identifying quality apps (ones that respond to the diverse experiences of families) for guidance on child development can be challenging.

Objective: This review of mobile health apps aimed to document the landscape, design, and content of apps in the United States available to parents as they promote their child's developmental health.

Methods: To understand the availability and quality of apps for early childhood health promotion, we completed a content analysis of apps in 2 major app stores (Google Play and Apple App stores).

Results: We found that most apps do not provide tailored experiences to parents, including cultural considerations, and instead promote generic guidance that may be useful to parents in some contexts. We discuss the need for an evaluative framework to assess apps aimed to support parents on child development topics.

Conclusions: Future work is needed on how to support designers in this area, specifically related to avoiding potential burdens on users and providing culturally informed and equity-driven experiences.

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KEYWORDS

mobile health technologies; early childhood health promotion; child development; parent support technologies; pediatrics; parenting; mobile app; mobile health; mHealth; mobile phone

Introduction

Background

Intervening early (for children aged 0-5 years) in childhood health has been demonstrated to improve child outcomes [1]. For children born in environments that pose risks to their healthy development (eg, food or housing insecurity), intervening early can offset the degree of impact those risks have on their health outcomes. By enabling parents and caregivers to engage in consistent and evidence-based behaviors that promote their child's healthy development, more at-risk children will have opportunities to overcome environmental challenges in their development. Children in at-risk environments are less likely to have access to regular pediatric visits [2]. As such, parents and caregivers may need different types of support in being educated about their child's developmental milestones and engaging their child in activities that support them in meeting those milestones. Parents can find information about developmental milestones through internet searches, from pediatric clinics, at community centers, and other accessible locations [3]. However, translating that information to parenting practices can be difficult and is often exacerbated by ambiguity in how to apply information in limited contexts (eg, in food-insecure environments).

Fortunately, >97% of adults (aged >18 years) in the United States own cell phones with texting capabilities, and 85% of the population in the United States owns smartphones that can download and access apps, with these numbers growing rapidly,

particularly for people aged <49 years, who are the most likely the generation to include parents of young children [4]. Researchers have studied the efficacy of phone-based interventions for early childhood health promotion through texting-based programs and mobile apps [5-7]. These apps support parenting practices, including tracking feeding, sleep, and diapers; tracking if a child is meeting essential developmental milestones; facilitating communication with health professionals; finding and implementing health-promoting activities; and collaborating with relevant caregivers. These interventions were designed and tested following guidelines from health and computing fields, with content informed by evidence in the pediatric literature. These apps are also often tested in diverse populations to identify opportunities to promote health equity through design choices [7]. Unfortunately, beyond testing in research contexts, many of these apps are not maintained or deployed to the public because of funding and organizational constraints [8].

Most apps to which parents have access exist in the Apple App and Google Play stores, where app developer experience or qualifications vary widely. These app stores do not have comprehensive guidelines or regulatory oversight for the development of child health apps aside from legal restrictions on claims promising specific health outcomes [9]. App developers may not have access to or knowledge of how to apply design guidelines set by pediatric and human-centered computing researchers. The apps that parents have access to also may not be developed and tested with the same rigor as apps developed in research settings. Although most mobile apps provide a disclaimer that they are not meant to be used to diagnose and thus not directly responsible for health outcomes, they are particularly influential in parenting practice [10,11]. For example, mobile apps can support parents to identify and document patterns in their child's health that would otherwise go unnoticed and prompt parents to communicate concerning health information to health providers. At the same time, these apps can risk pathologizing health behaviors, raising unfounded concerns, performing self-diagnosis, and causing additional stress in families to micromanage their health. For these reasons, there is a need to critically examine apps aimed to support child development.

In pediatric visit settings, pediatricians sometimes work with parents and caregivers to identify their current resources for child health promotion. These resources can include local community organizations, parent support groups, or access to more immediate communication with health professionals. Pediatricians might also suggest mobile apps to parents to help them organize observations of their child's development and facilitate collaboration among caregivers. Mobile apps for child development are uniquely positioned to impact multiple areas of parenting experience and child development. By documenting the existing apps available to parents, pediatricians can learn what types of apps parents might be accessing, leading to informed clinical practice when identifying gaps in parenting support. To our knowledge, there has not been any assessment of the quality of these apps to identify how many developers follow evidence-based guidelines in the creation of these mobile apps.

Related Work

Mobile Apps for Child Health Intervention Delivery

Prior work has explored the efficacy of early childhood health interventions administered through mobile systems. Evans et al [6] contributed a pilot evaluation of a texting system that communicated health-related parenting messages to new mothers and measured significant changes in parenting confidence levels. Humphrey et al [12] conducted a feasibility assessment of a mobile app that offered parents feedback on their child's nutrition and physical activity levels. In this evaluation, they focused on the feasibility of the mobile app specifically for underserved parents and reported both parents' perceptions of cultural irrelevance in the content and recommendations of the app and dissatisfaction with the quality of the user interface. Wong et al [13] evaluated a mobile app for parent-child collaborative physical activity, reported increased psychosocial wellness for parents and their children, and found the gamified approach for content delivery more effective in improving wellness than the nongamified approach. The content of these mobile health technologies can focus on just 1 aspect of early childhood health (eg, nutrition) or address and support multiple areas of child health (eg, nutrition and sleep). As these are fairly novel technologies, most of these evaluations are limited to documenting if people adhere to these interventions in testing conditions and contribute recommendations for future testing (at larger scales) or design improvements that would improve adherence. Unfortunately, owing to funding constraints, difficulty in coordinating publishing apps, and a lack of incentive for scientists to commercialize their work [8], few of these apps evaluated in academic spaces are published for use in the general public [14,15].

Mobile App Design and Regulation in the App Store

Mobile apps present in the public app stores can be developed by both companies and individual developers. Developers are sometimes affiliated with larger companies that partner with health care providers who oversee content and health recommendations. Other developers use their personal experiences to inform the content of their apps [16] or reference published guidelines for health experiences. In the United States, the Food and Drug Administration oversees the development of mobile apps aimed to diagnose and treat any medical conditions [9]. However, oversight into minimal-risk mobile apps, such as those aimed to help patients self-manage their conditions without treatment suggestions or supporting health care providers complete noncomplex tasks, is at the discretion of the Food and Drug Administration.

Both the Apple App and Google Play stores require reviews of mobile apps before reaching the app store. These companies determine the criteria for review, including proof of review processes from external regulatory groups. However, there are several gaps between these processes in assessing the quality and content of the apps. For example, neither of these regulatory processes has requirements for developers to report the sources of the content of their apps, although developers sometimes optionally include their content sources to gain credibility for their app [16]. Developers are also not required to document their design and testing strategies for mobile health apps. For

health promotion interventions, researchers recommend extensive engagement with the target population and their environment to inform the content of the intervention [17]. Generally, it is the discretion of the developer to decide when and how the app is modified and when to engage the target population in the design process. Often, developers have multiple feedback mechanisms for future iterations of their apps, including prompts that they build into their app and the app store to engage with user experiences with the mobile app and create plans for updating the app. However, it is important to recognize that many app developers are unable to engage meaningfully with their target populations during the app development process. Instead, developers can refer to guidelines for design and content set by researchers across fields. There is an opportunity to further support developers in generating app content that is responsive to diverse user needs.

User Burden in Experiences With Mobile Apps

Mobile apps are uniquely positioned as highly accessible resources with many potential benefits. However, people still sometimes fail to adopt mobile apps with potential benefits or stop using them after a short period, despite having experienced benefits [18]. Often, people may continue to use mobile apps out of necessity while enduring the negative experiences associated with the apps. Suh et al [18] defined this phenomenon as user burden, where computing systems have negative impacts on users. User burden encompasses issues with usability and user experience, as well as burdens defined by Suh et al [18] in their User Burden Scale: difficulty of use, physical, time and social, mental and emotional, privacy, and financial. Suh et al [18] posit that each of these burdens can make it difficult for people to adopt a technology or continue its use. Within health apps, this is particularly important, as the adoption and continued use of mobile apps informs larger scale health outcomes [19]. User Burden Scale has been translated into tangible guidelines for mobile app designers to use [20]. Researchers have also used User Burden Scale to evaluate mobile apps in clinical trials [21] and case studies [22]. In these evaluations, User Burden Scale is posited as particularly useful to address the potential for user burden during the design cycle. User Burden Scale provides a guiding framework to evaluate potential user burdens in mobile app designs.

Cultural Competence as an Approach to Health Practice

Cultural competence is commonly defined as an approach to deliver health services that focus on the relevance of culture in health experiences [23]. Cross et al [24] defined cultural competence as supporting changes in health practitioners' attitudes, health care policies, and practices within the health system. Cultural competence promotes the recognition of how health is affected by diverse cultural experiences and how care practices are more effective when a patient's health beliefs, values, behaviors, and preferences are emphasized in their interactions with health providers and health systems. Some examples of adaptations to health systems derived from the inclusion of cultural competence include providing interpretation services, partnering with community health workers and traditional healers, and representing diverse populations and experiences using tangible health promotion tools [25]. Cultural competence has been used as a framework to address racial and ethnic disparities in health care [26], highlighting the organizational, structural, and clinical levels as areas of impact. Researchers have also used the cultural competence framework to evaluate the quality of health care delivery in clinical and hospital settings [27].

Researchers in the fields of computing, medicine, and health informatics have identified that health disparities are sometimes worsened by health technologies [28]. Veinot et al [29] identified that technology-generated disparities are pervasive through the adoption, retention, and effectiveness of health technologies. Researchers have used cultural frameworks to improve the design of their mobile apps. For example, the Centers for Disease Control and Prevention (CDC) redesigned their child development app *CDC's Milestone Tracker App*, to extend the cultural responsiveness of their app to Spanish-speaking families [7]. After evaluating the old version of their mobile app, the CDC found that while the mobile app did offer Spanish translation, the translations were not culturally relevant and thus ineffective for Spanish-speaking families. Their redesign focused on the cultural relevance of translations of contents in the mobile app. Therefore, there is a need for guidance that can support health technology developers as they design and test their systems to respond directly to health disparities and prevent widening them. There is an opportunity to explore the apps of cultural competence as a framework for the evaluation of existing health technologies or as a guide for design and research on health technologies in development.

Content Analyses of Mobile Apps

The content analysis method has been used to identify and evaluate mobile apps aimed to address specific health experiences. This method has been used in computing, medical, and health informatics literature to assess mobile health apps in multiple areas. Lukoff et al [30] completed an exploratory review of mindfulness apps and used their findings to engage mindfulness practitioners in conversations about the utility of those apps. Content analysis is also frequently used to evaluate apps related to pregnancy support and postnatal care and in the realm of child development support. Bry et al [31] documented the quality and scope of apps for child and adolescent anxiety and identified the need for apps that use advanced smartphone features and are of higher quality. Mangone et al [32] documented the features and content of apps aimed to support people in pregnancy prevention, highlighting missed opportunities to inform users of helpful information. Yu et al [33] documented the quality of pregnancy and postpartum apps available in both China and the United States by using the content analysis method, finding that many of these apps lacked evidence-based information and functions that supported mental health care. Garland et al [34] designed Psyberguide as another user-friendly resource that supports reviewing and recommending mental health apps. Researchers have also developed and applied evaluation frameworks in their analysis of consumer apps. Meyer et al [35] used the "Four Pillars of Learning" framework to identify opportunities to improve educational apps supported by developmental science. Henson et al [36] developed a framework for evaluating mental health apps, specifically aimed to support patients and clinicians in

deciding which apps best support treatment needs. Along that aim, Gordon et al [15] developed an evaluation framework to support the implementation of apps in clinical practice.

To assess the current state of mobile apps for early childhood development and health promotion, we have the following research objectives:

1. What is the landscape of apps that support parents promoting their child's developmental health, for children aged 0 to 5 years?
2. What aspects of child development support do specific features or design choices address?
3. What burdens are these apps potentially placing on parents or caregivers as they use them?
4. What is the cultural competency of these apps?

Methods

App Search and Selection Strategy

We used a content analysis approach based on methodological guidance from Downe-Wamboldt [37] and Mendiola et al [38] to guide the collection and coding of early childhood wellness apps. In January 2022, we searched across Apple (iTunes or App Store) and Android (Google Play) app stores, as identified by Statista [39] as the top 2 most popular app stores in the United States. Our search strings included terms describing child development in simple words (eg, *baby health* and *baby app*). We developed our search terms by combining different strings of terms that are synonymous with *child development app*. The full search strings used in each app store are presented in Multimedia Appendix 1. We limited our search to apps that were available in English and were free to download, as it is recommended that mobile apps for lower-income or disadvantaged communities should be freely accessible [40].

We completed a unique search for each search string in the app stores. We searched for Android apps using the mobile version of the Google Play store, accessed through a web-based smartphone interface. We accessed the Apple apps by searching in the mobile version of the Apple App store. For each of the search result lists, we recorded app titles, respective app stores, and search terms used for all apps yielded from the search. We downloaded all Apple apps to an Apple device running iOS 14 and Android apps to an Android emulator running Android 7.2 on a desktop computer. To mitigate potential biases based on tailored search results, we completed all searches without being logged in to an account on the app stores.

Selection Criteria

The 3 members of the research team collaborated to develop the inclusion and exclusion criteria for the mobile apps. We included apps if they (1) supported screening or tracking of developmental milestones up to at least the age of 5 years, (2) supported tracking of health promotion behaviors for children up to the age of 5 years (eg, feeding or sleeping), (3) supported English (as the primary language or translations), and (4) were free to download. We excluded apps from the analysis that (1) did not involve baby or child information tracking in some capacity (eg, pregnancy tracking, fertility tracking, or period tracking); (2) only allowed tracking of sentimental mementos; (3) did not offer English translations; (4) were paid apps; or (5) were not downloadable or had restrictions (eg, requiring an early access password).

Selection Process

We documented the search results on a spreadsheet and flagged duplicates for follow-up across stores. Several apps were present in both app stores but used different names in each app store. A researcher screened the search results in 2 phases by using the inclusion and exclusion criteria. The first phase involved screening the titles of the apps for duplicates between Android and Apple stores and marking apps as potentially relevant. For duplicate apps, we downloaded each and first compared for differences in functionality before excluding a version of the app. In the second phase, we applied the inclusion and exclusion criteria to the app's descriptions in the app store and confirmed the availability for download. A flow diagram detailing the number of apps present in and after each phase is presented in Section B in Multimedia Appendix 2.

Data Extraction

A researcher downloaded and reviewed the included apps, documented content into a web-based survey form, and reviewed the data generated on a spreadsheet. This content included (1) the name of the app, app store downloaded from, category in the app store, size in megabytes, highest operating system supported, and latest date of update; (2) the developer name or company, developer's classification (eg, individual or company), and developer's self-reported credentials related to early childhood health (if provided in the app posting); (3) privacy permissions that the app requests; (4) in-app purchase content and prices (if offered) and if advertisements are present in the app; (5) other languages offered by apps where English was set as the primary language; and (6) content and delivery structures of the apps, meaning what features each app used (eg, tracking functions or reminders) and what topics were addressed in the apps. We also documented other barriers to accessing mobile apps guided by the literature in health informatics related to mobile health app efficacy for diverse populations, including technical requirements such as internet access, size and data demands of the app, 1-time or subscription costs, and language availability [17].

Data Analysis

The authors developed codes for the app's features and content by referencing the national Bright Futures Guidelines for early childhood health promotion [1] and User Burden Scale [20]. With guidance from an author, who is an academic researcher in developmental screening and pediatric health promotion, we reviewed Bright Futures Guidelines and categorized contents by topics covered in well-child visits with pediatricians. From User Burden Scale, we included topics present in the user experience of mobile apps. We have categorized our coding scheme and the peer-reviewed content that informed the coding scheme in Table S1 in Multimedia Appendix 1. We also completed a search of all included apps in January 2022 on Google Scholar to identify if the apps had evaluations published in peer-reviewed venues. An overview of the app characteristics is available in Table S2 in Multimedia Appendix 1.

Results

Selection and Inclusion of Mobile Apps

Our initial searches yielded 1348 apps between the Apple App store (574 apps) and Google Play store (774 apps). We excluded 1199 apps during the screening process. We removed 324 (24.1%) duplicates that appeared in both the Apple App and Google Play stores' search results after comparing functionalities among apps and prioritized including Google Play store versions over the Apple App store versions for the convenience of app review in a web-based emulator. Of the remaining 1024 apps, we excluded 560 (54.7%) apps by title, 400 (39.1%) apps by relevance, and 64 (6.3%) by cost or password-protected download, leaving 149 (39.1%) apps that met the inclusion criteria and were coded. Section B in Multimedia Appendix 2 illustrates the number of apps excluded from the search at each stage of the screening process.

App Store Characteristics

Table S2 in Multimedia Appendix 1 summarizes the coded app characteristics. In the sample of coded apps, 52 (34.8%) came from the Apple App store and 97 (65.1%) came from the Google Play store. In the Apple App store, 52 apps were distributed across the following categories developed by the Apple App store: Medical (n=28, 54%), Health & Fitness (n=16, 31%), Education (n=5, 10%), Utilities (n=2, 4%), and Lifestyle (n=1, 2%). In the Google Play store, 97 apps were distributed across the following categories developed by the Google Play store: Parenting (n=68, 45%), Medical (n=10, 6%), Health & Fitness (n=8, 5%), Education (n=7, 4%), Books & Reference (n=2, 1%), Lifestyle (n=1, 0.7%), and Tools (n=1, 0.7%).

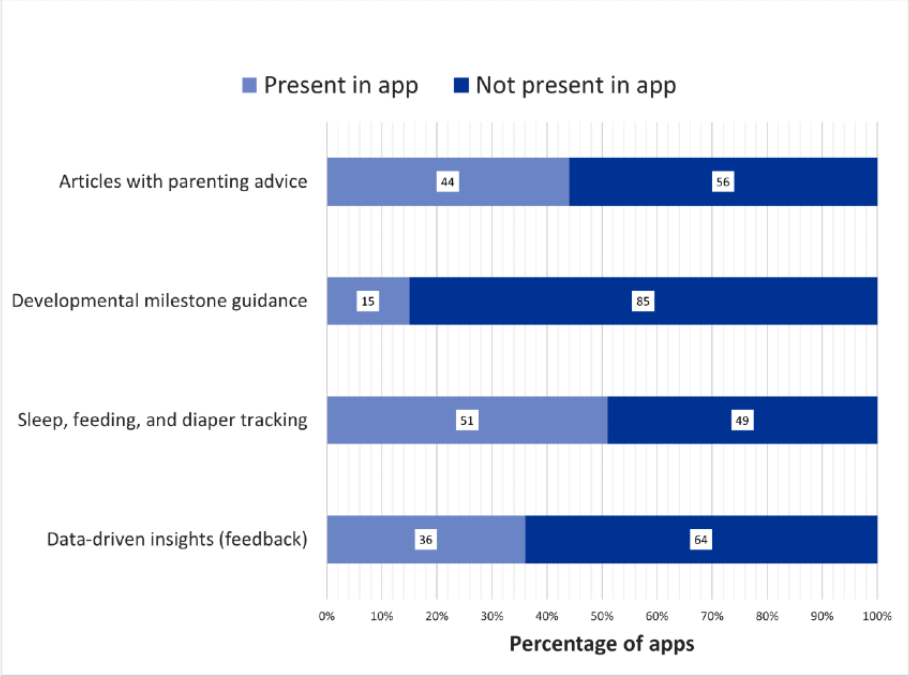
The earliest operating systems supported ranged from 2010 to 2016 (Google Play store) and from 2014 to 2017 (Apple App store). On average, apps supporting operating systems have been released in the last 7 years. The oldest operating systems were supported by apps from the Google Play store: an app supported phones running operating systems released in 2010. Approximately 38% (37/97) of the apps from the Google Play store supported phones running operating systems released in 2013 or older.

Across both the Google Play and Apple App stores, the dates of the app's last update ranged from 2014 to 2022. In the Google Play store, the oldest date of the last update was 2015. On average, apps have had at least one update in the last 2 years. Approximately 45.6% (68/149) of the apps were updated in 2022. An app from the Apple App store had not been updated since July 11, 2014, but at the time of writing, it was still available for download from the app store. Unless specified otherwise, the remaining findings are generalized across both the Apple App and Google Play stores.

App Features

We also categorized apps based on those that provided feedback to guide parent action and those that did not provide feedback. This categorization was based on the functionalities related to the user experience for data entry that emerged from the apps during the data-gathering stage. Figure 1 depicts the features present or absent in the mobile apps used in this study.

Figure 1. Features present in mobile apps.



Apps that provided feedback supported parents in tracking their child's health data and analyzed the data to recommend that parents pursue specific actions. For example, a parent might use an app to track their child's milestones, and the app consolidates information (eg, in a summary for parents to review), determines if there is a delay, and recommends the parent contact a pediatrician for a more detailed assessment of their child's milestone progress. Apps that did not provide feedback allowed parents to track data such as milestones but did not generate personalized feedback on milestones or recommend that parents seek consultation from a pediatrician if their child was delayed in certain milestones. We classified

the apps as providing feedback based on their primary and secondary functions offered in the app. Of the 149 apps included in this study, 54 (36.2%) provided feedback to parents. The remaining 63.7% (95/149) of the apps included in this study were classified into the nonfeedback category, as neither their primary nor secondary functions provided feedback informed by personalized information entered by the parent. Textbox 1 highlights some of the main features present across apps that provided feedback to parents and those that did not.

Textbox 1. List of features in included apps.

Features that provide feedback to parents (in no specific order)

- Data visualizations or summaries of user-generated data
- Dynamic checklist of developmental milestones by age (highlighting on track or off track)
- List of development-promoting activities that parents can try
- Screening checklist for specific child health conditions
- Trivia or quiz questions about child health and parenting topics
- Weight, head, and height centile calculator
- Data entry (eg, diapers, feeding or sleep times, words, vaccines, or new teeth) paired with insights and analysis of data
- Growth chart for weight, height, and head circumference that maps and provides guidance about the child's measurements

Features that do not provide feedback to parents (in no specific order)

- In-app articles with parenting guidance
- Sentence-long parenting tips
- Sentimental milestone diary
- Social media forum to connect with other parents
- Videos demonstrating activities
- In-app shopping for baby and parents
- Data entry (eg, diapers, feeding or sleep times, words, vaccines, or new teeth) without insights or analysis of data
- Growth chart for weight, height, and head circumference that does not map or provide guidance about the child's measurements

Content and Delivery Methods of Apps

We classified the apps into 2 primary categories. The first category included apps that tracked feeding, sleep, and diaper tracking similar to the tracking recommended for parents immediately following birth. The second category of apps included those that proctored developmental milestone screenings through dynamic questionnaires. In all, 6.7% (10/149) of the apps reviewed in this analysis supported feeding, sleep, diaper tracking, and developmental milestone tracking.

Half (76/149, 51%) of the apps reviewed in this study had a primary function related to feeding, sleep, and diaper tracking. In these apps, parents create a data entry of (1) when their infants fall asleep and for how long; (2) how many diaper changes they have in a day and the quality of the infant's excretion; and (3) when the infant was fed, for how long, what they were fed with (eg, breastfeeding or bottle), and which breast the breastfeeding parent used during their feeding session. Some apps include advanced features, such as generating charts detailing average sleep duration, feeding duration, or feeding patterns, if multiple methods are used. However, none of the apps in this category offered feedback based on the data entered by parents. For example, to test the functionalities, a researcher made multiple entries in the apps, demonstrating that the infant had not excreted in over 3 days, as national guidelines for infant health recommend contacting a pediatrician if the infant does not excrete for >3 days. None of the apps flagged this pattern as an issue or recommended the parent contact a health professional.

Of these 149 apps, 66 (44.3%) provided secondary functions, such as access to articles with generic information, which were not personalized to the parent or infant's unique characteristics. These articles included nonspecific parenting advice, information about child developmental milestones, activities to promote children meeting milestones, or photos and video trackers for sentimental child milestones.

Of the 149 apps in total, 23 (15.4%) in this analysis had primary functions related to developmental health promotion and developmental milestone screening. In these apps, parents complete question sets to check their child's progress toward milestones in the 5 key skills outlined by Bright Futures: gross motor, fine motor, speech and language, cognitive, and social and emotional skills. After completing question sets, the apps generated a summary of milestone progress, sharing if the child was on track to meet milestones, required extra support to meet a milestone, was ahead in their milestones, or was behind on a milestone. On average, these apps supported milestone tracking from birth to the age of 5 years, and apps ranged in support across health promotion themes from birth to the age of 8 years. All apps in this category recommended that parents connect with a pediatrician to follow up on their child's developmental progress. In all, 4% (2/53) of the apps in this category shared

milestone-dependent activities that parents could follow to promote their child's progress toward milestones; however, these activities were not tailored to unique constraints that families had (eg, safe environment or resources).

Of the 149 apps, 50 (33.6%) offered content related to early childhood health through articles, web-based forums, or growth charts. Apps in this category typically provide information about child health in a noninteractive way, either through lengthy articles or sentence-long trivia facts. An app in this category allowed users to engage with content in a semitailored way, using a chatbot with predetermined chat options, enabling the user to filter information through interactive means.

User Burden

We coded apps for their perceived user burden based on 6 user burden constructs [20], including the difficulty of use burden, privacy burden, and financial burden. Using these constructs, we coded for user burdens that might deter users from continuing to use the app in a meaningful way. To address time-based burdens, defined by Suh et al [18] as "requires frequent use or a significant amount of time to use," we documented the time that it took the researchers to complete onboarding tutorials and develop an understanding of how to use the app. We identified that of the 149 apps, 62 (41.6%) required less than a minute to complete onboarding tutorials. In total, 80 (53.6%) apps required <5 minutes to complete onboarding tutorials, whereas 7 (4.7%) apps required >5 minutes to complete the tutorials. In total, 24 (16.1%) apps required >10 minutes for researchers to understand how to use them. However, it is important to note that the research team is not representative of the target population, and as such, these estimates cannot be extended beyond this context.

To address the difficulty of use burdens, we coded for the amount of information presented all at once and whether that information was overwhelming (ie, identifying learning curves). Suh et al [18] define difficulty of use burdens as "The system does not fit with the abilities of the user and is difficult to use. Example systems: i) A photo editing soft-ware package with a steep learning curve; ii) A website that is not compatible with a blind user's preferred screen reader." Following this guideline, we documented the presentation of information in the app, and important information about the app's user experience (eg, key functions or menus) were readily surfaced to the user. A total of 23 (15.4%) apps presented high amounts of information to the user right away, such as long, text-heavy articles about parenting that required long durations of scrolling in the app, highly detailed charts without clear labels, or cluttered home screen or menu items that required the user to click through all of them to understand what they were for. We coded 78 (52.3%) apps that presented large amounts of text without audio or video alternatives, which could present accessibility issues for users with low literacy or vision challenges. We did not directly try out the smartphone's system accessibility tools in these apps.

More than half of the apps did not require the user to remember extensive information on their own, including the cadence for data entry in apps that require data tracking, key takeaways from guidance on child behaviors and related parenting actions, and returnability for content that may be relevant for the parent later. A total of 136 (91.3%) apps offered functionality within the app that remembered and surfaced information for the user, such as including reminders to track a child's health metrics or allowing the user to pin relevant pages to access later. We also tracked potential usability concerns related to the mobile app's system responsiveness, within reliability and user experience. A total of 33 (22.1%) apps posed usability and reliability concerns, including delays in functioning or frequent crashes. These apps also posed additional concerns within the user experience, including requiring repetitive actions to track information (not providing a seamless data-entry experience) or not labeling icons with text descriptions that would require the user to interpret imagery on their own to discern functionality. A total of 6 (4%) apps had color schemes with low contrast between the text and backgrounds. Furthermore, 32 (21.5%) apps had text sizes smaller than 16- to 17-point font, which is not recommended by Google in its Material Design guidelines for developers and Apple's Human Interface Guidelines.

Financial Burdens

We also tracked potential financial burdens on the user. Almost half of the mobile apps required in-app purchases to access the full extent of the app's capabilities or to remove advertisements from the app. Liu et al [41] described the business strategy of these apps as *Freemium*, where apps are free to download but have highly limited functionality without the user paying for premium content. A total of 45 (30.2%) apps required an average 1-time payment of US $8 (SD 11.89), ranging from US $1 to US $60. Furthermore, 25 (16.8%) apps required subscription fees to access the full functionality of the mobile app or remove in-app advertisements. Of those apps, subscriptions averaged to US $57 (SD 48.75) per year, ranging from US $3 to US $225 per year, with an average subscription price of US $23.99 per month. A total of 6 (4%) apps in this analysis included companion tools to supplement app features, which parents would need to purchase to take advantage of the full functionality of the app.

We identified that advertisements were another potentially burdensome feature of some apps. Some advertisements could be bypassed by paying for premium features in the app; as such, advertisements frequently interrupted the user's experience with the functions of the mobile apps. In total, 3 (2%) apps had advertisement pop-ups that blocked features in the app for at least 20 seconds. Furthermore, 4 (2.7%) apps had advertisements that presented adult content, such as weapons, drugstores, or adult games.

Privacy and Permissions

The Google Play and Apple App stores have unique systems for tracking the privacy policies of apps, although each store includes information about data-use permissions. Between Apple and Android apps, 30.9% (46/149) of apps listed that data collected from the app would not be linked to the primary user. Among those, 13% (6/46) of apps requested access to potentially sensitive data, such as location, contacts, photos, camera, network connection information (access to internet connection information or Bluetooth devices connected), or existing data on the device. A total of 75 (50.3%) apps requested access to

potentially sensitive data such as those outlined earlier but did not provide information on how the data would be used on the download page. For these apps, data-use policies were located directly in the app. Furthermore, of the 149 apps, 40 (26.9%) apps did not provide any information related to privacy policies or data-use permissions and only 12 (8%) apps allowed users to delete their profiles or data collected in the app. All apps requested potentially identifying information, such as the parent's name and age, child's name and age, and zip code or approximate location.

Developers and Credentials

Using information from individual app pages in the app store and external web-based resources (linked from app pages or within the app), broadly, apps were developed by companies; 125 (83.9%) apps were developed by individual associations. Of these apps, 2 (1.6%) were developed by companies in partnership with researchers at a university. We reviewed the company websites posted on app store pages where the app development teams and credentials were listed. Of these associations, only 12 (9.6%) listed subject-matter experts on their app development teams. A total of 7 (5.6%) apps were developed by parents or people who had parented previously. In total, 106 associations did not mention that they included subject-matter experts or parents or caregivers in their development teams. In all, 3 (2.4%) apps were developed by teams from hospitals or medical centers, 2 (1.6%) apps were developed by government agencies, and 1 (0.8%) app was developed by a nonprofit organization. In total, 14 (9.4%) apps were developed by individuals who did not specify their subject-matter expertise or lived parenting experience. An app was developed by 2 parents with an education in sports science. Among the 149 apps, only 13 (8.7%) apps referenced building content in the app following guidelines from government standards (eg, CDC or World Health Organization guidelines) or by citing relevant literature on early childhood health milestones.

Technical Requirements

We coded technical requirements that may prevent users from continuing to use the mobile app after download. Of the 149 apps, 60 (40.3%) required Wi-Fi or paid cellular data plans to function. In total, 11 (7.4%) apps required more space than specified on the app download page for the downloaded content. Furthermore, 48 (32.2%) apps required an email address to use the full functionality of the app, and 2 (1.3%) apps required a Google account. Of these apps, 4 (8.3%) required a phone number that could receive text messages to sign up for the app.

On average, smartphones made since 2016 hold between 64 and 128 GB of memory storage [42]. On average, operating systems released in 2016 and later require 20 GB of memory to run, leaving between 44 and 108 GB for the smartphone owner's personal data, including app downloads. For the apps included in this analysis, the average size of the apps across both the Apple App and Google Play stores was 0.0314 GB or approximately 0.07% of the space for a smartphone with only 44 GB of space available. The sizes of the apps ranged from 0.0016 GB (approximately 0.004% of space) to 0.3455 GB (approximately 0.8% of space). For the Apple App store specifically, the average app size was 0.06 GB, while the apps from the Google Play store had a lower average size of 0.02 GB.

Health Literacy Requirements

We tracked the health and reading literacy [43] levels required by the apps. The content of an app had substantial grammatical problems that hindered the reader's understanding of the content. We also documented the reading levels required for the content in the apps by selecting samples of reading required for all features in the app. Using the Flesch Reading Ease method, we entered text samples from the apps into a web-based resource that calculated the reading level. In sum, 42.9% (64/149) of the apps in this review presented content below the 7th or 8th grade reading level [44]. Of the 149 apps, 3 (2%) used languages categorized at the college reading level. Of the 113 apps that offered explanations of health topics, 108 (95.8%) apps used simple language (below the 7th or 8th grade reading level) to explain health terms.

Cultural Competence and Personalization

We also included a dimension of evaluation that focused on cultural competency and tailoring of the apps for diverse groups. A limitation of this work is that we did not include apps developed and presented in primary language aside from English. Mobile apps published in app stores require additional steps to optimize them for globalization or availability across >1 language version of the app store [45]. To access apps with primary languages other than English, a user is required to complete additional steps, including modifying their country or region for their settings across their device, obtaining a virtual private network, or having access to a payment card authorized for use in another country [46]. To represent the search experience of people with limited technology literacy, we retained the default search experience for users operating their devices in the United States.

In this study, only 20.1% (30/149) of the apps included offered languages other than English, including Spanish, Mandarin (Chinese), and German. Although we did not include mobile apps developed in a primary language other than English, we did intend to document other aspects of cultural competency that could be present in the design of mobile apps. In this area, we examined the perceived support of multiple cultural experiences following guidance from the theories of cultural competence, an approach to patient care [47]. We documented the diversity of visual aids in apps that included pictures and videos. Only 12.1% (18/149) of the apps in this study offered images, videos, or icons that depicted people of color. In addition, 24.2% (36/149) of the apps did not offer any personalization features. Of the 75.8% (113/149) of apps that did offer personalization features, those features included changing the name of the child or parent profiles in the app, adding images of a child or family, and changing the colors or themes of the user interface. It is also important to note that several of the apps in this study used gendered language when referring to family configurations (eg, referencing mom and dad, offering only male or female choice for child and parent). An app included in the study, *Baby Sparks—Development App*, offers personalization features that address diverse

configurations of families. When getting started in the app, users have the option to self-identify with a broad set of titles, including grandparents, aunt or uncle, development professional, or babysitter. However, similar to the other 12.1% (18/149) of the apps in this study that included diverse imagery, this only includes pictures of families from different races and ethnicities. None of the apps in this study included imagery that presented queer families; caregivers of different ages; or family members with disabilities, different weight ranges, or different religions.

Discussion

This content analysis found that early childhood health apps support 3 categories of child health monitoring: tracking feeding, development tracking, and learning new information about parenting behaviors. By classifying apps, we documented some of the available apps that can support parents in promoting their child's healthy growth.

Searching for Quality Apps

Assessing the quality of mobile apps is an extremely difficult process if the end user is not informed about what qualities they should examine. Parents sometimes seek guidance from trusted sources to navigate the breadth of parenting knowledge available to them, relying on friends and family, curated content from web-based sources, and discussions with web-based communities. Conversations with health providers also inform the decisions that parents make about their parenting practice. Currently, other parents and medical professionals contribute their reviews of mobile apps for child development support on the web. However, reviewing these resources and making an informed decision requires more time and effort from the parents. For this reason, parents generally rely on the content present in the app store to make decisions about which apps are most appropriate for their family's needs [48].

There is an ongoing discussion on the role of the regulation of mobile apps for health promotion, particularly among apps promoting weight loss and dieting, mental health support, and chronic disease management [9]. Within these areas, it is unclear which groups are responsible for the regulation of content and format for mobile apps [49] and at what level in the app development and publishing process. Mobile apps are positioned to spread information widely and directly impact family actions. For this reason, it is important that mobile apps do not promote inaccurate and potentially harmful information. As mentioned earlier, there are some regulations of mobile apps offered by federal organizations, but the provisions of those regulations can be difficult to interpret for people who are not app developers. However, because the question of regulation in mobile apps is ongoing across business, economics, government, medicine, and design, there is a need to support parents who are actively seeking support from mobile apps and prevent the spread of inaccurate and potentially harmful information to families. As mentioned, mobile app users look toward reviews in the app store for more information about the quality of apps before downloading, but these can sometimes be untrustworthy [50]. As parents seek guidance from trusted sources, there is an opportunity to both develop a framework for the evaluation of mobile apps that parents and pediatricians might rely on when comparing apps in the app store and for designers as they develop child health promotion apps. For example, in both the Google Play and Apple App stores, there are categories (eg, device compatibility, languages offered, and images) that communicate high-level information to users before download. There is an opportunity to leverage how information about apps is presented in the app store (eg, screenshots of app content and descriptions of functionality available in the app), with potential to support end users and people who recommend apps (ie, health providers) as they navigate the available apps in the app store.

Finally, for designers, an evaluation framework can act both as a guide for ethical design outcomes and as a method for evaluating the ethics of apps. In this study, some of the content of our coding framework is directly related to digital ethics (ie, user burden). There is ongoing discussion in computing that references digital ethics and opportunities for digital ethics to act as a guide for design decisions, especially among mobile apps [51]. The Associated Computing Machinery provides a code of ethics [52,53] that designers have previously referenced in their work, to develop useful systems without harming users. Although a review of ethical and unethical practices in mobile app design is beyond the scope of this paper, future work in this area might extend the criteria for the evaluation of mobile apps explored in this paper, supporting designers as they make ethical decisions. For example, the criteria for evaluation might include user burden ratings, technical requirements, areas of child development addressed, cultural competency, health literacy required, and content supported by scientific guidelines. The findings of this study can be used as a foundation for researchers to develop an evaluation framework. Designers and researchers might collaborate in this area to develop a set of criteria that represents both the research and design perspectives and requirements for useful and practical guidelines.

In Table 1 we share a few examples of evaluation criteria that researchers and designers might develop for the evaluation of mobile health apps for child health promotion.

There is also an opportunity to improve the search experience in the app store. For example, compatibility with accessibility features in smartphones can be listed directly in the app store such that the user knows what to expect when downloading an app. The search experience can also be improved by providing search filters; for example, which apps are free and which have advertisements. This information is already available in the app store but cannot be reviewed across multiple apps simplistically (eg, when comparing multiple apps). Another potential barrier in the app store search experience is the prevalence of promoted apps, which are prioritized in the search before other apps, regardless of their quality. This is potentially harmful, as it may mislead users to believing that these apps are of higher quality. Radesky and Hiniker [54] broadly promote platforms (which include app stores) being redesigned to be more child-friendly and suggest that through these design changes, systems will widely be less predatory. Finally, there is a need for future work to examine the readability of privacy statements present in both app stores and mobile apps themselves. Currently, the Google Play and Apple App stores offer high-level summaries of privacy and data-use information, and future work might examine the

potential for these summaries to support communicating information related to health data and privacy specifically.

Another adjacent finding worth mentioning is the volume of apps in this study that used a *freemium* business model. App managers have referenced using the *freemium* model to improve the likelihood of users purchasing a premium app after a free trial [41,55], despite lower reviews in the app store. Other researchers have identified that users are willing to pay for apps if they offer more advanced features and improved quality compared with free apps [50]. In this study, the costs of apps ranged significantly, and some app subscriptions were expensive. It is worth considering how lower-income users may be excluded from benefiting from higher-quality apps because of the price burden [20]. Although the use of this business model is at the discretion of companies developing apps and their priorities for app use, there is a need for future work that examines the broad impacts of the *freemium* model for low-income communities and further discussion in industry spaces of the ethics of using *freemium* models for health-promoting mobile apps.

Although beyond the scope of this paper, it is worth noting that several apps included in this analysis were rated as family-friendly but included adult-only content in their advertisements. Other studies have mentioned advertisements in apps that are inappropriate; for example, showing inappropriate advertisement content to children [56]. Although parents are the primary users of the apps examined in this study, future work might address the effectiveness and accuracy of current rating systems for *familyfriendliness* among mobile apps.

Table 1. Examples of criteria for the evaluation of mobile apps for child health promotion.

Criteria	Definition	Professionals involved in refining the criteria
Scientific evidence foundation	What are the sources used for health information in the mobile app? Are these sources based on well-founded scientific claims?	Child health researchers, pediatricians, and public health organizations
Areas of child development covered	Does the mobile app address all the areas of child development based on guidance from health authorities?	Child health researchers, pediatricians, and public health organizations
Information communication format	Does the app offer multiple modes of communication (eg, video, audio, text, or pictures)?	Mobile app designers, human-centered computing researchers, and accessibility and inclusion researchers and practitioners
Technical requirements	Does the app require Wi-Fi or data services? Is the app inclusive of devices that are older or have fewer functionalities?	Mobile app designers and human-centered computing researchers
User burdens of the interface	Does the app prevent user burdens on the user as they interact with the app?	Mobile app designers, human-centered computing researchers, and mobile app designers
User burden of access	Does the app prevent cost, health literacy, reading literacy, or security burdens for the user?	Families, public health professionals, health providers, community health workers, and community organizations
Cultural competence	Does the app support a diversity of family experiences by including languages other than English, using nongendered language, presenting diverse family imagery, and offering inclusive health guidance?	Community health workers, community organizations, health providers following culturally informed practices, and diverse families

Relevancy of Apps for Underserved Groups

Considering the experience of underserved and marginalized people in this space is crucial. Smartphones are widely owned and have the potential to provide new access to information for people without access to care providers or health resources in health networks. We reported space requirements for mobile apps and found that, on average, the size of apps in this category is feasible for the average space available on smartphones. We want to highlight the potential financial burden of these apps. Of the apps reviewed, subscriptions averaged US $57 per year, ranging from US $3 per year to US $225 per year, with an average subscription price of US $23.99 per month. There is a need to further examine the role of financial burdens from apps as a barrier to use by people from lower-income backgrounds in space, as researchers have done for other health apps [57]. Another key finding in this review was related to the lack of culturally diverse visual aids in apps and personalization features. Apps are demonstrated to be more effective when highly tailored to the user's unique experience [58], and culturally informed approaches to health care discourage using one-size-fits-all approaches to patient care and communication [47]. Finally, the apps included in this review have ≤3 primary features at a time. There is potential for more features in a singular app to burden the user and reduce the likelihood that they will learn all the features present in the app or continue to use the app over a longer period. As such, there is a need for future work that documents the use patterns of parents in this area. To specify, what apps do parents use at different stages of their child's growth? What is their experience with managing information across multiple apps at a time? Answering these questions may illuminate opportunities for growth in the field when designing new apps for parent support.

Limitations of This Work

There are several limitations to this work. First, the app market is constantly changing. Since we began this review, it is likely that nearly all of the apps in the study have been updated and improved on. As such, the findings of this study may become obsolete for this domain as apps improve in the future. Another

limitation is that we did not assess the compatibility of the built-in accessibility features of these apps. There is a need for future work that examines how these apps respond when features such as screen readers or text magnification are enabled to capture the diversity of experiences for people using smartphones.

Future work may also address the personalization and cultural relevance of experiences in these apps. Tailoring and personalization of care approaches are extremely important in clinical practice, and for apps to be compatible with care happening in clinical contexts, apps should address this need as well. Finally, unlike other content analyses in this field, we did not include app reviews from the app store in the analysis process. This leaves out a key component of information that is usually relevant as users decide what apps to use and engage with other users in the community [59]. Overall, there is a need for more assessments of mobile apps in this area to continue to capture how mobile health apps for child health promotion are changing over time and how they continue to support families.

Conclusions

We conclude this review by sharing that a plethora of apps are available to parents seeking guidance and support related to their child's developmental progress. Many of these apps are evidence based, provide tailored feedback, and connect parents with supportive resources outside of their immediate networks. However, these apps are difficult to find within the app store because of the high volume of apps that do not support parents in a meaningful way. In addition, for parents working with their providers to seek mobile apps that work in tandem with clinical care, identifying apps that are high quality and have objectives that meet parent needs can be difficult. There is a need for app stores to promote more apps with evidence-based and inclusive content, accessibility features, and high-quality features. In addition, medical, computing, and health informatics researchers might collaborate to develop an evaluation framework specifically aimed at parents seeking child development support through mobile apps. To respond to systemic changes in health care, researchers and developers may also consider the role of health equity in future evaluations and development of new apps.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Coding scheme and characteristics of included mobile apps.
[DOCX File , 49 KB - pediatrics_v5i4e38793_app1.docx]

Multimedia Appendix 2
Search strings and screening process.
[DOCX File , 55 KB - pediatrics_v5i4e38793_app2.docx]

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Abbreviations

CDC: Centers for Disease Control and Prevention

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Original Paper

The Current State of Mobile Apps Owned by Large Pediatric Hospitals in the United States: Systematic Search and Analysis on Google Play and Apple App Stores

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Abstract

Background: Pediatric hospitals in the United States are increasingly leveraging patient-facing mobile apps as their digital front doors for patients, families, and caretakers. These mobile health apps are sanctioned by pediatric hospitals to inform the public or populations about pediatric care to provide individualized information, to enhance communication, and to improve patient experience. Yet the functionalities and user feedback of these hospital mobile apps have not been systematically investigated.

Objective: Our aim was to understand the current state of hospital-owned mobile apps provided by large pediatric hospitals, comparatively analyze and report the services provided, and identify potential gaps to inform developers and providers. The American Hospital Association defines large hospitals as those having a bed count of more than 400.

Methods: We conducted a systematic search on Google Play and Apple App Store to identify all hospital-owned mobile apps from the large pediatric hospitals included in our review. Our inclusion criteria were (1) apps provided by large pediatric hospitals; (2) hospital-owned apps available in Apple App Store and Google Play; and (3) apps that are provided for general populations. Specialty apps that serve specific user groups or populations focusing on education, telehealth, specific conditions or procedures, or apps intended for research or clinician use were excluded. The features and functionality of the included apps were examined.

Results: Of the 16 pediatric hospitals included in our review, 4 (25%) had no general patient-facing apps, 4 (25%) had one app, and 8 (50%) had more than one app available on Google Play or Apple App Store. The 12 hospitals with at least one mobile app had a combined total of 72 apps. Of these 72 apps, 61 (85%) were considered specialty and were excluded from our review, leaving a total of 11 (15%) apps to analyze. Among the 11 apps analyzed, the most common feature was appointment scheduling or reminder (n=9, 82%). Doctor search (n=8, 73%) and patient resources (n=8, 73%) were the second most common, followed by payment, billing, or claims (n=7, 64%), patient portal integration (n=6, 55%), personal health management (n=6, 55%), hospital way finding (n=5, 45%), message a provider (n=4, 36%), urgent care wait times (n=4, 36%), video chat (n=4, 36%), and health information access (n=4, 36%). Parking information (n=3, 27%) was the least common.

Conclusions: Out of the 16 pediatric hospitals identified for our review, 75% (n=12) offer mobile apps. Based on the most common features, these apps were intended to help improve accessibility for patients and families in terms of finding providers, scheduling appointments, and accessing patient resources. We believe the findings will inform pediatric hospital administrators, developers, and other stakeholders to improve app feature offerings and increase their impact on service accessibility and patient experience.

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KEYWORDS

pediatric; child; hospital; mobile app; mobile health; mHealth; health app; digital health; eHealth; hospital-owned app; telehealth; review; app feature; accessibility; patient experience; functionality

Introduction

Ownership of smartphones has continued to increase since their introduction in the mid-2000s. According to Pew Research, 85% of Americans own a smartphone, and over half (53%) of US adults own a tablet computer [1]. The way we interact and engage with the world has become increasingly mobile. Currently, there are over 4.8 million apps available on the Apple App Store and Google Play [2] with over 350,000 of those in the health care domain [3], which shows a more than 3-fold increase since 2014 [4]. This rapid adoption of health care mobile apps shows that more people are using their mobile devices for their health and health care needs. Consumer's expectations of how they interact with health care organizations are shifting toward a mobile-first mindset.

Similarly, recognizing this trend, hospitals have been offering their own apps to meet this demand. An earlier Accenture report presented that two-thirds of the largest US hospitals offer patient-facing mobile health apps [5]. Yet a number of these apps have been poorly implemented, failing to improve patient engagement or provide services. Out of those hospital-owned apps, few offered expected services or functionalities, and it resulted in 2% of patients using these apps [5]. Similar adoption problems have been observed with mobile patient portals as well [6]. Working with younger patients and parents who are more likely to be digital savvy and have stronger desire to be mobile first, pediatric hospitals have more urgency to adapt to this shifting mindset and needs. Pediatric hospitals need to develop their own mobile apps to improve accessibility to better serve their patients and families. There have been mobile health apps to inform the public or populations about pediatric care [7], yet mobile apps provided by pediatric hospitals have not been widely investigated.

The goal of this study is to investigate the hospital-owned apps by large pediatric hospitals in the United States. Large pediatric hospitals serve a high number of patients with a variety of conditions and different populations. Their web-based presence and supporting tools, built to address the patient's needs with hospital services and resources, are essential to serve the large patient population and potentially have a larger impact. Large hospitals usually have the financial resources to comprehensively develop their apps, and most of the time, they are the first in the market to provide new health care technologies and solutions. Therefore, this study focuses on the large pediatric hospitals with our aims being (1) to understand the current state of hospital-owned mobile apps provided by large pediatric hospitals, (2) to comparatively analyze and report the services provided, and (3) to identify potential gaps to inform hospital administration as they plan and improve their digital health strategies.

Methods

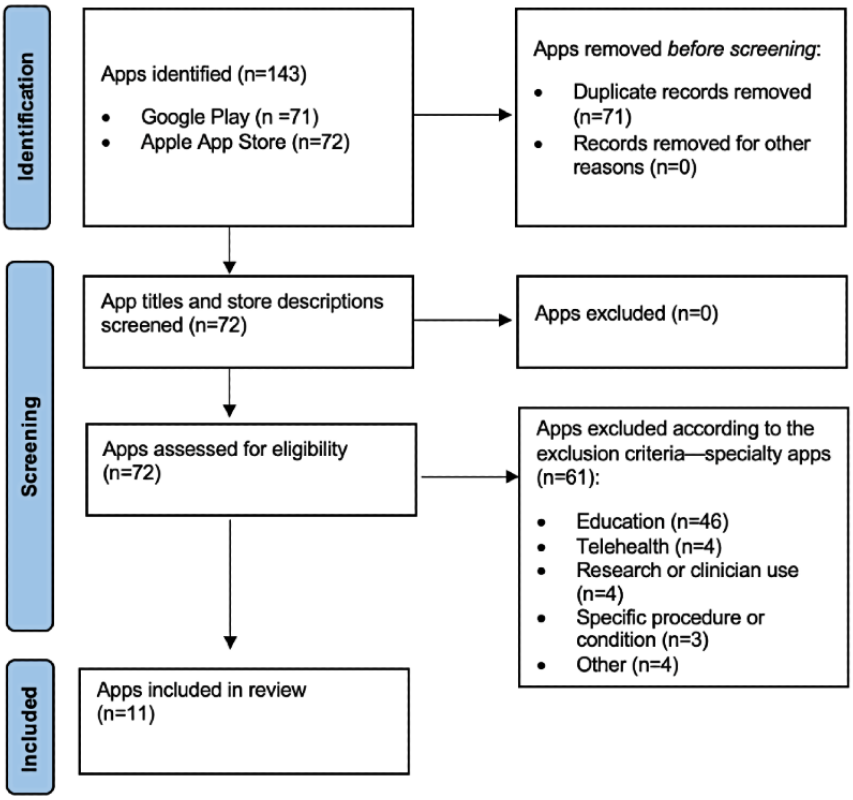
Mobile App Inclusion Criteria

Our inclusion criteria for the health care mobile apps for this study were as follows: (1) they are provided by large pediatric hospitals; (2) they are available in Apple App Store and Google Play; and (3) they are provided for general populations. The American Hospital Association defines large hospitals as having a bed count of more than 400 [8]. Figure 1 shows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram [9], reporting the review procedure.

To identify large pediatric hospitals to include in this review, we leveraged Pediatric Health Information System (PHIS), a comprehensive database with clinical and resource utilization data for inpatient, ambulatory surgery, emergency department, and observation unit encounters for more than 49 children's hospitals. It is frequently used to study pediatric inpatient care [10]. We queried PHIS, last updated in 2020, to identify pediatric hospitals that had a bed count of 390 or greater, to be inclusive of the hospitals that have a small margin to be rated as large hospitals in the following years.

We used the name of each identified hospital to conduct a systematic search on Google Play and Apple App Store platforms to identify all hospital-owned mobile apps. First, authors identified the keywords. Then, the search was conducted by the first author (TL) between November 2, 2021, and January 14, 2022. Specialty apps centered around education, telehealth, specific conditions or procedures, or apps intended for research or clinician use were excluded, as they are intended to serve a subset of the general population (see Multimedia Appendix 1 for the list of excluded apps). The selected apps were downloaded and reviewed by the authors (TL and ES). We downloaded each app from Google Play on a Google Pixel 4a smartphone to review available features. We used an iPhone 11 to download 1 app that only offered an iOS version (myChop). Out of 16 hospitals, apps were provided by 12 (75%), with a total of 72 hospital-owned and specialty apps. A total of 11 apps met our criteria and were included in this review.

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram.



Mobile App Data Extraction and Analysis

Data available on Google Play and Apple App Store were collected for each app including app name, developer, last update, number of downloads, rating, size, requirements, permissions, as well as app content rating. We used summary statistics to compare features among these hospital mobile apps. To compare features among hospitals, we created a chart and listed the features of each app (Multimedia Appendix 2).

We used appbot.co to conduct sentiment analysis on app reviews. appbot.com was claimed to be trained with 400+ million records and have 93% accuracy [11]. The algorithm analyzes and sorts the reviews into four categories: (1) positive sentiment (accounting in positive comments, eg, “Thanks for this app, it makes life a little more easier”), negative sentiment (accounting in negative comments, eg, “Does not accept same log in as online account...”), neutral sentiment (accounting in comments not having strong sentiment, eg, “I am not sure if I like the new design”), and mixed sentiment (accounting in comments with conflicting sentiment, eg, “Excellent app, with great information, but regrettably have to uninstall due its size”) [12].

Results

Overall

A large pediatric hospital identification query to PHIS resulted in 16 pediatric hospitals being included in our review. Of these 16 hospitals, 4 (25%) had no health care mobile apps, 4 (25%) had 1 app, and 8 (50%) had more than one app available on Google Play or Apple App Store. The 12 hospitals with at least one mobile app had a combined total of 72 apps. Of these apps, 61 (85%) were considered specialty and were excluded from our review, leaving a total of 11 (15%) apps for our analysis.

App Features

A total of 12 features were included in our comparison table (Table 1). The most common feature among apps was appointment scheduling or reminder (n=9, 82%). Doctor search (n=8, 73%) and patient resources (n=8, 73%) were the second most common, followed by payment, billing, or claims (n=7, 64%), patient portal integration (n=6, 55%), personal health management (n=6, 55%), hospital way finding (n=5, 45%), message a provider (n=4, 36%), urgent care wait times (n=4, 36%), video chat (n=4, 36%), and health information access (n=4, 36%). Parking information (n=3, 27%) was the least common.

Appointment scheduling and reminders, the most frequently included feature, allows users to schedule appointments with providers directly within the app. Users will also receive a reminder notification of an approaching appointment. Doctor search gives users the ability to search for providers and review their contact information. Patient resources include features such as FAQs, games, blogs, information about nearby hotels, food, and entertainment. Payment, billing, or claims enable users to see statement balances or claims and make a payment within the app. Patient portal integration allows users to log in to Electronic Health Record patient portal, such as EPIC MyChart, directly from the app. Personal health management features allow users to actively manage their health with features such as requesting prescription refills, listing of medications, dosage and immunizations, as well as the ability to enter and track symptoms and medications. Hospital way finding helps direct users to various locations in the hospital using photos or

active navigation. Messaging providers and video chat let users directly message providers and allow them to meet via video. Urgent care wait times allow users to review and receive updates on current wait times at urgent care. Health information access is the feature for the patients and caregivers to access detailed medical information. Finally, parking information lets users see available parking prior to arriving at the hospital.

Table 1. Categorized features of the apps.

Features or pediatric hospitals	Texas Children's Hospital	Cincinnati Children's Hospital Medical Center	Nationwide Children's Hospital	Children's Hospital of Philadelphia	Children's Healthcare of Atlanta	Akron Children's Hospital	Children's Health, Dallas	Phoenix Children's	Boston Children's Hospital	St. Louis Children's Hospital	Cook Children's Medical Center	Apps with the listed feature, n (%)
Appointment scheduling and reminder	X[a]	X		X	X	X	X		X	X	X	9 (82)
Doctor search		X		X	X	X	X	X		X	X	8 (73)
Patient resources	X	X	X		X	X	X	X		X		8 (73)
Payment, billing, or claims	X			X		X	X		X	X	X	7 (64)
Patient portal integration			X		X	X	X	X		X		6 (55)
Personal health management		X	X	X	X	X				X		6 (55)
Hospital way finding		X			X	X	X	X				5 (45)
Message provider	X			X					X		X	4 (36)
Urgent care wait times		X	X		X		X					4 (36)
Video chat	X			X			X				X	4 (36)
Health information access				X		X			X		X	4 (36)
Parking information		X					X	X				3 (27)

[a]X: indicates whether or not a hospital's mobile app offers that feature.

App Data

All apps in this comparison have been updated within the last 2 years, with 82% (9/11) having been updated in 2021. In terms of number of downloads, 55% (6/11) have >10,000 downloads, 27% (3/11) have >5000 downloads, and 1 app has been downloaded >100 times. The number of downloads is only available for Android versions on Google Play store. Therefore, we were unable to find the number of downloads for 1 app, as it is only offered in the iOS version. App size ranged from 16 MB to 152.2 MB with an average size of 68 MB. All apps were available in English with 90% (10/11) also offering one or more additional languages. Texas Children's, Children's Healthcare of Atlanta, Akron Children's, Children's Health, Phoenix Children's, St. Louis Children's, and Cook Children's Medical Center all offer their app in Spanish, in addition to English. Nationwide Children's, Children's Hospital of Philadelphia,

Boston Children's, and Cook Children's Medical Center offer Spanish and other languages.

App Ratings and Sentiment Analysis

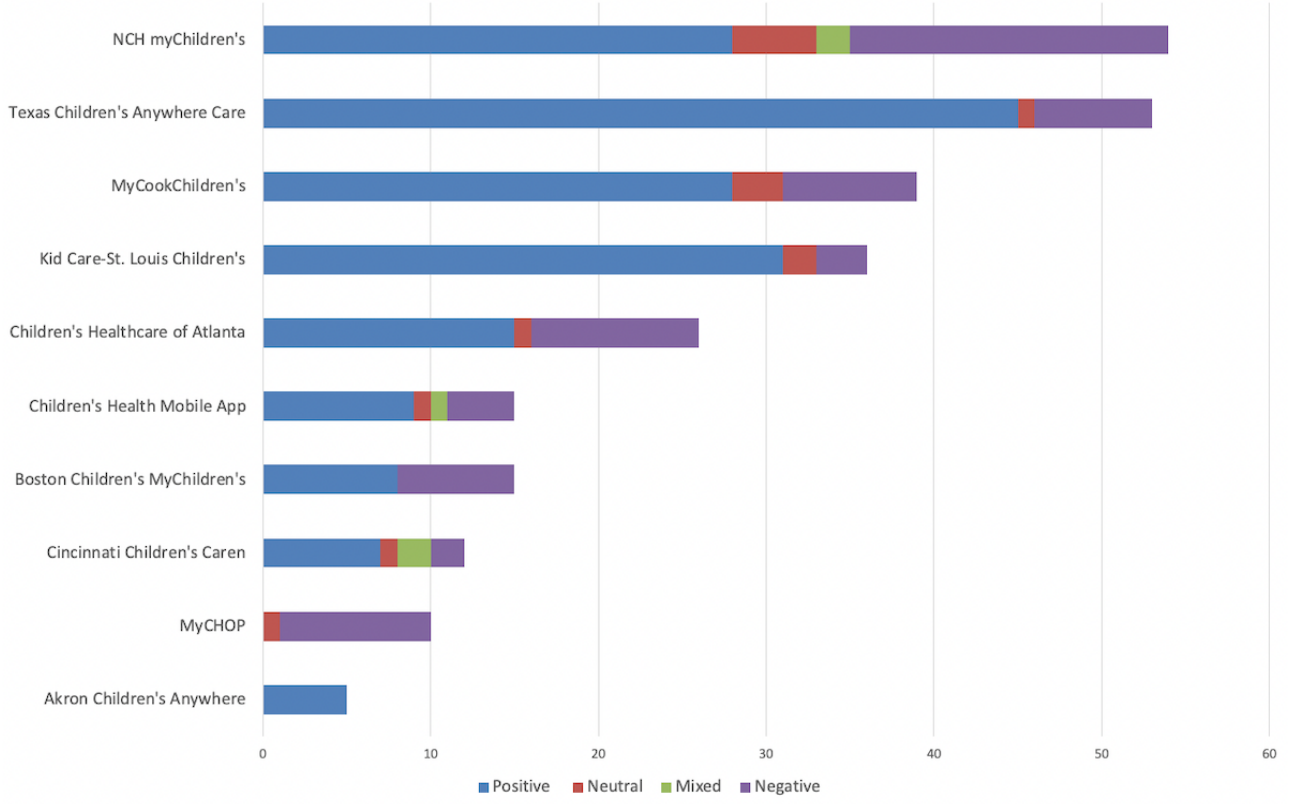
We combined app ratings and number of reviews from both Google Play and Apple App Stores for each app (MyChop was only available in iOS) to determine the average rating and total number of reviews. Ratings for the selected apps, with minimum and maximum allowed as 1 and 5, respectively, ranged from 3.1 to 5, with an average rating of 4.4. Only 265 people left written reviews, and their ratings averaged at 3.4 (Table 2). Texas Children's Anywhere Care app and Nationwide Children's myChildren's app had the highest number of reviews among others (n≥50). The total number of app reviews was 1433. We conducted sentiment analysis (Figure 2) of app reviews using AppBot, a third-party review and ratings analysis tool, to determine positive, neutral, mixed, and negative sentiment of user reviews. Phoenix Children's was excluded because the app had no reviews.

Table 2. App ratings and comments.

Pediatric hospitals	Number of ratings given (n=1433), n (%)	Average rating (out of 5)	Number of app comments (n=265), n (%)	Average rating with comments (out of 5)
Texas Children's Anywhere Care	488 (34)	4.8	53 (20)	4.15
MyCookChildren's	320 (22)	4.7	39 (15)	4.1
NCH[a] myChildren's	218 (15)	4.2	54 (20)	3.15
Kid Care-St. Louis Children's	105 (7)	4.7	36 (14)	4.55
Children's Healthcare of Atlanta	74 (5)	4.25	26 (10)	3.65
Cincinnati Children's Caren	62 (4)	4.5	12 (5)	4.6
Children's Health Mobile App	61 (4)	4.7	15 (6)	4.05
Boston Children's MyChildren's	40 (3)	3.7	15 (6)	3
MyCHOP	39 (3)	3.1	10 (4)	1.5
Akron Children's Anywhere	20 (1)	4.45	5 (19)	5
Phoenix Children's Hospital	6 (0.04)	5	0 (0)	0

[a]NCH: Nationwide Children's Hospital.

Figure 2. Sentiment analysis distribution (Phoenix Children's excluded due to 0 reviews). NCH: Nationwide Children's Hospital.



Mobile Operating System Requirements and Privacy

Software requirements for each app differed, for both Android and iOS platforms. Apps downloaded from Google Play required Android versions ranging from 4.4 (originally released in 2013) to 7 (originally released in 2016). iOS versions of apps were available on iPhone, iPad, iPod Touch, and Mac devices, and required iOS versions 9 (originally released in 2015) to 13.2 (originally released in 2019). In terms of privacy, Texas Children's Anywhere Care app required the highest number of permissions (24) including access requests to device location, photos, camera, microphone, etc. MyCHOP required the least with no permissions or data being collected from the app.

Discussion

Principal Findings

This review provides an overview of current state features and functionalities of large pediatric hospital–owned mobile apps in 2022. Out of 16 large pediatric hospitals in the United States, most of them (n=11, 85%) owned at least one app. This suggests the significance and investments on mobile apps by large pediatric hospitals to support communications with patients and caregivers via smartphones. This finding could be essential for decision makers for pediatric hospital investment strategies in mobile health apps [13]. The 7 hospitals in our review that do not offer any mobile apps may be at risk of seeing a decline in patient satisfaction, as hospital mobile app use has been shown to increase overall patient experience [14]. Hospitals without mobile apps should consider how features made available by other hospital apps could benefit their own patients and families.

Most of the apps offered similar functionalities. We identified personal health management and patient resources, appointment scheduling and reminders, and doctor search as the top features among included apps, followed by payment, billing, or claims, patient portal integration, hospital way finding, message a provider, urgent care wait times, and parking information. These categories suggest that hospitals aim to facilitate primarily remote care and in-hospital navigation and care management over their apps. Such practices can reduce hospitals' operation costs, improve efficiency [15], and enhance patient engagement [16]. Doctor search as well as appointment scheduling and reminders were top features in a similar app review conducted in Taiwan [17].

Accessibility

Accessibility is reported in terms of app size, cost, maintenance, and language availability in this section. All the apps have been actively maintained, given the fact that they have been updated within a year period (in 2021 or later). They are all free to download. App sizes ranged from 16 MB to 152.2 MB with an average size of 68 MB. With the minimum storage of modern smartphones at or above 32 GB [18], these free health care mobile apps offer great accessibility in terms of users being able to download and store an app on their phone without sacrificing storage capacity. Nonetheless, there may still be a digital divide such as lack of access to a smartphone, insufficient data plans or internet access, or low digital literacy, which may limit the access of these mobile services for underserved populations (eg, low-income patients, senior citizens, and rural patients). Practitioners should consider the digital divide and barriers in owning and using technologies by the populations; 1 in 5 low-income adults and approximately 30% of senior citizens do not own a smartphone but have a cell phone. In addition, rural residents, racial and ethnic minorities, people living on tribal lands, low-income families, and senior citizens are less likely to have broadband at home [19].

Language could be another potential barrier to patients accessing these apps. Language barriers in health care lead to miscommunication between the medical professional and patient, reducing both parties' satisfaction and decreasing the quality of health care delivery and patient safety [17,20]. All apps were offered in English, with 90% also offering the app in Spanish. Only 36% (n=11) of hospitals offered their app in more than English and Spanish. Pediatric hospitals serve diverse populations and must account for a broader spectrum of languages.

App Rating

The total number of ratings among all 11 apps was 1433 with an average rating of 4.4 out of 5. There was a total of 265 app comments among all 11 apps with an average comment rating of 3.4. Overall, the sentiment of comments left by users in the app stores was positive. There was a 1-point rating difference between average ratings among all raters (4.4) and among raters who provided user comments (3.4). This difference may indicate that a higher volume of less satisfied app users are leaving reviews and comments on the app stores versus satisfied users. However, it is hard to quantitatively interpret correlation among user review sentiments and app ratings and review quantity [21].

There is a broad range for the number of ratings per app—Texas Children's has 488 ratings while Phoenix Children's has 6. This range may be impacted by factors such as patient volume, location, app functionalities, and more. The apps with high number of ratings and average rating scores and sentiment analysis results could be considered as a benchmark by other hospitals to identify the features to include. For instance, Texas Children's received the highest average rating and positive sentiment comments (4.8/5). The volume of raters and high ratings may indicate that the features from these apps may offer insight when developing hospital apps (considering potential reviewer biases). Developers should consider user feedback to improve pediatric hospital–owned apps to be more aware of user needs and proactively address app issues and fill the identified gaps [22].

Privacy

Privacy and security concerns of user data remain one of the top barriers to adoption of mobile health apps. Users could be concerned about what data are being collected and stored, who can access the data, and what purposes the data are being used for [23]. We found that the number of access permissions for pediatric hospital–owned apps goes up to 24 access points, which consist of collecting data from phone sensors and controlling phones (see Multimedia Appendix 1 for permission requests by each app). The MyCHOP app does not collect any

data from the user, while Texas Children's Anywhere Care app requested 24 permissions for data collection. Most of the data collected from apps included location, access to photos, videos and camera, microphone, Wi-Fi connections, and more. Several apps collected data that would not be linked to the user's identity but may be used for the developer's advertising or marketing purposes.

Even though privacy is one of the user's concerns, literature shows that most mobile apps do not prioritize privacy of user data. For example, of the 79 mobile health apps certified as being clinically safe and trustworthy by the United Kingdom National Health Service, 89% were found to transfer information online, 66% of which was not encrypted [24]. Developers of pediatric hospital–owned apps must follow privacy policies of hospitals and health institutions to ensure the apps are compliant and collect only necessary data and explain how those data will be used and protected to the end users.

Limitations

One limitation was the study being limited to large pediatric hospitals in the United States. This limited the study to opt out smaller sized pediatric hospitals or adult hospitals in the United States or abroad. Second, hospitals included in this review were based on bed count. This limitation excludes hospitals that may have lower bed count, but higher number of annual visits. Third, features outlined in this review are subject to change, as these apps are continually being updated on a regular basis. Fourth, we were not able to assess the quality of the mobile apps due to limited access to the apps (without being a hospital patient or having an account). Fifth, due to time and resource constraints, we were not able to analyze user comments to identify which features users felt needed to be improved or which features were lacking from each app. Sixth, the comments and ratings could be impacted from behavioral biases; based on the experience of the reviewer, there could be polarized reviews that we were not able to analyze and identify [25]. In addition, negativity bias or confirmation bias could be considered while reviewing the results [26,27]. Lastly, we did not focus on the impact of these apps to improve patient care or health outcomes. In that regard, future works are suggested to investigate how hospital-owned mobile apps impact patient experience, health outcomes, as well as comparing app quality across hospitals (eg, using mobile app rating scales [28,29]).

Specialty apps (n=61) were excluded from our study, which were provided by specific clinical departments, or focused on research studies, education, telehealth, procedures, or conditions. The number of specialty apps may indicate that app development within some pediatric hospitals is conducted in silos within clinical departments or research groups, which raises questions about their governance, cross-integration, and contributions to the hospital operations. Further studies are suggested toward the specialty apps.

Conclusions

In this study, we reviewed hospital-owned mobile apps provided by large pediatric hospitals in the United States. Out of 16 hospitals identified, 75% of pediatric hospitals in our review offer mobile apps. Based on the most common features, these apps were intended to help improve accessibility for patients and families in terms of finding providers, scheduling appointments, and accessing patient resources. Inferring actual usage of the health care apps from the number of downloads and user ratings, the adoption of mobile apps is still a major issue. Future works should study the processes that hospitals use when developing mobile apps to ensure user feedback is considered, as well as accessibility and privacy considerations, when determining the features to be implemented. Gathering user feedback will help developers determine the most desired features and may help increase adoption. Developing apps using user-centric, iterative approaches, soliciting inputs from representative user bases, and incorporating feedback from active users will be key to continuously improving health care mobile apps to reach the goals of having them serve as the digital front door, enhancing patient communication and improving patient experience, among others. We believe our findings will inform hospital administrators, developers, practitioners, and other stakeholders to identify and improve app features and services in pediatric hospitals.

Conflicts of Interest

None declared.

Multimedia Appendix 1
This file is a list of apps that met our exclusion criteria and were not included our review.
[PDF File (Adobe PDF File), 112 KB - pediatrics_v5i4e38940_app1.pdf]

Multimedia Appendix 2
Spreadsheet containing full app comparison.
[PDF File (Adobe PDF File), 145 KB - pediatrics_v5i4e38940_app2.pdf]

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Abbreviations

PHIS: Pediatric Health Information System
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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Original Paper

Associations Between Adolescent Problematic Internet Use and Relationship Problems in Chinese Families: Findings from a Large-scale Survey

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Abstract

Background: Problematic internet use (PIU) is prevalent among Chinese adolescents. There is a need to better understand how the quality of parent-adolescent relationship is associated with adolescent PIU to guide the development of effective prevention and early intervention programs.

Objective: This study aims to evaluate parent-adolescent conflict and parenting styles as potential risk factors associated with adolescent PIU.

Methods: A sample of 6552 students (aged 10-19 years) from 22 schools in Guangdong, China, was recruited. The participants completed self-report questionnaires measuring their perceptions of conflict with their parents (involving verbal conflict, emotional abuse, and physical abuse) as well as their perceptions of their parents' parenting styles (including parental care and parental control as measured by the Parental Bonding Inventory), and PIU using the Adolescent Pathological Internet Use Scale. Grade level and gender were examined as moderators of these associations.

Results: Using multiple regression analyses, we found that greater mother-adolescent conflict, father-adolescent conflict, and parental control, and lower levels of parental care, were associated with higher levels of adolescent PIU (P<.001). The association between mother-adolescent conflict and PIU was stronger in older students than in younger students (P=.04), whereas the association between father-adolescent conflict and PIU was stronger in male students than in female students (P=.02). Compared with those who reported no mother-adolescent conflict, participants who experienced verbal conflict and emotional abuse, but not physical abuse from their mothers, reported higher levels of PIU (P<.001). Compared with those who reported no father-adolescent conflict, participants who experienced verbal conflict, emotional abuse, and physical abuse from their fathers had significantly higher levels of PIU (P<.001, P<.001, and P=.02, respectively).

Conclusions: These findings point to the value of interventions to reduce parental verbal conflict, emotional abuse, and physical abuse, and to increase positive parenting styles, to lower the risk of PIU in Chinese adolescents.

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KEYWORDS

problematic internet use; parental bonding; verbal conflict; emotional abuse; physical abuse; adolescent; teenager; internet use; internet usage; abuse; abusive; conflict; family; parental bond; student; Asia; China; parent-child bond; high school; child

Introduction

Problematic internet use (PIU) involves a strong compulsion to use the internet to the extent that it creates significant problems for the user, including social isolation, mental health concerns, and academic performance problems [1-3]. While internet use is beneficial in many aspects, for a proportion of adolescents, internet use dominates daily life and is associated with negative psychological, social, and physical impacts, resulting in PIU. Given that adolescence has been shown to be a vulnerable period for a range of mental health problems [4], it is important to identify the risk/protective factors of PIU for early prevention. PIU is reported by around 9% of Chinese adolescents [5]. A systematic review found that the main risk and protective factors for adolescent PIU that have been investigated appear to be individual factors (eg, psychopathology, academic disposition, or personal attributes), with the authors calling for more research exploring contextual risk/protective factors (eg, family, peer, and school relationships) and internet activity–related factors (ie, internet application used) [6]. Given the emerging evidence that family relationships are likely to be an important contextual risk/protective factor for adolescent PIU [7], this study aims to contribute to the literature by further investigating potential family relationships that may be risk and protective factors of adolescent PIU in China.

Based on Attachment Theory [8,9], adolescent's emotional security is largely influenced by the quality of the parent-child relationship, with less care from parents and feeling more controlled by parents linked to higher emotional insecurity, which in turn can increase the risk of adolescent problematic behaviors [10]. This is because adolescents may develop internal working models of themselves as unworthy of love, and of others as unreliable in providing emotional security, based on their interactions with attachment figures (eg, parents) [11]. From this perspective, adolescent PIU can be seen as a maladaptive coping strategy to manage an adolescent's distress, or unmet emotional needs, arising from parent-child relationships [12]. For example, Yu et al [13] investigated the prospective relations between parental control and maladjustment in Chinese adolescents. Their results found that high levels of paternal control were predictive of depressed mood, anxiety, and aggression among Chinese adolescents. Similarly, Siomos et al [14] found that parental control is a parenting style that is prospectively and positively associated with PIU after taking into account parental online safety practices. In addition, adolescents with PIU report experiencing a greater lack of emotional warmth and feelings of rejection from parents than adolescents without PIU [15]. Moreover, Faltýnková et al [16] found that a parenting style that exhibited more warmth was a protective factor, while parental control was a risk factor, for adolescent PIU after considering other family factors such as parental monitoring. Such research highlights the importance of examining the relationships between the 2 main dimensions of parenting style that have been shown to be associated with adolescents bonding to their parents (parental control and parental care) and the presence of adolescent PIU. However, previous studies have not examined the unique contribution of multiple aspects of parenting styles to Chinese adolescents' PIU. Therefore, more research is needed to investigate the independent effects of parenting styles, such as parental warmth/care and control, on PIU among Chinese adolescents.

In addition to parental bonding, there is evidence that other specific parent-adolescent interactions may be important risk factors for adolescent maladaptive coping and mental health problems. For instance, longitudinal studies have demonstrated that family conflict is consistently associated with poor adolescent mental health [17,18]. More specifically, emerging evidence shows that parent-adolescent conflict is likely to predict PIU. For example, Lo et al [19] reported that more harsh parenting (defined by physical abuse and verbal aggression) was related to higher PIU in a sample of 1204 Chinese adolescents from 7th to 9th grade [19]. However, there is little research exploring whether conflict with parents is an additional risk factor for PIU after controlling for parental bonding. Only a recent study has found that both higher levels of parental control and physical/verbal abuse by parents (forms of parent-adolescent conflict) were associated with higher levels of internet gaming disorder (a related construct to PIU) among 2666 Chinese students aged 11-13 years [20]. As such, there is emerging empirical evidence indicating that there may be multiple parent-adolescent interactions that are independent risk and protective factors for adolescent PIU. Gaining a more comprehensive understanding of the range and relative strength of these independent risk and protective factors will help guide the development of more targeted family-based intervention programs for adolescent PIU.

Furthermore, given that the prevalence of PIU varies by gender and grade [21], it is possible that association between risk and protective factors and PIU may be moderated by gender and age. In terms of gender as a potential moderator, there is evidence that adolescent girls tend to be more reactive to interpersonal conflict, leading to a greater use of maladaptive coping in response to interpersonal conflict, compared with adolescent boys [9]. Similarly, previous research has found that the positive associations of mother-adolescent conflict and teacher-adolescent conflict with adolescent depressive symptoms were stronger in female students than in male students [22]. We, therefore, anticipate that the associations between family-based relationships (ie, parent-adolescent conflict and parenting styles) and PIU will be stronger in female adolescents than in male students. In terms of grade level as a potential moderator, previous research has reported that older adolescents are likely to have higher PIU [23]. Older adolescents are more inclined to anxiety and depressed mood than younger adolescents, and previous research has found that the association of peer-adolescent conflict with PIU is stronger in older adolescents than in younger adolescents [24]. Therefore, we expect that the effects of family-based relationships on PIU will be stronger in older adolescents than in younger adolescents.

In addition, this study aims to explore the relations between specific forms of parent-adolescent conflict such as verbal conflict, emotional and physical abuse, and adolescent PIU. Parent-adolescent conflict has been considered as a risk factor for adolescent maladjustment [25], including adolescent PIU [26], but it has also been considered as developmentally normal

and may be an important social developmental experience for acquiring expressive and problem-solving skills [27]. Moreover, there is some evidence that different forms of adolescent conflict with parents have varying effects on adolescent mental health [28,29]. It is therefore possible that different forms of parent-adolescent conflict may produce different levels of risk for adolescent PIU. Associated with this, there is evidence that father-adolescent relationships may have different associations with adolescent PIU than mother-adolescent relationships. For example, Liu et al [30] found that lower levels of father-adolescent relationships (defined by dimensions such as perceived emotional closeness and communication), but not mother-adolescent relationships, were associated with higher levels of PIU [30]. Hsieh et al [31] also discovered that paternal but not maternal physical abuse predicted PIU among Chinese fourth-grade students. As such, we will compare the associations between different forms of adolescent-parent conflict and PIU separately for mothers and fathers.

In summary, the key hypotheses and exploration aims for this study are as follows:

- Mother-adolescent conflict and father-adolescent conflict will be positively associated with PIU after controlling for gender, grade level, maternal and paternal education level, family structure, and academic rank.
- After accounting for the aforesaid variables, higher levels of parental care will be associated with lower levels of PIU, whereas higher levels of parental control will be associated with higher levels of PIU.
- These associations will be moderated by gender and grade in that the effects for parenting styles and parent-adolescent conflict will be stronger for females than for males, and stronger for older students than for younger students.
- Compared with adolescents experiencing no mother-/father-adolescent conflict, those experiencing verbal conflict, emotional abuse, or physical abuse from their mothers/fathers will experience varying effects on PIU.

Methods

Participants

The sample was recruited from schools in Longhua District, Shenzhen, Guangdong, China. In phase 1, 22 out of 59 schools from 4 administrative districts were randomly selected. In phase 2, 3 classes were selected from each grade out of grades 5, 6, 7, 8, 10, and 11 among the selected schools. Students from grades 9 and 12 were not included as they were in tight study schedules. A total of 6638 students were invited in the study with a response rate of 98.70% (6552/6638). According to the World Health Organization's recommended age for adolescent [32], we only included participants aged 10-19 years, resulting in 6552 adolescents included in the final analysis.

Measures

Demographics

The demographic variables in our study were age; gender; academic ranking; grade level (primary school including grades 5 and 6, secondary school including grades 7, 8, 10, and 11); family structure (ie, the first category, including those living as nuclear families, and others category, including but not limited to single-parent families or reconstituted families); maternal and paternal education level (9th grade or less, 10–12th grade, and undergraduate degree or above).

Problematic Internet Use

Adolescents reported on the degree of PIU using the 5-item Adolescent Pathological Internet Use Scale [2]. This scale includes 38 items, with each item rated on a Likert scale (from 1="not true at all" to 5="true all the time"). Higher scores indicate higher PIU. The scale has good convergent validity compared with other commonly used scales (eg, Young's Internet Addiction Test, Chen Internet Addiction Scale). Its test-retest reliability and internal consistency were also high (0.86 and 0.97, respectively), as reported in a previous study [33]. In our study, the Cronbach α for the scale was .97.

Mother-/Father-Adolescent Conflict

This was assessed using the following 3 questions in Mandarin: verbal conflict "In the past 12 months, have you ever had a serious quarrel with your mother/father?"; emotional abuse "In the past 12 months, have you been emotionally punished (eg, being scold, threatened) by your mother/father?"; physical abuse "In the past 12 months, have you ever been physically punished (eg, being forced to stand for some time) by your mother/father?". Conflict measurement was rated using the 5-point Likert scale (from 0="never" to 4="always"), with higher scores indicating higher levels of mother-/father-adolescent conflict. These items have been applied in previous studies on Chinese adolescents [22,34]. The Cronbach α in this study was .64 for mother-adolescent conflict and .74 for father-adolescent conflict.

Parenting Styles

Parenting styles are commonly measured using the Parental Bonding Instrument (PBI), which defines optimal parental bonding in terms of a combination of high parental care (eg, warmth, empathy) and low parental control (eg, overprotection, intrusion) [35]. The PBI consists of 20 items and uses a 5-point Likert scale ranging from "strongly agree" to "strongly disagree." The PBI has 2 subscales (parental care and parental control), for mothers and fathers separately, each with 10 items. Items 1, 4, 5, 6, and 8 score from 0 (strongly agree) to 4 (strongly disagree). Items 2, 3, 7, 9, and 10 score from 4 (strongly agree) to 0 (strongly disagree). Higher scores indicate higher levels of parental care and lower levels of parental control that adolescents perceive. The PBI has 2 subscales (care and control), for mother and father separately, each with 10 items. Examples include "My mother/father appeared to understand my problems and worries" and "My mother/father tried to control everything I did." A composite α value for each subscale (eg, mother care and father care combined) was reported in previous research [35]. The Cronbach α values for this study (.61 for parental control and .81 for parental care) were comparable with previous research [16] (.65 for parental control and .88 for parental care).

Procedure

Students completed this survey during class time. All items on the survey were written in Mandarin. Research assistants supervised the survey completion in the absence of the teachers. Participation in the survey was voluntary without any information that can be identified.

Statistical Analyses

All statistical analyses were performed using SPSS version 25.0 (IBM Corp.). Of the total sample size (N=6552), the percentage of missing data for all variables was less than 6% (386/6552, 5.89%). Missing values were imputed 20 times using multiple imputations in SPSS and the pooled value was used for the results. Pearson correlation was used to examine the bivariate associations between the variables. To examine whether there was a significant difference between schools, a 2-level (individuals nested within schools) linear regression was performed, which indicated that only around 4% of variance was explained at the school level, suggesting that there was low clustering of observations (intraclass correlation <0.05). Hence, multiple linear regression was used to examine the associations between the quality of family relationships and PIU after controlling for the covariates (see hypotheses). The independent variables were transformed into centered values to avoid multicollinearity before building into the regression models. In addition, moderation effects of gender and grade on PIU were tested by adding interaction terms to the model (ie, mother-/father-adolescent conflict × gender, mother-/father-adolescent conflict × grade, parental care/control × gender, parental care/control × grade). Furthermore, planned comparison analyses were used to test the difference between participants reporting no mother-/father-adolescent conflict and those reporting any verbal conflict, emotional abuse, and physical abuse from their mothers/fathers, with “0”=no score of conflict on all 3 questions regarding conflict; “1”=only score verbal conflict, no emotional or physical abuse; “2”=only score emotional abuse, no verbal conflict or physical abuse; “3”=only score physical abuse, no verbal conflict or emotional abuse; “4”=score all verbal conflicts, emotional abuse, and physical abuse.

Ethics Approval

This project was approved by the Ethics Committee of the School of Public Health at Sun Yat-sen University, Guangzhou, China (number 2015-016). Written informed consent was provided by parents and assent was collected from all adolescent participants. This project also obtained administrative approval from the Queensland University of Technology Human Research Ethics Committee (Reference number: 108117).

Results

Preliminary Analyses

Table 1 shows the demographics of all the participants in this study. The mean age of participants (N=6552) was 13.51 (SD 2.93) years. In summary, 57.94% (3573/6166) of total participants were male; 43.71% (1734/3967) were from primary schools, with the remaining attending secondary school. Furthermore, 91.33% (5984/6552) were from nuclear families, and 10.82% (709/6552) of participants’ mothers and 15.55% (617/3697) of participant’s fathers had undergraduate degrees or above.

Table 1. Demographic characteristics of study participants (N=6552)[a].

Demographic variables	Boys (n=3967), n (%)	Girls (n=2585), n (%)	Total sample, n (%)
Grade			
Primary school	1734 (43.71)	1121 (43.37)	2855 (43.57)
Secondary school	2233 (56.29)	1464 (56.63)	3697 (56.43)
Family structure			
Nuclear families	3593 (90.57)	2391 (92.50)	5984 (91.33)
Others[a]	374 (9.43)	194 (7.50)	568 (8.67)
Maternal education level			
9th grade or less	2585 (65.16)	1637 (63.33)	4222 (64.44)
10-12th grade	950 (23.95)	671 (25.96)	1621 (24.74)
Undergraduate or above	432 (10.89)	277 (10.72)	709 (10.82)
Paternal education level			
9th grade or less	2164 (54.55)	1320 (51.06)	3484 (53.17)
10-12th grade	1186 (29.90)	835 (32.30)	2021 (30.85)
Undergraduate or above	617 (15.55)	430 (16.63)	1047 (15.98)

[a]Includes but limited to, for example, single-parent families or separated families.

Bivariate Correlation Analyses

Tables 2 and 3 show the means and SDs of the key variables categorized by sex. In addition, independent correlations between mother/father conflict, parental care/control, and PIU are presented in Table 3. The results show that mother-adolescent conflict and father-adolescent conflict were positively correlated with adolescent PIU. Moreover, parental care was negatively correlated with PIU, whereas parental control was positively correlated with PIU. These correlations were small in absolute magnitude ($0.1<r<0.3$).

Table 2. The mean and SD of variables.

Variables	Boys	Girls	Total
Mother-adolescent conflict	1.88 (1.79)	1.90 (1.93)	1.46 (1.96)
Father-adolescent conflict	1.56 (2.00)	1.29 (1.86)	1.91 (1.87)
Parental care	20.71 (5.26)	20.90 (5.29)	20.74 (5.28)
Parental control	12.61 (4.40)	12.11 (4.14)	12.48 (4.30)
Problematic internet use	73.32 (30.42)	64.32 (26.30)	69.47 (29.23)

Table 3. Correlation analysis (r).

Variables	Mother-adolescent conflict	Father-adolescent conflict	Parental care	Parental control	Problematic internet use
Mother-adolescent conflict	—[a]	0.49[b]	–0.42[b]	0.14[b]	0.26[b]
Father-adolescent conflict	—	—	–0.38[b]	0.17[b]	0.21[b]
Parental care	—	—	—	–0.21[b]	–0.25[b]
Parental control	—	—	—	—	0.12[b]
Problematic internet use	—	—	—	—	—

[a]Not applicable.

[b]$P<.01$.

Multiple Linear Regression Analyses

Hypotheses 1 and 2 were tested using step 1 of a stepwise regression, with mother-adolescent conflict, father-adolescent conflict, parental care, and parental control as the independent variables and PIU as the dependent variable (Table 4). After the covariates were entered, higher mother-adolescent conflict, higher father-adolescent conflict, and higher parental control were independently associated with higher PIU (β=.145, $P<.001$; β=.077, $P<.001$; β=.055, $P<.001$, respectively), whereas higher parental care was independently associated with lower PIU (β=–.141, $P<.001$).

Hypothesis 3 was tested by adding interaction terms (see the "Statistical Analyses" section) to the aforesaid stepwise regression (also see Table 4). This analysis identified 2 moderating relationships only between parent-adolescent conflict and PIU. It shows that there was a significant association of adolescent-mother conflict and grade with the PIU reported by the adolescents (β=.045, $P=.04$), with the relationship being stronger in older students than in younger students. Another significant interaction effect was found between father-adolescent conflict and gender with the PIU reported (β=–.054, $P=.02$), with the relationship being stronger in male students than in female students.

Hypothesis 4 was tested using planned comparison analyses to compare adolescents reporting no mother-/father-adolescent conflict and those reporting any mother-/father-adolescent conflict (Table 5). For mother-adolescent conflict, the findings indicated that there was a significant difference between adolescents who reported no conflict and those reporting at least some level of verbal conflict, and emotional abuse ($P<.001$, respectively). However, no significant difference was found between those experiencing no conflict and those experiencing some level of physical abuse ($P=.23$). For father-adolescent conflict, there was a significant difference between those who reported no conflict and those reporting some verbal conflict ($P<.001$), emotional abuse ($P<.001$), and physical abuse ($P=.02$).

Table 4. Multiple linear regression analysis of the association of family-based relationships on adolescent's levels of problematic internet use[a].

Variables	Step 1		Step 2	
	β	$t_{10,6542}$[b]	β	$t_{18,6534}$[b]
Gender	–.139	–9.231[c]	–.143	–9.349[c]
Grade	.143	9.484[c]	.149	9.671[c]
Family structure	.036	2.075[d]	.036	2.069[e]
Maternal education level	.005	0.380	.005	–0.601
Paternal education level	.008	0.324	.008	0.377
Academic rank	.026	1.650	.028	0.307
Mother-adolescent conflict (C)	.145	8.134[c]	.136	4.586[c]
C × gender	—[f]	—	–.029	–0.797
C × grade	—	—	.045	2.018[d]
Father-adolescent conflict (C)	.077	4.376[c]	.102	3.402[e]
C × gender	—	—	–.054	–2.314[d]
C × grade	—	—	.012	0.534
Parental care	–.141	–8.315[c]	–.154	–5.964[c]
Parental care × gender	—	—	–.003	0.094
Parental care × grade	—	—	.022	0.979
Parental control	.055	3.590[c]	.060	2.360[d]
Parental control × gender			.004	0.311
Parental control × grade			–.013	–0.598

[a]R^2=0.150 in step 2 and adjusted R^2=0.145 (P<.05).
[b]2-tailed.
[c]P<.001.
[d]P<.05.
[e]P<.01.
[f]Not applicable.

Table 5. Descriptive statistics and planned comparison outcome of forms of mother-/father-adolescent conflict levels.

Group (R)	Mean (SD)	95% CI	Mean difference (R–C); SD
No conflict (reference)	59.61 (0.69)	58.24-60.98	
Mother-adolescent conflict (C)			
Only verbal conflict	68.97 (0.72)	67.55-70.40	–9.36; 1.00[a]
Only emotional abuse	66.85 (1.24)	64.40-69.30	–7.22; 1.43[a]
Only physical abuse	65.03 (2.26)	60.62-69.48	–5.42; 2.36
With all forms above	79.52 (0.89)	77.76-81.28	–19.91; 1.13[a]
No conflict (reference)	63.28 (0.52)	62.26-64.30	
Father-adolescent conflict (C)			
Only verbal conflict	72.17 (1.03)	70.14-74.20	–8.89; 1.16[a]
Only emotional abuse	70.45 (1.19)	68.11-72.70	–7.17; 1.30[a]
Only physical abuse	68.67 (1.68)	65.39-71.95	–5.39; 1.76[b]
With all forms above	79.95 (0.96)	78.07-81.80	–16.67; 1.09[a]

[a]$P<.001$.

[b]$P<.05$.

Discussion

Principal Findings

This study examined the associations between mother-/father-adolescent conflict (including verbal conflict, emotional abuse, and physical abuse), parenting styles (ie, parental care and parental control), and PIU in a large sample of Chinese adolescents after accounting for key demographics. Our findings were consistent with hypothesis 1, that is, greater mother-adolescent conflict and father-adolescent conflict were independently associated with higher PIU. The data were also consistent with hypothesis 2, that is, higher parental care was independently associated with lower PIU, whereas higher parental control was independently associated with higher PIU. The results were partially consistent with hypothesis 3, in that the association between father-adolescent conflict and PIU was stronger in male adolescents than in female adolescents, and the association of mother-adolescent conflict with PIU was stronger in older adolescents than in younger adolescents. The results for the last exploration found that, compared with adolescents reporting no conflict, adolescents experiencing more father-adolescent verbal conflict, emotional abuse, and physical abuse reported higher levels of PIU. When compared with those who reported no conflict with their mother, adolescents with more mother-adolescent verbal conflict and emotional abuse, but not physical abuse, reported higher levels of PIU.

The finding of an association between parenting styles of lower care/warmth or higher control and adolescent PIU is consistent with previous research studies [14-16], as are the findings of an association between adolescent-parent conflict and PIU [19,20]. Our findings add to the literature by identifying the unique effects of mother-/father-adolescent conflict and parental bonding (ie, parental care and parental control) on adolescent PIU after controlling for a range of demographics. This is important as the results highlight that there are multiple forms or qualities of the parent-adolescent relationship that need to be considered when identifying family risk factors for PIU, as well as when considering family interventions for PIU. A recent meta-analysis suggested that in addition to parental care and control, an authoritarian parental style was associated with adolescent PIU, whereas media-specific parenting styles and active mediation by parents were not associated with adolescent PIU [36]. As such, our findings add to the emerging body of evidence on the importance of identifying specific forms of parent-adolescent interactions that are toxic or protective for adolescent PIU.

Our study also found that gender moderated the association between father-adolescent conflict and PIU, with this association being stronger in male students than in female students. Given the gender stereotypes in traditional culture, boys are expected to be primary providers for their own family in adulthood and responsible for taking care of aged parents. Thus, there is a strong tendency for Chinese fathers to discipline their sons' misbehaviors [37], which in turn may trigger more father-adolescent conflict among boys compared with girls. Similarly, a father's overprotection/control may be more damaging to male adolescents than females [38]. In addition, grade moderated the association between mother-adolescent conflict and PIU, with this association being stronger in older students than in younger students. As adolescents grow older, they are exposed to the internet more, as well as subjected to higher academic expectations compared with younger adolescents [34]. In addition, older adolescents are more inclined to anxiety and depressed mood than younger adolescents [39]. This might be concerning for mothers as primary caregivers spending more time with adolescents [40,41]. Our findings point to the complexity in associations between the parent-adolescent relationship and PIU as moderated by the gender of the parent, as well as by the gender and age of the adolescent. These

complexities are starting to be highlighted in other research. For example, there is meta-analytic evidence that the association between physical abuse and externalizing behaviors is stronger in female than in male Chinese children and adolescents, whereas the association between emotional abuse and externalizing behaviors is stronger in male and female Chinese children and adolescents [42]. In addition, there is meta-analytic evidence that a parenting style termed "restrictive mediation" is associated with PIU in older adolescents but not in younger adolescents [36]. Therefore, there is a need for further research to explore the impact of moderators such as the gender of the parent and adolescent, as well as the age of the adolescent on the associations between parent-adolescent relationships and PIU.

Interestingly, this study found that PIU was only related to paternal physical abuse and not maternal physical abuse. As paternal physical aggression is commonly associated with greater fear and intimidation than maternal physical aggression [43], it is possible that increases in adolescent anxiety add to the likelihood of adolescent problematic behaviors (including PIU) to escape, avoid, or seek support for family relationship distress [29,43-46]. In Chinese culture, fathers as disciplinary figures tend to harshly punish their children when behavioral expectations are not met and show less warmth toward children [47]. Although replication of these findings is needed, there is also a need for qualitative research to explore adolescents' perceptions of why physical abuse from father but not mothers may be associated with adolescent PIU.

Implications of Our Findings

Our findings have theoretical and practical implications for the prevention of and early intervention for adolescent PIU. In terms of theoretical implication, consistent with the Attachment Theory, this study demonstrated that the sense of connectedness or closeness adolescents have with their parents is important in understanding their maladaptive behaviors such as PIU. If this sense of connectedness or closeness is threatened by either a range of forms of interpersonal conflict or overcontrolling parenting style, then an adolescent is more likely to engage in PIU. Conversely, if this sense of connectedness or closeness to parents is enhanced by a parenting style exhibiting care and warmth, then an adolescent is less likely to engage in PIU. As such, our findings support a model of adolescent psychopathology based on Attachment Theory.

In terms of practical implications, the results support the expansion of current prevention strategies to include a focus on improving parenting styles (ie, increase parental care and decrease parental control) and managing parent-adolescent conflict and strengthening support for adolescents experiencing significant family conflict [18,48,49]. There is some preliminary evidence from a small study of 57 Chinese adolescents that a 14-session family-based group therapy can reduce PIU compared with an active control group [50]. This family-based therapy involved a range of therapeutic components (ie, promoting a supportive environment, studying how to correctly perceive and use the internet, changing cognition of themselves and establishing self-confidence, improving family functioning, and fostering hope for future recovery), and therefore, the extent to which the intervention addressed and improved the parent-adolescent relationship factors identified in this study remains unclear. A more direct application of the findings from our study to therapy would be the implementation of attachment-based family therapy for PIU. To date, no study has applied this therapy; however, there is strong evidence of its effectiveness for the treatment of adolescent depression, suicidal behavior, and anxiety [51]. Attachment-based family therapy is grounded in Attachment Theory and aims to reduce parent-adolescent conflict, repair interpersonal ruptures, and strengthen secure attachments between adolescents and parents [52]. As such, it has a strong theoretical alignment with the constructs identified in our study as risk and protective factors for PIU and we recommend that it be trialed in future research as an intervention for adolescent PIU.

Strengths

The strengths of this study are the large sample size and a high response rate (6552/6638, 98.70%), which result in limited selection bias [53]. Another strength is that the proposed model controlled for several covariates that have previously been suggested to be strong predictors of adolescent PIU [54,55]. However, given the cross-sectional design, conclusions about causal relationships are not possible. Evidence suggests that adolescent's behaviors (eg, having deviant peers) may also shape parenting style [13], and that parents may become frustrated, anxious/hostile, or rejecting in response to adolescent PIU, which then triggers parent-adolescent conflict and further escape/avoidance through internet use [56]. Further prospective research is therefore required to examine the possible bidirectional causality of the associations found in this study. In addition, as the focus of this study was on the relationship between adolescents and each parent individually, we combined nuclear families with single-parent families in the analyses. However, it will be useful for future studies to examine the associations identified in our study separately for nuclear families and single-parent families. It is also worth noting that the findings of this study were limited to general PIU rather than to specific PIU, for example, internet gaming addiction [57]. Moreover, the self-reported data are purely reflective of the adolescents' perspective of their experiences with their parents and with PIU, leading to possible reporting biases. Previous research investigated whether there is consistency between mothers' and children's' perceptions of parenting [58]. In addition, there is evidence that self-report measures of PIU may not be strongly congruent with both client log data [59] and clinical diagnostic interviews of adolescents [60]. Future research is therefore needed to confirm the findings from this study using multiple measures of adolescent-parent conflict, parental bonding, and PIU. We were unable to control for parental supervision and monitoring, and interparental conflict was not included as a covariate or as a possible risk factor. Future research should also consider including these variables in models of PIU given that they have been shown to be predictors of other adolescent risky behaviors [61-63]. Furthermore, it seems that maternal and paternal psychological and behavioral control have different effects on adolescent PIU [7]; therefore, future studies could subgroup parental care and control for a better understanding of how specific dimensions

of parental bonding impact on adolescent PIU. Finally, given the relatively high comorbidity between adolescent PIU and externalizing behaviors such as conduct problems, hyperactivity, physical health problems, and depression [64-66], there is a need for future research building upon the findings of this study to compare the risk and protective factors for adolescent PIU and adolescent externalizing behaviors to identify unique and common risk/protective factors.

Conclusions

In conclusion, higher levels of mother-adolescent conflict and father-adolescent conflict, higher levels of parental control, and lower levels of parental care were associated with higher PIU among Chinese adolescents. Furthermore, the effect for mother-adolescent conflict on PIU was stronger in older adolescents than in younger adolescents, whereas the effect for father-adolescent conflict on PIU was stronger in male adolescents than in female adolescents. These findings point to the potential utility of family-oriented education and early intervention for adolescent PIU by reducing verbal conflict as well as emotional and physical abuse, and strengthening parent-adolescent relationships through more affection from parents and less psychological control at home.

Conflicts of Interest

None declared.

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Abbreviations

PBI: Parental Bonding Instrument
PIU: problematic internet use
WHO: World Health Organization

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Original Paper

Youth Perspectives on the Recommended Age of Mobile Phone Adoption: Survey Study

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Abstract

Background: Despite increasing prevalence of phone ownership in early adolescence, there is a deficit of evidence-based guidance on the appropriate time to provide youth their first phone.

Objective: This survey study explored age recommendations for phone ownership among a diverse panel of youths, as their experiences are an important contribution to the development of ownership guidelines.

Methods: Participants were recruited from MyVoice, a national panel of over 765 youth (14 to 24 years old) who respond to weekly SMS text message–based surveys. Questions were distributed between January 24 2018, and March 20, 2018. Inductive qualitative analysis was used to identify major themes among youths' open-ended responses.

Results: In all, 469 youth (mean age 18.8 years; female: 299/469, 63.8%; White race: 332/468, 70.8%) responded. On average, respondents obtained their first phone at 12.2 years of age. Most participants (325/459, 71.1%) stated they received their first phone out of necessity rather than for entertainment or social reasons. Youth recommended that early adolescents receive their first phone between 12 and 13 years of age primarily for reasons of necessity (146/448, 32.6%).

Conclusions: According to the participants, phones supported safety and independence by allowing communication with parents and participation in activities. Youth-serving professionals and parents can incorporate these youth perspectives into shared decision-making about phone ownership among families. This can include discussions about essential features, safety, or phone use, as well as maturity and responsibility milestones, which were all key considerations reported by participants in the survey.

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KEYWORDS

adolescent; youth; child; mobile phone; technology; media; phone use; phone ownership; parental guidance; parenting; cell phone; smartphone

Introduction

Mobile phone adoption in the United States is starting in late childhood and early adolescence; currently, 53% of children have a smartphone by age 11 [1]. Later in adolescence, mobile phone use remains high, with over 95% of teens ages 13 to 17 years having access to a cell phone [2]. In addition, over 90% of teens report using their phones to pass the time, connect with others (84%), and learn new things (83%) [3,4].

The introduction and frequent use of mobile technology during adolescence comes at a critical stage of cognitive, emotional, and social development. Between the ages of 10 and 25 years, youths are in a transitory state between childhood and adulthood. According to Erikson's theory of psychosocial development, adolescents are primarily concerned with the task of identity formation [5]. More specifically, they are learning about their values, desires, and future roles [5]. In addition, adolescents are confronted with other milestones, including learning how to navigate intimate relationships and gain social connectivity [5,6]. During this stage, adolescents spend more time with peers and gain independence from their caregivers [7]. This period is sometimes referred to as separation-individuation, a developmental term that has been used to define the

phenomenon of adolescents needing less support and approval from their caregivers while seeking approval from peers and finding new social networks to help develop individual concepts of self-esteem and identity [8,9].

As adolescents' exposure to new digital technologies increases, they are progressively experiencing these milestones online, with online communication being used as a tool offering access to friendships and other relationships, as well as increasing cohesion and connectedness between peers and school [10]. Mobile phone adoption poses as a major concern for parents or caregivers and youth-serving professionals [11]. However, sources that explore mobile phone adoption, such as the American Academy of Pediatrics, only offer general suggestions, like encouraging family discussions about the type and quantity of media consumed and monitoring impacts of phone use on sleep, homework, and family time [12,13]. Official guidelines on the appropriate age to get a phone have yet to be established.

Evidence-based recommendations for mobile phone ownership are needed to establish best practices for parents and youth-serving professionals and alleviate apprehension towards mobile phone adoption. Despite the ubiquity of mobile phone use among adolescents and the personal stake that adolescents have in guidelines about mobile phone adoption, the youth voice regarding this topic is understudied. Exploring youth experiences with mobile phone ownership may benefit parent involvement and guidance, as well as aid in the development of rules and expectations that promote safe use, are developmentally appropriate, and account for social and cultural pressures. Therefore, the purpose of this study is to explore age recommendations for mobile phone ownership among a diverse text message–based panel of youths.

Methods

Participants

Participants were members of MyVoice, a national panel of over 765 adolescents and young adults (14 to 24 years old) who respond to weekly surveys delivered through text messages [14]. MyVoice recruits participants through advertisements on social media platforms (Facebook, Instagram) and in person at community events. Youth consented to receive surveys (parental permission was waived), and youth could indicate if they wanted to skip or stop participation at any time through a text message. Participants received a US $5 gift card for completing a demographic survey after enrollment and US $1 for each survey completed afterward [14]. Demographic data, including age, gender, race, ethnicity, and education, were self-reported during enrollment using validated questions from the Youth Risk Behavior Survey [15].

Ethics Approval

This study was approved by the University of Michigan Institutional Review Board (#HUM00119982).

Survey

Our survey consisted of 4 questions which were delivered via SMS text message to participants between January 24, 2018, and March 20, 2018. The questions were authored by several youth medicine providers and researchers with specialty knowledge in this research area. Participants had 1 week to answer the survey questions, all questions were open ended, and participants had the option to skip questions they did not want to answer. We asked the following four questions: (1) "How old were you when you got your first cell phone?" (2) "Did you ask for your first cell phone or did you get it without asking?" (3) "Why did you get your first cell phone?" (4) "What do you think is the right age for someone to get their first cell phone and why?"

Analysis

Two study team members (LR and VA) reviewed the answers to the questions of the first 100 participants and used inductive qualitative analysis to independently develop a codebook based on their responses. The final codebook was formed by merging the independently developed codebooks and by arriving at a mutual agreement on final definitions. Each question had its own set of codes that could be applied, and multiple codes could be assigned to each participant response. The responses to each question were coded in rounds of 100; since there were a limited number of responses, the first 100 were recoded as well. After each round, the team met to discuss discrepancies. Interrater reliability over all rounds of coding was between 77% and 95% for each question. A third study team member (ES) broke a total of 5 discrepancies that could not be agreed on. Descriptive statistics for code frequencies were calculated using Microsoft Excel. This coding and analysis scheme has been used in previous MyVoice studies [16-19].

Results

Overview

From a total of 765 MyVoice participants, 469 respondents completed at least 1 text message–based survey question about mobile phone ownership (61.3% response rate). Specifically, 465 respondents provided the age at which they got their first cell phone (60.8%), 465 respondents discussed if they asked for a phone or received it without asking (60.8% response rate), 459 respondents described why they got their first cell phone (60% response rate), and 448 respondents shared their recommendations for mobile phone ownership (58.6% response rate). Respondents had an average age of 18.8 (SD 3.01) years, and 63.8% (299/469) identified as being female and 70.8% (332/469) as being White, non-Hispanic. Demographic characteristics of these 469 respondents are described in Table 1.

Table 1. Demographic characteristics of the study sample.

Characteristic	Respondents (n=469)	Nonrespondents (n=80)
Age, mean (SD)	18.79 (3.0)	17.73 (2.7)
14-17 years, n (%)	174 (37.1)	45 (56.2)
18-21 years, n (%)	184 (39.2)	27 (33.7)
22-24 years, n (%)	109 (23.2)	8 (10)
Gender, n (%)		
Female	299 (63.8)	35 (43.7)
Male	139 (29.6)	41 (51.2)
Other gender	12 (2.5)	0 (0)
Nonbinary	10 (2.1)	0 (0)
Transgender FTM[a]	8 (1.7)	3 (3.7)
Transgender MTF[b]	0 (0)	1 (1.2)
Race, n (%)		
White	332 (70.8)	66 (82.5)
Asian	51 (10.8)	3 (3.7)
African American	45 (9.5)	12 (15)
Multiracial	29 (6.1)	0 (0)
Other race	7 (1.4)	4 (5)
American Indian	3 (0.6)	5 (6.2)
Pacific Islander	1 (0.2)	1 (1.2)
Ethnicity, n (%)		
Non-Hispanic	430 (91.6)	67 (83.7)
Hispanic	38 (8.1)	13 (16.2)
Education level, n (%)		
Some college	155 (33.0)	27 (33.7)
Some high school	149 (31.7)	40 (50)
Bachelor's degree	66 (14.0)	3 (3.7)
High school graduate	44 (9.3)	3 (3.7)
Associate degree	17 (3.6)	1 (1.2)
8th grade or less	15 (3.2)	3 (3.7)
Some graduate school	14 (2.9)	1 (1.2)
Master's degree	4 (0.8)	1 (1.2)
Some graduate training beyond a master's degree	2 (0.4)	0 (0)
Some vocational/technical training	1 (0.2)	0 (0)
Completed vocational/technical training	1 (0.2)	1 (1.2)
Doctoral degree	0 (0)	0 (0)
School free or reduced lunch, n (%)		
No	339 (72.2)	57 (71.2)
Yes	124 (26.4)	22 (27.5)

[a]FTM: female to male.

[b]MTF: male to female.

Question 1: How Old Were You When You Got Your First Cell Phone?

The average reported age at which respondents obtained their first phone was 12.2 (SD 2.01) years, with answers ranging from 4 to 18 years old.

Question 2: Did You Ask for Your First Cell Phone or Did You Get It Without Asking?

When asked how they obtained their phone, 59.1% (275/465) of participants reported asking for it while 34.2% (159/465) received their phone without asking. These data are summarized in Table 2. The remainder of participants did not answer if they asked for their phone or got it without asking; instead, they provided other answers such as making a mutual decision with their parents to get their first phone or buying it on their own. Some participants (57/465, 12.2%) qualified their responses by describing the circumstances of their phone ownership, including that they received their phone from a nonparental source—such as an extended family member (5/465, 1.1%), their phone was inherited (7/465, 1.5%), they received their phone as a gift (6/465, 1.3%), or they got it out of convenience (6/465, 1.3%).

Table 2. Youth responses to Q1 and Q2 about when they got their first phone and if they asked for it.

Question	Value (N=465)
Q[a]1: How old were you when you got your first cell phone?	
Age (years), mean (SD)	12.2 (2.01)
Age (years), response range (min-max)	4-18
Q2: Did you ask for your first cell phone or did you get it without asking?, n (%)	
Asked	275 (59.1)
Did not ask	159 (34.2)

[a]Q: question.

Question 3. Why Did You Get Your First Cell Phone?

Note on Overlapping Themes

Two distinct categories emerged from participant responses in answers to both question 3 and question 4: (1) phone function, which refers to identifying the purpose of their phone usage; and (2) environmental context, which refers to providing perceptions about phone ownership within their current social environments. The following themes were identified across these categories in which participants described their mobile device use: necessity, maturity as a requirement, socialization, environmental context, and maturity as a result. Although these categories generally corresponded to the survey questions, there was overlap in the participants' responses that applied to multiple questions. Participant responses, themes, and representative quotes are described in Table 3.

Phone Function

The first category of responses focused on the functionality of phones; that is, the intended purpose(s) of phone use for each individual.

Necessity

Necessity for communication was cited by 71.1% (325/459) of respondents as their primary reason for getting a phone. Respondents obtained their phone to contact their parents (162/459, 35.4%), have it in case of emergency (83/459, 18.2%), and to participate in afterschool activities (68/459, 14.9%). One participant explained they got their first phone "To call my parents after school because I stayed late for sports and other things a lot."

Maturity as a Requirement

Respondents (59/459, 12.9%) also associated phone ownership with specific life experiences or as a part of growing up and becoming more mature. For example, respondents described reaching a certain point in their education (33/459, 7.2%) or having greater independence and going out more on their own without parental supervision (16/459, 3.5%) as contexts for obtaining their first phone. One respondent said they got their first phone because of the following:

> *…i [sic] was going to middle school, and getting more independent, so i [sic] needed communication. It was also normal for most middle schoolers to have phones.*

Socialization

Wanting to stay in touch with friends and family members was the primary reason why 12.9% (59/459) of participants got their first cell phone. A respondent reasoned, "I wanted to be able to talk to my friends without having to use my dad's phone."

Environmental Context

The second category of responses focused on environmental context or, more specifically, observations about phone ownership within surrounding social climates. Respondents (31/459, 6.8%) attributed their desire for phone ownership to the phone ownership of others; that is, via social comparison or just a general feeling of needing to fit in. These participants typically had responses like "Because everyone else had one."

Table 3. Youth responses to question 3 about reasons for getting their first phone (N=459).

Subtheme by theme	Respondents, n (%)	Representative quote
Overall theme: functionality		
Subtheme: necessity	325 (71.1)	N/A[a]
Contacting parents	162 (35.4)	"So my parents could communicate with me" (F[b]; age 14 y, got phone at 12 y)
Safety	83 (18.2)	"because i got lost once, and my parents wanted me to have one for security purposes" (F; age 16 y, got phone at 8.5 y)
Afterschool activities	68 (14.9)	"Because I had activities after school and needed a phone to call my parents to pick me up afterwards" (F; age 24 y, got phone at 13 y)
Subtheme: maturity as a requirement	59 (12.9)	N/A
Education	33 (7.2)	"At that point I was going into middle school and I had more need to be able to contact my parents" (M[c]; age 18 y, got phone at 13 y)
Independence	16 (3.5)	"…I [sic] was going to middle school, and getting more independent, so i needed communication. It was also normal for most middle schoolers to have phones." (F; age 16 y, got phone at 11 y)
Socialization	59 (12.9)	"I wanted to more easily communicate with my friends…" (M; age 24 y, got phone at 14 y)
Overall theme: environmental context	31 (6.8)	"Because everyone else had one." (No gender indicated; age 16 y, got phone at 9.5 y)

[a]N/A: not applicable.

[b]F: female.

[c]M: male.

Question 4. What Do You Think Is the Right Age for Someone To Get Their First Cell Phone and Why?

Overall, 79.9% (354/448) of respondents suggested a specific age or age range in their phone ownership recommendations. The average recommended age was 12.7 (SD 1.66) years. Participant responses, themes, and representative quotes are described in Table 4.

Necessity

Respondents (146/448, 32.6%) discussed the condition of necessity in their recommendations for phone ownership. When asked for their age recommendations, one respondent replied as follows:

> *Around 13 or when entering middle school, children become more independent and do things without their parents there. It's important to be able to stay in touch with your parents.*

Another respondent commented as follows:

> *As soon as they need it honestly. If a child is frequently out and about (eg community centers/clubs, friends, paper routes), has a situation where they need to contact their parent, has to wait after class, etc, then the actual age doesn't matter much…*

Maturity as a Requirement

In their recommendations, 10.8% (48/448) of respondents felt individuals tend to experience maturity at the specific ages they suggested and incorporated this reasoning into their recommendations. One respondent recommended, "[age] 14. Then they are mature enough for it." Conversely, 13.6% (60/448) of respondents felt an individual's readiness for phone ownership was contingent on individual internal factors such as achieved independence (38/448, 8.6%) and maturity (22/448, 4.9%). These respondents felt individuals experience independence and responsibility at different ages, so they did not offer specific age recommendations for phone ownership. Rather, they cited proxy indicators of maturity. For instance, one participant put it as follows:

> *I think it depends on the person. If someone is living a more independent life going out with friends alone or traveling on their own they should get a phone to communicate.*

Socialization

Additionally, 5.4% (24/448) of respondents recommended getting a phone to socialize with friends and manage relationships. One participant posited that the right time to get a phone was "maybe 8th grade? it's an important thing to have for social connection and most of their peers will have a phone in middle school."

Environmental Context

Reflection on changing trends regarding the initial age of phone ownership was included in 3.6% (16/448) of respondents' recommendations. For example, one respondent commented, "I think the age [to get a first phone] keeps getting younger and younger. Maybe 12 years old." Other age recommendations that expanded on this observation included the following:

> *I think now it's more necessary for kids to have them earlier. I think they shouldn't have a smart phone until their [sic] at least 14 though…*

> *15. Cellphones are a vital part of today's communication.*

Respondents (3/448, 0.7%) even felt adolescents would be at a disadvantage if they did not own a phone while their peers did:

> *I think that it's younger than when I received one, because the technology has advanced and withholding one would make the child stand out from their peers.*

Maturity as a Result

Further reflections described a bidirectional association between phone ownership and maturity. Although participants' responses showed that mobile phone ownership may be dependent on "maturity-indicating" milestones, such as reaching a certain grade level or spending more time away from home, they also presented phone ownership as its own significant adolescent milestone that could foster maturity. Specifically, 2.5% (11/448) of respondents felt phone ownership could provide adolescents the opportunity to learn about responsibility, and subsequently, become more mature. When asked for their recommended age for phone ownership, one participant replied as follows:

> *I would say late middle school to the start of high school. This is the time when young people need to learn more about freedom and responsibility as well as when they may need it to communicate with their parents.*

Similar responses included the following:

> *2-13. Kids start to become more independent at that age, and a cell phone helps establish that independence.*
>
> *The best age would be 12-14, because this is the best time to teach them the value of responsibility.*

Table 4. Youth responses to Q4 about mobile phone ownership recommendations (N=448).

Subtheme by theme and question	Value	Representative quote
Q4[a]: What do you think is the right age for someone to get their first cell phone and why?		
Suggested a specific age or age range	354 (79.9)	N/A[b]
Recommended age (years), mean (SD)	12.7 (1.6)	N/A
Recommended age (years), response range (min-max)	7-20	N/A
Qualitative responses, n (%)		
Subtheme: necessity	146 (33)	"If a child is frequently out and about (eg community centers/clubs, friends, paper routes), has a situation where they need to contact their parent, has to wait after class, etc, then the actual age doesn't matter much…" (M[c]; age 20 y, got phone at 12 y)
Subtheme: maturity as a requirement	60 (13.6)	
Conditional independence	38 (8.6)	"I think it depends on the person. If someone is living a more independent life going out with friends alone or traveling on their own they should get a phone to communicate." (M; age 14 y, got phone at 12 y)
Conditional responsibility	22 (5)	"when they are mature enough to use it responsibly, so i think it depends per person." (F[d]; age 20 y, got phone at 12 y)
Responsibility	48 (10.8)	"[age] 14. Then they are mature enough for it." (No gender indicated; age 17 y, got phone at 14 y)
Subtheme: socialization	24 (5.4)	"maybe 8th grade? it's an important thing to have for social connection and most of their peers will have a phone in middle school." (F; age 23 y, got phone at 11 y)
Subtheme: environmental context		
Observation	16 (3.6)	"I think the age [to get a first phone] keeps getting younger and younger. Maybe 12 years old." (F; age 24 y, got phone at 14 y)
Social disadvantage	3 (0.7)	"I think that it's younger than when I received one, because the technology has advanced and withholding one would make the child stand out from their peers." (Nonbinary; age 18 y, got phone at 11 y)
Subtheme: maturity as a result		
Learning opportunity	11 (2.5)	"The best age would be 12-14, because this is the best time to teach them the value of responsibility." (M; age 14 y, got phone at 12 y)

[a]Q4: question 4.

[b]N/A: not applicable.

[c]M: male.

[d]F: female.

Additional Findings

Although the survey questions did not explicitly ask about possible negative aspects of early mobile phone ownership, a small proportion of youth (34/448, 7.7%) brought up concerns in their phone ownership recommendations. Participant responses, themes, and representative quotes are described in Table 5. The highest cited concern was that of distraction (13/448, 2.9%), where participants voiced concerns about phones producing interference with daily activities and even overreliance. One participant commented in their age recommendation: "14. Kids are inundated in a life reliant on their phones if they're introduced any earlier." Another concern included unrestricted internet access (4/448, 0.9%), where a respondent recommended the following:

> *12, but it's important that they don't start with a smart phone. Being safe on the internet requires maturity - kids shouldn't have access to the web on their phones until they're ~15.*

Addiction (4/448, 0.9%) was another concern found in phone ownership recommendations. One recommendation mentioned that "…apps are addictive, unregulated substances, and shouldn't be given freely to young children."

Participants also discussed concerns regarding illicit activities such as sexting (4/448, 0.9%). In their age recommendation, a participant explained as follows:

> *The problem is that, nowadays, the phones do so much more than my Nokia did - I don't think 11 would be okay for an iPhone, for example. There have to be more conversations with kids nowadays with what is and is not okay to do online - look at the amount of kids who get in trouble with nudes. It's troubling because you want to teach them to safely use the internet, but I think we all know we can't just give them full access, so where is the line?*

Table 5. Concerns of mobile phone use as an additional theme (N=448).

Theme or subtheme	Respondents n (%)	Representative quote
Theme: concerns	34 (7.7)	N/A[a]
Distraction	13 (2.9)	"14. Kids are inundated in a life reliant on their phones if they're introduced any earlier." (M[b]; age 19 y, got phone at 11 y)
Unrestricted internet access	4 (0.9)	"12, but it's important that they don't start with a smart phone. Being safe on the internet requires maturity - kids shouldn't have access to the web on their phones until they're ~15." (M; age 17 y, got phone at 12.5 y)
Addiction	4 (0.9)	"…apps are addictive, unregulated substances, and shouldn't be given freely to young children." (nonbinary; age 18 y, got phone at 11 y)

[a]N/A: not applicable.

[b]M: male.

Discussion

Principal Results

For this study, youth participants responded to text message–based survey questions about mobile phone ownership through MyVoice. With exception of a few studies examining early adolescent smartphone ownership, adolescent perspectives remain largely unexplored in research [20,21]. This is the first study of youths' experiences with phone ownership using a large national sample.

For the majority of our respondents, receiving their first cellphone coincided with starting middle school, a significant milestone where many youths are using public transportation on their own, staying after school for activities, and hanging out with friends. It is not surprising that the main reason for getting a phone was for necessity and specifically for contacting parents. Participants' recommendations for phone ownership also involved these adolescent milestones.

It is important to note that some participants believed phone ownership stands as its own milestone, specifically as a mechanism to learn about responsibility. This is an intriguing concept that parents and youth-serving professionals should explore. During adolescence, youth are experiencing the process of separation-individuation, where they are learning how to navigate social situations with less support from caregivers and establishing their own identity and self-esteem; they are also seeking out peer approval as opposed to parental approval [9]. However, studies have shown that while youth may have less need for parental support, parental involvement is still important [8,9]. Prior research shows that youth who feel they can tell their caregiver of their activities and friendships and feel they can negotiate setting limits are more likely to tell their caregiver when there is a safety concern and are less likely to engage in risky behaviors [22-25]. More research is needed on the impact of phones in the parent-child relationship, but there is a possibility that phones could serve as tools that allow youths to maintain their autonomy while remaining connected to their parents.

The desire for socialization was cited by participants as a reason for getting their first phone, and their recommendations reflected the importance of staying in touch with friends and family. This is an indication that phones can serve as tools for managing and strengthening the quality of peer and parent-youth relationships. The nurturing of these relationships is a crucial task of adolescence, as peer connections help establish separation from parents and encourage independence while simultaneously maintaining a line of communication with caregivers [7].

Although this was not a focus of the study, some participants voiced concerns about mobile phone ownership in their age recommendations, including distraction and overreliance, unrestricted internet access, addiction, and illicit activities. Our report showed a small proportion of youths shared concerns about phone ownership. In other studies, more youths have raised concerns, such as worrying about how much time they spend on their phone [4]. However, since our respondents were not explicitly asked about negative aspects or concerns of phone ownership, our report may not be reflective of our entire sample's concerns. Based on previous research, parents or caregivers share similar concerns about their children spending too much time on their phones and how phones impact their ability to focus and allow access to inappropriate online content [4,11,26].

Other major concerns that were brought up in previous research are primarily shared by parents or caregivers but were not found in our youth respondents' recommendations; they include stranger interaction, impact on reputation, and advertisers' use of data [27]. These parent or caregiver and youth concerns can be included in conversations about mobile phone ownership and shared decision-making. Additionally, as youths and parents are entering the phone market, technology companies producing phones and associated apps can further adjust the experience to maximize safety and provide appropriate features depending on the need and maturity level of the child.

Comparison With Prior Work

Our findings are concordant with other studies that suggest positive outcomes associated with digital technology use, such as strengthened relationships, promotion of safety, preservation of youth freedom, and greater self-esteem [28-32], as well as with research that presents negative outcomes associated with mobile phone usage, including problematic mobile phone and internet usage, online harassment, and cyberbullying involvement [33-39]. Our study complements other studies' findings and adds the unique perspective that phones could foster maturity and feelings of responsibility among youths.

Limitations

MyVoice served as a useful online platform for the recruitment and engagement of youth participants. However, the scope of our survey questions was not as broad as that of traditional qualitative survey questions since respondents had limited space to discuss their experiences (given the character limitations placed on text messages from some phone carriers). Our ability to seek additional context and clarification was also inhibited due to the automated nature of our survey questions. No research was available to guide the formation of our survey questions. Although we posed questions about "mobile phone" ownership, the lack of specification for certain types of phones and, subsequently, consideration of different features, such as internet access on smart phones, could have skewed participants' age recommendations. Although the MyVoice sample spans the entirety of the United States, the generalizability of our findings may also be limited since MyVoice is not specifically designed to be nationally representative in terms of race, ethnicity, or other demographics. However, the sample is still racially and ethnically diverse and inclusive of multiple sexual and gender minorities. The average age of respondents at the time of survey completion (18.8 years) was older than the reported age at which they received their first phone (12.2 years), which introduces the potential issue of recall bias. Future studies could further explore perspectives from youths at the actual age of phone acquisition. In addition, since our study was conducted prior to the COVID-19 pandemic, youth perspectives on mobile phone ownership might have changed in the context of the pandemic. Further research is needed to characterize any new youth perspectives.

Conclusions

Our study presents valuable implications about youth mobile phone ownership. Parents report a desire for guidance to navigate their children's phone ownership and experience, but there remains a lack of evidence-based recommendations [12,21]. In addition, youth viewpoints about their own technology use are understudied in research despite the fact that mobile phone ownership often occurs during adolescence. Our study's examination of youth perspectives provides insights to the motivations for mobile phone ownership, informs parent decisions about when to introduce a phone, and may promote safe use and behavior. Families and youth-serving professionals can use our findings to facilitate shared decision-making about mobile phone ownership with youths. Shared decision-making allows parents and youths to mutually negotiate rules and expectations about their phone ownership that promote their health and well-being, independence, and safety.

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Conflicts of Interest

None declared.

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Review

Technology-Based Obesity Prevention Interventions Among Hispanic Adolescents in the United States: Scoping Review

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Abstract

Background: Given that today's adolescents are digital front-runners, technology-based obesity prevention strategies are age-appropriate for this population. The use of remote and wireless technologies may be suitable for extending the reach and engagement of obesity prevention efforts among high-risk Hispanic youths, as this subgroup is disproportionately affected by barriers that limit participation in traditional, in-person interventions.

Objective: The purpose of this scoping review was to examine the intervention and sample characteristics of technology-based obesity prevention interventions among Hispanic adolescents. We also examined feasibility criteria to assess the acceptability and appropriateness of technology-based strategies among Hispanic youths.

Methods: A comprehensive search of Embase and PubMed identified 7 studies that met the inclusion criteria. Data were extracted by 2 independent reviewers.

Results: Of the 7 included studies, half (n=4, 57%) used a randomized control trial design, with equal implementation in school (n=3, 43%) and clinic (n=4, 57%) settings. Studies commonly targeted improvements in diet (n=4, 57%) and physical activity (n=7, 100%), with only 1 (14%) study focused on sedentary behaviors. Just 2 (29%) studies reported the use of behavioral theories or models. Studies focused primarily on youths in early (n=5, 71%) or middle (n=6, 86%) adolescence, and there was limited information reported on socioeconomic status. Only 3 (43%) study conducted formative work, and few (n=3, 43%) reported on acceptability. Only 1 (14%) study reported that materials were available in Spanish and English, and only 1 (14%) study used culturally tailored content. Additionally, 3 (43%) studies used strategies that considered social determinants of health.

Conclusions: To increase our understanding of the feasibility and effectiveness of technology-based obesity prevention strategies among Hispanic adolescents, there is a need for more feasibility studies that are theoretically grounded and comprehensively report on feasibility-related outcomes. Future studies should also leverage technology to simultaneously address multiple health behaviors beyond diet and physical activity. The result of this review can be used to guide the development of future technology-based obesity prevention strategies among Hispanic adolescents.

Trial Registration: ClinicalTrials.gov NCT04953442; https://clinicaltrials.gov/ct2/show/NCT04953442

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KEYWORDS

obesity; technology; adolescents; health disparities; prevention interventions; prevention; intervention; feasibility; effectiveness; Hispanic; engagement

Introduction

Lifestyle interventions that promote healthy diet and physical activity habits are the cornerstone for obesity prevention among adults and youths [1]. However, current lifestyle interventions have had a modest impact on reducing obesity and obesity-related behaviors among Hispanic youths [2-4]. For some Hispanic youths, the time-intensive nature of in-person interventions and the lack of studies that address negative social determinants of health (SDoH) can limit program participation and one's ability to make healthy behavior changes [1,5]. SDoH that impact Hispanic youths include limitations in transportation, parent-work schedules, childcare needs, and access to health insurance, which can impact access to disease prevention opportunities in clinical settings [5,6]. Hispanic youths are disproportionately affected by obesity and obesity-related diseases and are the largest pediatric subgroup in the United States [7,8]. To address growing disparities, there is a substantial need to reach and engage this key population with obesity prevention strategies that are tailored to meet their needs and context [9].

Technology-based interventions use digital devices, such as computers, tablets, smartphones, and wearable devices, to deliver personalized and real-time health promotion and disease prevention interventions [10-13]. Given that Hispanic youths and families are disproportionately impacted by SDoH, the use of digital devices as behavior change tools has been suggested as a potential strategy for overcoming some of the negative SDoH that limit participation in traditional, in-person lifestyle interventions [14,15]. For example, web-based interventions are not confined by location and can be delivered across geographic regions directly to participants in their home environment, alleviating the burden of transportation [14]. Technology-based interventions can also offer flexible scheduling options or be continuously delivered using SMS text messaging, prerecorded video content, or eHealth apps, impacting the dose and timing in which an intervention can be delivered [14]. This flexibility may be helpful for engaging some Hispanic youths and families, given that many Hispanic parents have nontraditional working hours (eg, night shifts) or work more than 1 job, which can make attendance to in-person interventions challenging [16]. Technology-based strategies may also be cost-effective given that they leverage devices (ie, smartphones and tablets) and services (ie, SMS text messaging and social media) already owned and used by participants [17]. About 95% of Hispanic teens in the United States report that they have daily access to a smartphone, which is comparable to non-Hispanic White youths (94%), indicating that smartphones can be leveraged to reach this population [18]. However, despite their potential for overcoming barriers to in-person interventions, most technology-based interventions have been conducted among high-income populations [15,19]. Thus, there is a need for studies that are developed and tested among high-risk, vulnerable populations that are disproportionately impacted by these barriers [15,19].

Technology-based health promotion and disease prevention strategies are also recommended as being age-appropriate for adolescents [20]. Adolescents today are exposed to technology at a younger age and are digital front-runners [21]. Furthermore, nearly two-thirds of adolescents and young adults in the United States have reported using an app to support changes in diet or physical activity behaviors, suggesting a desire for technology-based behavioral strategies among this population [22]. Among adults, technology-based lifestyle interventions have led to significant improvements in weight-loss and the management of chronic diseases including type 2 diabetes and cardiovascular diseases [23-26]. However, the evidence base for the feasibility and efficacy of technology-based lifestyle interventions among adolescents is limited [10,27,28], and few studies have been tested among minority youths [19].

The purpose of this scoping review was to systematically examine the current state of the science on technology-based obesity prevention interventions among Hispanic adolescents. This review will provide descriptive information regarding the intervention and sample characteristics with a focus on feasibility criteria including formative work, measures of acceptability, and adaptations made for SDoH and cultural considerations. The focus on feasibility criteria will provide meaningful information on the appropriateness of technology-based intervention components and targets among Hispanic youths with obesity. Following an extensive review of the literature, we will summarize findings, identify knowledge gaps, and highlight next steps for future research among this population.

Methods

This scoping review was conducted using the 5-stage methodological framework for scoping studies developed by Arksey and O'Malley [29]. In accordance with this framework, the steps used to complete the scoping review included (1) identifying the research question, (2) identifying relevant studies, (3) selecting studies, (4) charting the data, and (5) synthesizing and summarizing the results. The detailed methodology used to complete these steps are outlined below.

Identifying the Research Questions

The following research questions guided this review: (1) What approaches were used to develop technology-based obesity prevention interventions among Hispanic adolescents? (2) What are the intervention and sample characteristics of technology-based prevention interventions implemented among Hispanic adolescents? and (3) Were outcomes regarding the feasibility of technology-based obesity prevention interventions among Hispanic youths reported in a feasibility or pilot study or earlier in the development of a fully powered trial? Given that few technology-based interventions have been developed for Hispanic youths, studies that have applied technology-based strategies among this population are primarily still in the pre-efficacy phase, and the feasibility of intervention components has yet to be confirmed [30]. To address this gap in the literature, we reviewed the current studies or previously published studies by the research team to evaluate outcomes related to the acceptability of the intervention, formative work conducted in the development phase, technical issues or barriers experienced, and any other factors that impacted the

development or implementation of the intervention among this population [31].

Identifying Relevant Studies

Studies identified as relevant to this scoping review were defined as empirical, peer-reviewed articles that described a technology-based obesity prevention intervention among Hispanic adolescents with obesity. A literature search of PubMed was conducted using a combination of the following Medical Subject Headings terms: obesity, adolescent, Hispanic, and intervention. The search strategy and combination of terms that were used are provided in Multimedia Appendix 1. This same search strategy was then applied to the Embase database. We reviewed the references for eligible articles; however, no other sources or search strategies were used to identify articles.

Selecting Studies

Studies were selected using the following eligibility criteria: (1) included adolescents aged 13-18 years; (2) focused on obesity prevention or included a lifestyle intervention focused on reducing obesity outcomes (eg, weight, body mass index, and body fat) and cardiometabolic disease risk factors (eg, insulin, glucose, and cortisol); (3) written in English, (4) used a technology-based component; (5) conducted within the United States, given that Hispanic adolescents in this country have a unique sociocultural and environmental context; and (6) included a sample of at least 50% of participants who self-identify as Hispanic/Latino. This criterion has been used in previous reviews to ensure that studies are focused on Hispanic adolescents and that study findings are applicable to this population [32-34]. We did not have any criteria or limitations on publication date. Relevant studies were identified during the search and were screened first by the study title and then by the abstract using Endnote (Clarivate) referencing software. For the articles that met eligibility criteria based on title and abstract, the full article was assessed by 2 independent reviewers to confirm eligibility. Disagreements about study eligibility were discussed between the 2 reviewers and brought to a third party, when necessary, until a consensus was reached. There were no requirements for sample size, adolescent weight status, or study location. Articles were excluded if they (1) did not involve a technology-based component; (2) were protocol studies or nonintervention studies (eg, cross-sectional studies, qualitative studies, and review articles); or (3) were duplicates or had overlap with another study.

Charting the Data

Once relevant articles were selected, information from all studies was extracted using a narrative review approach [35]. We developed an extraction framework that included 32 categories focused on information from the PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) checklist and our research questions. In all, 2 reviewers independently extracted information from each article across each data extraction category and met to compare the extracted information. Discrepancies were discussed between the 2 reviewers and a third party, when necessary, until a consensus was reached. The presence of available information across extraction categories is presented in Multimedia Appendix 2 [36-42].

Synthesizing and Summarizing the Results

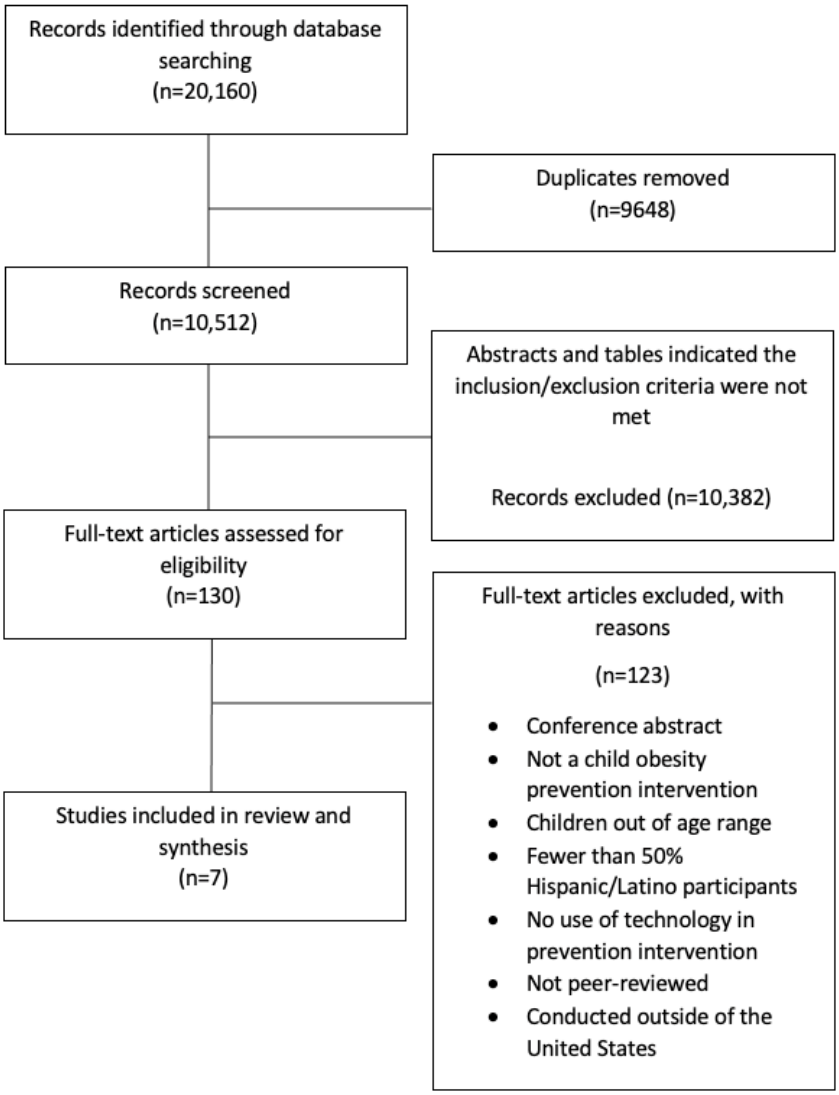
Descriptive statistics (ie, frequencies) were calculated for intervention and sample characteristics as well as feasibility-related components. A content analysis approach was used to summarize patterns found in the information extracted across data extraction categories [29]. Data synthesis and summation was focused on answering the research questions.

Results

Database Search and Screening

The search yielded a total of 20,160 results, with 10,512 remaining after duplicates were removed. The Consolidated Standards of Reporting Trials (CONSORT) diagram in Figure 1 summarizes the review process. A total of 10,382 papers were eliminated by the blind screening of titles and abstracts. After reading the full article, 123 papers were eliminated for the following reasons: being a conference abstract, not being an adolescent obesity prevention intervention, adolescents were out of the age range, conducted outside of the United States, included fewer than 50% Hispanic/Latino participants, no use of technology in prevention intervention, and not being a peer-reviewed paper. The search yielded a total of 7 papers published between 2010-2021 that were included in this scoping review.

Figure 1. Consolidated Standards of Reporting Trials (CONSORT) diagram.



Intervention Characteristics

Table 1 provides a summary of intervention characteristics. Of the 7 included papers, half (n=4, 57%) of all studies were randomized control trials, with the other half (n=3, 43%) representing quasi-experimental study designs including pre-post feasibility and pilot studies. There were about equal numbers of interventions that were implemented in the school (n=3, 43%) and clinic (n=4, 57%) settings. Additionally, 2 interventions implemented in the school setting and 2 interventions implemented in the clinic setting also had a home-based component. Most (n=5, 71%) interventions were fewer than or equal to 12 weeks in duration, with a few (n=2, 29%) lasting from 11-52 weeks, and no study lasting longer than 1 year. Regarding obesity-related health behaviors, all (n=7, 100%) interventions targeted physical activity and most (n=4, 57%) focused on dietary habits. Most (n=5, 71%) studies did not report the use of a theoretical framework. For the studies that did, they reported the use of multiple theories including the following: Transtheoretical Model of Change, Mindset Theory, Achievement Motivation Theory, and Behavioral Determinants Model. Web-based sessions were the most (n=4, 57%) commonly used technology-based approach sessions, typically lasted 30-45 minutes. All (n=7, 100%) the studies reviewed described the use of at least one behavior change techniques, with many studies using more than one. Enhancing social support (n=5, 71%) and self-efficacy (n=6, 86%) were the most commonly used techniques, followed by the use of didactic health education sessions (n=5, 71%). Regarding primary outcomes, all (n=7, 100%) studies assessed physical activity with over half of the studies also assessing diet (n=4, 57%), anthropometrics or cardiometabolic outcomes (n=6, 86%), and a psychosocial outcome (n=5, 71%). We found 4 (57%) studies that reported significant improvements in health behaviors, 3 (43%) studies that reported improvements in obesity or cardiometabolic disease outcomes, and 3 (43%) studies that reported improvements to psychosocial outcomes.

Table 1. Intervention characteristics.

Characteristic	Study (N=7), n (%)
Study design[a]	
Randomized controlled trial	4 (57)
Quasi-experimental	3 (43)
Intervention setting[a]	
School	3 (43)
Clinic	4 (57)
Home	4 (57)
Length of intervention	
≤12 weeks	5 (71)
13 weeks to 1 year	2 (29)
Health behaviors targeted[a]	
Dietary habits	4 (57)
Physical activity	7 (100)
Weight loss or regulation	2 (29)
Sedentary behaviors	1 (14)
Theoretical framework[a]	
Transtheoretical Model of Behavior Change	1 (14)
Mindset Theory	1 (14)
Achievement Motivation Theory	1 (14)
Behavioral Determinants Model	1 (14)
Not specified	5 (71)
Technology components used[a]	
Web-based sessions	4 (57)
Fitness tracker or pedometer	2 (29)
Telephone-based	2 (29)
SMS text messaging	1 (14)
Heart rate monitor	1 (14)
Video gaming system	1 (14)
Behavior change techniques[a]	
Social support	5 (71)
Promoting self-efficacy	6 (86)
Behavioral counseling	1 (14)
Stop light approach	1 (14)
Self-monitoring	1 (14)
Health education	5 (71)
Primary outcomes[a]	
Anthropometrics	6 (86)
Diet	4 (57)
Physical activity	7 (100)
Sedentary behaviors	1 (14)
Screen time	1 (14)

Characteristic	Study (N=7), n (%)
Biomarkers	2 (29)
Fitness	2 (29)
Psychosocial outcomes	5 (71)

[a]Indicates that categories are not mutually exclusive, and total may exceed 100%.

Sample Characteristics

Participant characteristics are presented in Table 2. Almost all interventions included an overlapping population of youths in early and middle adolescence aged 10-13 years (n=5, 71%) and 14-17 years (n=6, 86%), respectively, with just 1 (14%) study including older adolescents aged 18-21 years. Sample sizes varied, with most (n=6, 86%) studies having 200 participants or fewer, and just 1 (14%) study having over 300 participants. Most (n=5, 71%) studies did not present data on family socioeconomic status. Among studies that did (n=2, 29%), they focused on youths from lower socioeconomic backgrounds. Most (n=6, 86%) interventions were designed to engage adolescents only; however, 1 (14%) study focused on both the parent and adolescent.

Table 2. Sample characteristics.

Characteristic	Study (N=7), n (%)
Age[a]	
Early adolescence (10-13 years)	5 (71)
Middle adolescence (14-17 years)	6 (86)
Late adolescence (18-21 years)	1 (14)
Sample size	
0-100	4 (57)
101-200	2 (29)
>300	1 (14)
Family socioeconomic status	
Low socioeconomic status	2 (29)
Not specified	5 (71)
Program participant	
Youths and family	1 (14)
Youths only	6 (86)

[a]Indicates that categories are not mutually exclusive, and total may exceed 100%.

Feasibility-Related Criteria

Feasibility-related characteristics are presented in Table 3. Only 3 (43%) studies conducted formative work. Formative work included pilot-testing intervention strategies [36], usability testing [37], and qualitative focus groups to guide intervention development [38]. The formative work conducted yielded information on the technical issues, level of participant engagement, and age-appropriateness of technology-based components [36-38]. Additionally, 1 (14%) study was delivered simultaneously in Spanish and English [36]. No other study specified the language used (n=6, 86%). There was also no study that reported the use of culturally tailored content in their intervention. Regarding SDoH, only a few (n=3, 43%) studies addressed or considered SDoH that were barriers in their development or implementation phase of the intervention. These strategies included identifying perceived self-reported barriers to physical activity [39], delivering the intervention on the web to overcome barriers such as transportation [40], and collaborating with community clinics and conducting provider trainings to focus on high-risk patients [36]. Only a few (n=3, 43%) studies included a measure of acceptability [38-40]. These studies used qualitative interviews, focus groups, and a postintervention satisfaction survey to measure acceptability. Flynn et al [39] reported 90% enjoyment among participants; Weigensberg et al [38] rated enjoyment on a scale from 1 to 10, and all participants reported scores of 9-10; whereas Jones et al [40] reported high satisfaction; however, only survey findings were presented. Only 2 (29%) studies reported on technical issues, which included device malfunctioning [41] and technical issues with computers in the school setting [40]. Finally, a few (n=3, 42%) studies reported retention rates above 80%, with a few (n=2, 29%) studies reporting retention rates below 80%, including Bowen-Jallow et al [41] (54.2%) and Patrick et al [36] (63%).

Table 3. Feasibility-related characteristics.

Characteristic	Study (N=7), n (%)
Formative work	
Yes	3 (43)
Not specified	4 (57)
Language	
Bilingual	1 (14)
Not specified	6 (86)
Culturally tailored content	
Not specified	7 (100)
Acknowledged social determinants of health	
Yes	3 (43)
Not specified	4 (57)
Acceptability measure	
Yes	3 (43)
Not specified	4 (57)
Technology issues reported	
Yes	2 (29)
Not specified	5 (71)
Retention rates	
0%-80%	2 (29)
81%-90%	3 (43)
Not specified	2 (29)

Discussion

Principal Findings

Technology-based interventions are a promising, age-appropriate, and accessible approach for engaging high-risk youths in disease prevention efforts; however, few such interventions have been developed and tested specifically for Hispanic youths. This scoping review used rigorous methods to review technology-based obesity prevention interventions among Hispanic adolescents. This review examined intervention and sample characteristics. Strengths in intervention and sample characteristics include the use of a rigorous randomized controlled trial study designs among half of all studies, although only 2 reported that they were fully powered. Most studies assessed physical activity, diet, anthropometrics, cardiometabolic biomarkers, and a psychosocial outcome. Although the focus of a scoping review is not on study outcomes, it is worth noting that studies that reported significant improvements to anthropometric or cardiometabolic outcomes used a hybrid approach of in-person and remote technology strategies and reported high acceptability and retention (≥80%) [38,40,42]. Although it is not clear what the most effective behavior change techniques are for Hispanic youths given the broad range of techniques used, all studies reported the use of 1 or more behavior change technique, which is a noteworthy strength [43,44].

This review also focused on the reporting of feasibility-related outcomes in each study. Only a few studies reported on technical issues, and it is not clear if this is because few technical issues were experienced or if the investigators did not publish this information. Of the studies that did publish on acceptability, they reported very high levels of satisfaction and enjoyment. Attrition, another indicator of engagement and feasibility, was mixed, with some studies reporting high levels of attrition. Taken together, reporting on feasibility criteria across studies in this review are limited, and although the technology-based strategies used in these interventions are promising, there is a greater need for the testing and publishing of feasibility-related criteria. To increase the feasibility, reach, and begin to move toward efficacy, there are substantial gaps that future technology-based prevention strategies should address.

Identified Gaps and Implications for Future Research

Lack of Theoretical Framework

Only 2 studies in this review reported the use of behavioral theories and models [36,37]. These 2 studies reported the use and integration of multiple theories; however, neither study assessed theoretical constructs nor examined them as mediators of intervention effects [36,37]. Given this gap in reporting, there is limited information on the theoretical constructs that drive behavior change in technology-based interventions among this population [1,45,46]. It has been suggested that technology-based interventions require new, adaptable

theoretical approaches that build upon existing behavioral theories to integrate the design, implementation, and engineering needs of technology-based strategies [47,48]. Among racial and ethnic subgroups, theoretical approaches should also address the social and cultural needs of the population of focus [45]. To advance the state of the science in technology-based interventions among Hispanic youths, there is a need for more theoretically grounded interventions. Future studies should provide more detail on the theoretical approaches used and any adaptations that are made. This information is critical for identifying and understanding the underlying theoretical mechanisms by which these interventions drive behavior change and reduce obesity among Hispanic youths [49,50].

Lack of Reporting on Feasibility Criteria

To assess the acceptability and appropriateness of technology-based strategies among Hispanic adolescents, we examined the reporting of feasibility-related criteria including formative work, measures of acceptability, and adaptations for SDoH or cultural considerations. Just half of studies conducted formative work [36-38], which is consistent with previous reports that youths are often not included in the development of technology-based interventions [20]. User-centered or co-design approaches that engage the end user in the design and development process can significantly increase the acceptability, engagement, and effectiveness of technology-based strategies [28]. Only 3 studies included measures of acceptability, limiting our understanding of the age and cultural appropriateness of the strategies used. Similarly, just 3 studies acknowledged SDoH. Hispanic youths are disproportionately burdened by inequitable experiences across obesity-related SDoH [51]. This finding underscores the need to address negative SDoH such as the lack of transportation as well as seek opportunities to leverage positive SDoH such as family social support and connectedness in the design and implementation of prevention efforts [52]. Regarding cultural considerations, just 1 study reported that they offered materials to participants in Spanish and English in consideration of language barriers [36]. Although peripheral strategies such as language translations are needed [9], there is also a need for more “deep structure” strategies that integrate broader social and cultural factors such as values, norms, and traditions [53]. Interventions that are culturally tailored to the focus population are the most effective and engaging interventions for addressing obesity disparities among minority youths [9,32,54]. Studies in this review also had limited reporting on other feasibility-related criteria including technical issues experienced by implementers or participants as well as the socioeconomic makeup of participants. These findings suggest that current technology-based interventions are not adapted to the cultural and social context of Hispanic adolescents. Furthermore, these findings highlight the substantial need for increased reporting on feasibility-related outcomes to discern if technology-based strategies are engaging and appropriate for high-risk youths and the barriers they may face [1,20].

Limitations in Health Behaviors Targeted

Lastly, similar to previously published reviews of obesity prevention interventions [32,46], we found that studies focused narrowly on diet and physical activity, with only 1 study that targeted sedentary behaviors [40] and no study focused on sleep behaviors. Time spent in sedentary pursuits, including screen time, is associated with higher BMI and poor lifestyle behaviors including increased caloric consumption and reduced activity [55]. Hispanic adolescents, particularly those from low-income households, engage in more screen time compared to non-Hispanic White youths [56], highlighting the importance for technology-based interventions among this population to address sedentary behaviors [1]. It has also been suggested that investigators specifically address screen time given that technology-based strategies may be seen as promoting screen time or as contrary to screen time recommendations [1]. Hispanic adolescents also report lower amounts of sleep compared to non-Hispanic White adolescents, and insufficient sleep is associated with greater risk for obesity [56]. Many technology devices such as personal activity trackers and some smartphone apps are already designed to promote and collect data on wake-time activity and nighttime sleep behaviors [57]. The 24-hour activity and sleep paradigm holds that to increase the effectiveness of current obesity prevention efforts, future interventions should leverage these devices to address the full continuum of wake-time activity and sleep behaviors [58].

Strengths and Limitations

This study focused on a high-risk population that is traditionally underrepresented in research. This review will contribute to the limited body of research describing technology-based obesity prevention interventions among Hispanic youths with obesity. Additional strengths included a rigorous, comprehensive search strategy across numerous databases and a systematic, in-depth data extraction process that was performed in duplicate to ensure reliability. Some studies may have had information missing across data extraction categories (ie, examined theoretical mediators) given that they were feasibility and pilot studies. We did not assess intervention effectiveness or quality, which may be seen as a limitation; however, a more rigorous assessment of outcomes is more in line with a systematic review and not a scoping review. Lastly, the results of this study may be influenced by the search terms that were used, the use of US-based search engines, the number of databases searched, the focus on English-language articles, and the selection of databases used in the search. As a result, this review may be subject to publication bias.

Conclusions

The literature on technology-based obesity prevention efforts among Hispanic adolescents is limited, making it difficult to determine the feasibility of this promising approach among this population. In addition to greater testing and reporting on feasibility-related outcomes, this review highlights 3 key gaps that should be addressed in future studies. There is a need for technology-based obesity prevention interventions that are theoretically grounded and that evaluate theoretical constructs to identify the underlying mechanism by which these strategies impact obesity-related outcomes and health behaviors among high-risk youths. There is a need for interventions that are tailored to the context of Hispanic youths and a need for increased evaluation and reporting of feasibility-related

outcomes of these interventions to determine the acceptability and appropriateness of technology-based strategies for Hispanic youths. Furthermore, given known disparities in screen time and sleep among Hispanic youths, intervention strategies among this population should leverage technology to address a broader range of health behaviors, including sedentary behaviors and sleep, to increase program effectiveness. Addressing these gaps in future work will guide the development and implementation of technology-based obesity prevention efforts that aim to reduce obesity disparities and promote health equity among Hispanic adolescents.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Search strategy used to identify eligible technology-based obesity prevention interventions among Hispanic adolescents with obesity.
[DOCX File , 15 KB - pediatrics_v5i4e39261_app1.docx]

Multimedia Appendix 2
Data extraction categories and availability of data within each article included in the review (n=7).
[DOCX File , 21 KB - pediatrics_v5i4e39261_app2.docx]

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Abbreviations

CONSORT: Consolidated Standards of Reporting Trials
PRISMA-ScR: Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews
SDoH: social determinants of health

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Original Paper

Time Spent Gaming, Device Type, Addiction Scores, and Well-being of Adolescent English Gamers in the 2021 OxWell Survey: Latent Profile Analysis

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Abstract

Background: The shift in the last decades to screen-based and increasingly web-based gaming activity has raised concerns about its impact on the development of children and adolescents. Despite decades of research into gaming and related psychosocial effects, the question remains how best to identify what degree or context of gaming may be a cause for concern.

Objective: This study aimed to classify adolescents into gamer profiles based on both gaming behaviors and well-being. Once we distinguished the different gamer profiles, we aimed to explore whether membership to a specific profile could be predicted based on a range of personal characteristics and experiences that could then help identify those at risk.

Methods: We explored gaming and well-being in an adolescent school population (aged 12-18 years) in England as part of the 2021 OxWell student survey. Self-report measures of time spent playing games on computers or consoles, time spent playing games on mobile phones, the Game Addiction Scale, and the Warwick-Edinburgh Mental Well-being Scale were used to classify adolescent heavy gamers (playing games for at least 3.5 hours a day) using latent profile analysis. We used multinomial logistic regression analysis to predict the profile membership based on a range of personal characteristics and experiences.

Results: In total, 12,725 participants answered the OxWell gaming questions. Almost one-third (3970/12,725, 31.2%) indicated that they play games for at least 3.5 hours a day. The correlation between time spent playing video games overall and well-being was not significant (P=.41). The latent profile analysis distinguished 6 profiles of adolescent heavy gamers: *adaptive computer gamers* (1747/3970, 44%); *casual computer gamers* (873/3970, 22%); *casual phone gamers* (595/3970, 15%); *unknown device gamers* (476/3970, 12%); *maladaptive computer gamers* (238/3970, 6%); and *maladaptive phone gamers* (79/3970, 2%). In comparison with *adaptive computer gamers*, *maladaptive phone gamers* were mostly female (odds ratio [OR] 0.08, 95% CI 0.03-0.21) and were more likely to have experienced abuse or neglect (OR 3.18, 95% CI 1.34-7.55). *Maladaptive computer gamers*, who reported gaming both on their mobile phones and on the computer, were mostly male and more likely to report anxiety (OR 2.25, 95% CI 1.23-4.12), aggressive behavior (OR 2.83, 95% CI 1.65-4.88), and web-based gambling (OR 2.18, 95% CI 1.24-3.81).

Conclusions: A substantial number of adolescents are spending ≥3.5 hours gaming each day, with almost 1 in 10 (317/3970, 8%) reporting co-occurring gaming and well-being issues. Long hours gaming using mobile phones, particularly common in female gamers, may signal poorer functioning and indicate a need for additional support. Although increased time gaming might be changing how adolescents spend their free time and might thus have public health implications, it does not seem to relate to co-occurring well-being issues or mental ill-health for the majority of adolescent gamers.

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KEYWORDS

gaming; adolescents; latent profile analysis; mobile phone; well-being; mental ill-health; mental health; digital technology

Introduction

Background

Significant behavioral changes take place with every generation; these are often accompanied by concern in people working with these populations. The shift in the last decades to screen-based and increasingly web-based gaming activity has raised concerns in published commentaries and the popular press about how this might affect the developing child and adolescent [1]. Nevertheless, games have always been a hallmark of childhood and adolescence, and video gaming can be both a positive and a negative experience [2,3]. However, despite decades of research into gaming and related psychosocial effects, the question remains how best to identify what degree or context of gaming may be a cause for concern. In an environment of increasing mental health difficulties [4] as well as digital technology use [5-8], we decided to explore gaming and well-being profiles in an adolescent school population (aged 12-18 years) in England as part of the 2021 OxWell student survey, which was conducted during the COVID-19 pandemic.

Determining when gaming may be a sign of impaired functioning is complex because intensive video game use in itself does not necessarily equate to problematic gaming. Although traditionally studies on video game or digital media use have found negative associations with well-being [9-12], a growing body of recent evidence from large-scale studies shows that direct links between time spent engaging with digital technology and adolescent well-being or mental ill-health are either nonexistent or weak [13-17]. Many researchers argue instead that there may be a minority of gamers for whom gaming can become problematic and interfere with psychological and social functioning [8,18,19]. Despite the ongoing debate about the nature and existence of problematic gaming [20-23], a new diagnosis for gaming disorder is now included in the International Classification of Diseases, Eleventh Revision [24]. Gaming addiction measures may be able to capture problematic gaming via impaired self-regulation and a loss of control over gaming, said to affect approximately 2% to 9% of adolescent gamers [25]. Such problematic gaming has been repeatedly shown to correlate with multiple negative psychosocial correlates, including aggressive behaviors, depression, loneliness, poor sleep quality, and lower social competence [18,26]. Nevertheless, the links between the scores on the Game Addiction Scale (GAS) and time spent playing video games as well as negative correlates are also not linear and likely context dependent [27-29].

Focusing on average patterns of association, as is done in correlational studies, can mask the heterogeneity of the gamer population. Person-centered approaches such as latent class analysis offer an opportunity to explore such heterogeneity by identifying unobserved (latent) subgroups that are inferred from a set of observed variables [30]. Most of the previous studies attempting to classify adolescent gamers have approached gaming as a disorder and only devised subgroups based on their gaming addiction score per individual item [31,32]. One study [33] categorized adolescent gamers based on their weekly web-based gaming time in addition to compulsive internet use–scale scores and distinguished, among others, addicted and not-addicted heavy gamer classes. However, they did not find clear relationships between these classes and mental ill-health. One possible explanation for their findings is that mental ill-health does not necessarily capture all aspects of successful functioning and is not the same as poor well-being [34]. However, this also suggests that well-being should be directly accounted for when classifying adolescent gamers to better understand how gaming habits may differ among those with impaired functioning or those with an inability to control their gaming habits.

Many of the studies of gaming behaviors among adolescents focus on PC games or massive multiplayer online role-playing games and have not included mobile phone game use. They have found that both gaming and higher gaming addiction scores are more prevalent in male adolescents [35]. Nevertheless, gaming is increasing in popularity among girls aged 5 to 15 years [3], and smartphone use is more prevalent in girls and women [36]. Paik et al [37] have described patterns of gaming behaviors across different gaming devices in a Korean adult sample. Although male gamers reported predominantly playing computer games, and female gamers reported predominantly playing mobile phone games, those who played games evenly on both a computer and a mobile phone were evenly distributed across the genders. This group also had the highest prevalence of depression, anxiety, and internet gaming disorder. Given that smartphone gaming has seen a rise in recent years, with 58% of those aged between 16 and 24 years reporting playing games on their mobile phones in 2020-2021 compared with 47% in 2019 and 31% in 2012 [38], smartphone gaming is also likely to play a role in adolescent gaming patterns.

Objectives

To best distinguish between those who engage in adaptive versus maladaptive gaming patterns, this study aimed to classify adolescent gamer profiles based not only on their gaming behaviors but also on their well-being. Specifically, we used a data-driven person-centered approach to explore whether latent gamer profiles can be determined based on how much time adolescents spend gaming on computers or consoles and mobile phones, their GAS scores, and their well-being. Once we distinguished the different gamer profiles, we aimed to explore whether their profile membership could then be predicted based on a range of personal characteristics and experiences that could help identify those at risk. These included sociodemographic information, specific gaming behaviors, school-related experiences and activities, family risk factors, and mental ill-health.

Methods

Study Design and Procedure

The OxWell student survey is a repeated cross-sectional survey of students, sampled from schools across 4 regions in England as described in the study protocol [39]. The OxWell survey collects data on a range of questions on mental ill-health and well-being, life experiences, and behaviors. It has 3 age-appropriate versions (divided into English school years 5 to 7, 8 to 11, and 12 to 13 and covering ages 9 to 18 years). The data analyzed here were collected from students in school years 8 to 13 in June and July 2021, a period during which schools were open, and most students had returned to in-person learning, but there were some classrooms affected by clusters of COVID-19 infection, causing whole classes to isolate. Participation in the OxWell survey was voluntary, and participants did not receive any monetary incentives to take part in the study.

Ethics Approval

The study was approved by the research ethics committee of the University of Oxford (R62366).

Participants

In total, 20,780 eligible students, based on predefined inclusion criteria [40], aged 12 to 18 years completed the OxWell survey in 2021. Of these 20,780 students, 8055 (38.76%) were excluded because of missing responses on gaming questions. To ensure survey completion during the designated school period (up to 45 minutes), the data on time spent gaming on a computer or console and a mobile phone, as well as from the GAS, were only collected from a subsample of participants. As previous research suggests that >4 hours of daily device-based engagement [41] or video gaming [42] is more likely to indicate impaired psychosocial functioning, only those participants who answered that they play games for at least 3.5 hours overall were asked these more targeted questions ("About how many hours a day do you usually play games on an electronic device [eg, computer, game console or phone]?"). Of the remaining 12,725 students, 8755 (68.8%) were excluded from further analysis because they were not playing for at least 3.5 hours and so were categorized as nongamers, resulting in a final sample of 3970 (31.2%) gamers (Table S1 in Multimedia Appendix 1).

Measures

Classification Variables

Time Spent Gaming

Those participants who reported playing games on electronic devices for at least 3.5 hours a day were asked to provide more precise information on how many hours a day they usually spend playing games on a computer or games console (*computer gaming*) and their mobile phone (*phone gaming*). Participants were asked to respond using a slider scale ranging from *0 hours* to *4 hours or more*. The responses were recoded into 2 discrete 5-point scales (0 to 4) for computer gaming and phone gaming.

Gaming Addiction

Participants who reported playing games on electronic devices for at least 3.5 hours a day were also asked to self-report on the short version of the GAS [25]. The short scale asks participants about their experiences with games over the last 6 months and aligns with the main criteria of internet gaming disorder in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition [43], and gaming disorder in the International Classification of Diseases, Eleventh Revision [44]. The items assess 7 addiction criteria: salience, tolerance, mood modification, relapse, withdrawal, conflict, and problems. All items are scored on a 5-point Likert scale ranging from 1 (*never*) to 5 (*very often*). These scores are averaged to represent a total GAS score. Generally, the GAS has been shown to have strong convergent and criterion validity and fair-to-excellent reliability [45].

Well-being

Adolescent self-reports on the Warwick-Edinburgh Mental Well-being Scale (WEMWBS) [46] were used to measure mental well-being. The WEMWBS comprises 14 positively phrased items that capture both feeling good and functioning well. Agreement with each item is indicated on a Likert scale ranging from 1 (*none of the time*) to 5 (*all the time*). Item scores are summed to produce a total score ranging from 14 to 70, with higher scores representing higher levels of mental well-being. The WEMWBS has been shown to be a psychometrically strong population measure of mental well-being and suitable for use with adolescent samples [47].

Predictor Variables

Participants reported on a number of personal characteristics and experiences that were examined as potential predictors of gamer profiles in this study. These included sociodemographic information such as age and gender as well as specific gaming behaviors such as playing video games before sleep (*late gaming*), experience of web-based gambling, or spending money on in-game purchases. Participants were also asked about school-related experiences and activities, including whether they felt a sense of belonging to the school community and how easy they found it to make and keep friends; experiences of school detention, aggressive behaviors, and bullying; and exercise frequency, as well as potential family risk factors, including whether they felt safe in the place they live, food poverty as a proxy for deprivation, and experiences of child abuse. Finally, a few different aspects of mental ill-health were examined, including anxiety and depression measured using the 25-item Revised Children's Anxiety and Depression Scale [48], insomnia measured using the 2-item version of the Sleep Condition Indicator [49], loneliness based on the 3-item version of the UCLA Loneliness Scale [50,51], and lifetime self-harm [52,53]. Full details of the measures used as predictor variables in the study are provided in Table S2 in Multimedia Appendix 1 [48-51] and the preregistration for this analysis [40].

Data Analysis

A latent profile analysis (LPA) using general mixture modeling was conducted in Mplus (Muthén & Muthén) [54] to determine latent profiles based on participants' scores on 4 measures:

computer gaming, phone gaming, GAS, and WEMWBS. LPA allows obtaining the probability that individuals belong to different groups, thus exposing hidden groups in the data [55]. Two 3-latent–profile models were initially fitted to determine whether profile covariance should be set to zero or constrained to be equal among profiles. A Satorra-Bentler scaled chi-square [56] test confirmed that the introduction of equality constraints significantly improved model fit (χ^2_{SB6}=701.2; P<.001). Therefore, models with 1 to 6 latent profiles that allowed the means but not variance or covariance to vary among profiles was fitted. All models used maximum likelihood estimation with robust SEs. To avoid the model identification at local maxima, each model used a set of 1000 random starting values, with 250 that yielded the highest log-likelihood to be used in the final optimizations, and 500 iterations.

Iterative evaluations of models comparing model fit indices were used to select the best-fitting model. The relative fit indices Bayesian information criterion and Vuong-Lo-Mendell-Rubin adjusted likelihood ratio [57,58] test were used to determine whether additional profiles in the LPA model improved the model fit.

In the second part of the analysis a multinomial logistic regression using *mlogit* package in R (version 4.1.3; The R Foundation for Statistical Computing) [59] was carried out to predict class membership using the categorical predictor variables. The individuals were assigned to their most likely profile using the posterior probability weights from the LPA to account for the assignment uncertainty. Next, their class membership was regressed onto the covariates (*gender*, *age*, *late gaming*, *tried web-based gambling*, *in-game purchases*, *school community*, *friendships*, *detention*, *aggression*, *bullying*, *exercise*, *sense of safety*, *food poverty*, *abuse*, *anxiety*, *depression*, *insomnia*, *loneliness*, and *self-harm*). Odds ratios (ORs) were used to determine the likelihood of association between the predictor variables and the profiles [60], and 95% CIs for the ORs were extracted to determine the significance of the association (ie, the 95% CIs should not cross the value of 1 to be reliable).

Results

Sample Characteristics and Spearman Correlation

In total, 12,725 participants answered the OxWell survey gaming questions, of whom 3970 (31.2%) *gamers* indicated that they play games on an electronic device for at least 3.5 hours a day, whereas 2779 (21.84%) reported not playing any games at all. The Spearman correlation between time spent playing video games overall and well-being was not significant when examined in the full sample ($r_{12,214}$<–0.01; P=.98). However, in the sample of gamers (Table 1), well-being was positively correlated with the amount of time spent playing video games on a computer or console but negatively correlated with the amount of time spent playing video games on a mobile phone and GAS scores. Of the 3970 gamers, 1798 (45.29%) had missing information on ≥1 predictor variable. To use the maximum available data, the full sample of gamers (n=3970) was included in the LPA classification, and the data from the adolescent gamers without missing predictor information (2172/3970, 54.71%) were used for the multinomial logistic regression (a comparison of excluded and included participants is presented in Tables S3 and S4 in Multimedia Appendix 1). Participant characteristics per analytical sample are described in Table 2.

Table 1. Spearman correlation matrix for classification variables.

Variable	Computer gaming	Phone gaming	GAS[a]	WEMWBS[b]
Computer gaming				
r	1	–0.03	0.37	0.12
P value	—[c]	.04	<.001	<.001
Phone gaming				
r	–0.03	1	0.17	–0.09
P value	.04	—	<.001	<.001
GAS				
r	0.37	0.17	1	–0.29
P value	<.001	<.001	—	<.001
WEMWBS				
r	0.12	–0.09	–0.29	1
P value	<.001	<.001	<.001	—

[a]GAS: Game Addiction Scale.

[b]WEMWBS: Warwick-Edinburgh Mental Well-being Scale.

[c]Not applicable.

Table 2. Sample characteristics per categorical predictor variable for the classification sample (N=3970) and the prediction subsample (n=2172).

Characteristic	Classification sample, n (%)	Prediction subsample, n (%)
Age (years)		
17 to 18	206 (5.2)	134 (6.2)
12 to 16	3764 (94.8)	2038 (93.8)
Gender		
Boy	2246 (56.6)	1416 (65.2)
Girl	1437 (36.2)	756 (34.8)
Other or prefer not to answer	287 (7.2)	0 (0)
Late gaming		
At least sometimes	3498 (88.1)	1961 (90.3)
Rarely	390 (9.8)	211 (9.7)
Missing	82 (2)	0 (0)
Tried web-based gambling		
Yes	425 (10.7)	234 (10.8)
No	3239 (81.6)	1938 (89.2)
Missing	306 (7.7)	0 (0)
In-game purchases		
Yes	3123 (78.7)	1794 (82.6)
No	718 (18.1)	378 (17.4)
Missing	129 (3.2)	0 (0)
School community		
Yes	674 (17)	456 (21)
No	3040 (76.6)	1716 (79)
Missing	256 (6.4)	0 (0)
Friendships		
Difficult	1782 (44.9)	953 (43.9)
Easy	1964 (49.5)	1219 (56.1)
Missing	224 (5.6)	0 (0)
Detention		
Several times	767 (19.3)	382 (17.6)
Once or twice	3112 (78.4)	1790 (82.4)
Missing	91 (2)	0 (0)
Aggression		
Yes	517 (13)	235 (10.8)
No	3316 (83.5)	1937 (89.2)
Missing	137 (3.5)	0 (0)
Bullying		
Bullied	303 (7.6)	135 (6.2)
Not bullied	3619 (91.2)	2037 (93.8)
Missing	48 (1.2)	0 (0)
Exercise (hours per day)		
>1	3270 (82.4)	1919 (88.4)
≤1	501 (12.6)	253 (11.6)

Characteristic	Classification sample, n (%)	Prediction subsample, n (%)
Missing	199 (5)	0 (0)
Sense of safety		
Unsafe	471 (11.9)	202 (9.3)
Safe	3422 (86.2)	1970 (90.7)
Missing	77 (2)	0 (0)
Food poverty		
Yes	683 (17.2)	323 (14.9)
No	3234 (81.5)	1849 (85.1)
Missing	53 (1)	0 (0)
Abuse		
Yes	929 (23.4)	457 (21)
No	3041 (76.6)	1715 (79)
Anxiety		
Above threshold	561 (14.1)	299 (13.8)
Below threshold	3077 (77.5)	1873 (86.2)
Missing	332 (8.4)	0 (0)
Depression		
Above threshold	743 (18.7)	383 (17.6)
Below threshold	2899 (73)	1789 (82.4)
Missing	328 (8.3)	0 (0)
Insomnia		
Yes	561 (14.1)	253 (11.6)
No	3346 (84.3)	1919 (88.4)
Missing	63 (2)	0 (0)
Loneliness		
Lonely	1720 (43.3)	834 (38.4)
Not lonely	2172 (54.7)	1338 (61.6)
Missing	78 (2)	0 (0)
Self-harm		
Yes	738 (18.6)	452 (20.8)
No	2348 (59.1)	1720 (79.2)
Missing	884 (22.3)	0 (0)

After fitting models with 2 to 6 latent classes (Table S5 in Multimedia Appendix 1), the 6-class model yielded the best fit. The best model fit was based on the drop in the Bayesian information criterion and Vuong-Lo-Mendell-Rubin adjusted likelihood ratio comparison, and it was acceptable based on additional diagnostic criteria such as entropy index and smallest class size.

Gamer Profiles

From this model, 6 distinct gamer profiles emerged (Figure 1; Table 3). Half (1973/3970, 49.7%) of the participants fell into 2 profiles characterized by the maximum amount of computer gaming (≥4 hours). Specifically, 43.53% (1728/3970) of our sample were most likely to be in the *adaptive computer gamers* group characterized by high scores on computer gaming, relatively low scores on phone gaming, medium GAS scores, and the highest well-being, whereas 6.17% (245/3970) of the participants with high scores on computer gaming were characterized by longer hours playing games on their mobile phone, the highest GAS scores, and lower well-being and thus were deemed to fall into the *maladaptive computer gamers* group.

Figure 1. Estimated latent profiles for adolescent gamers. The y-axis represents scaled and centered values for each classification variable. The shaded area represents 95% CIs. GAS: Gaming Addiction Scale; WEMWBS: Warwick-Edinburgh Mental Well-being Scale.

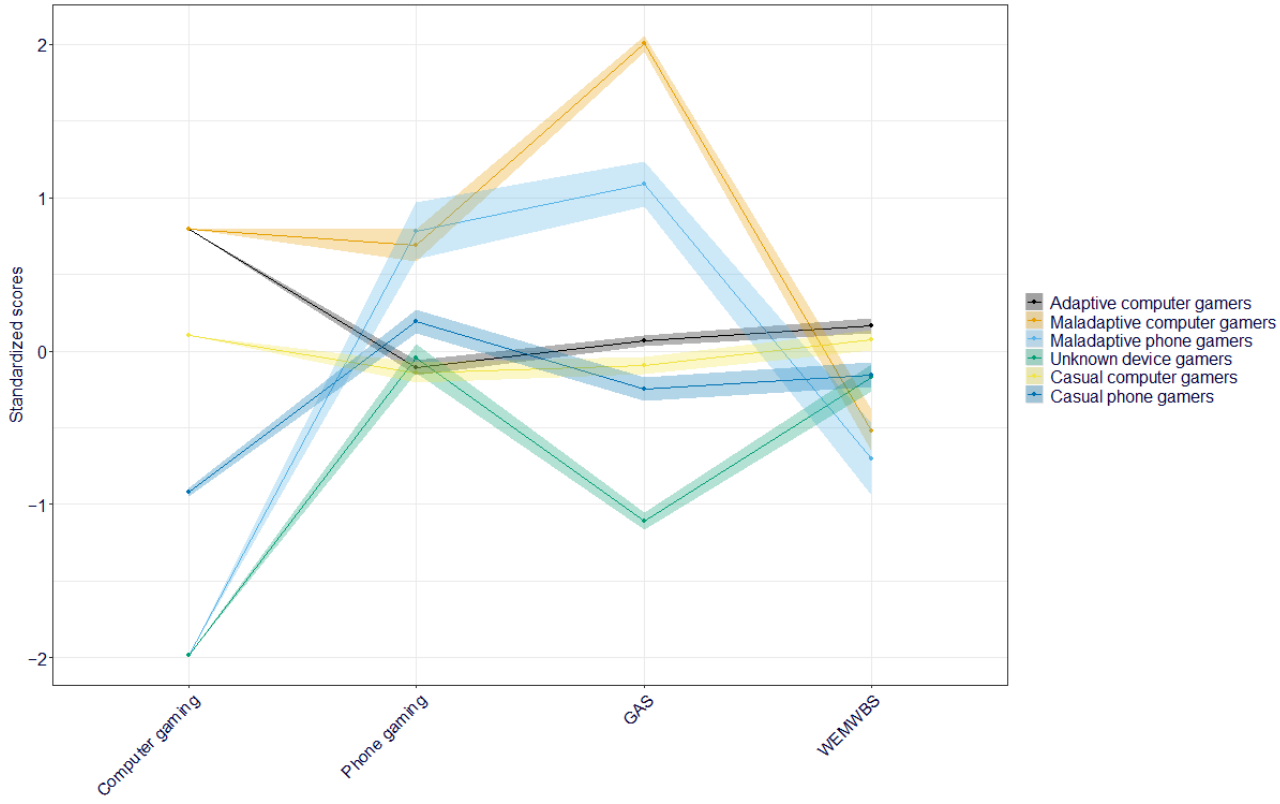


Table 3. Means and SDs of classification variables for gamer (n=3970) profiles and nongamers (n=8755).[a,b,c]

	Adaptive computer gamers	Maladaptive computer gamers	Maladaptive phone gamers	Unknown device gamers	Casual computer gamers	Casual phone gamers	Nongamers
Computer gaming, mean (SD)	4.00[d] (0.00)	4.00[d] (0.00)	0.00[e] (0.00)	0.00[e] (0.00)	3.00 (0.00)	1.53 (0.50)	N/A[f]
Phone gaming, mean (SD)	1.46[g,h] (1.21)	2.42[i] (0.99)	2.54[i] (0.93)	1.53[g,j] (1.30)	1.42[h,j] (1.17)	1.82 (1.10)	N/A
GAS[k], mean (SD)	2.60 (0.70)	4.43 (0.40)	3.56 (0.58)	1.49 (0.55)	2.45 (0.78)	2.31 (0.86)	N/A
WEMWBS[l], mean (SD)	45.70[m] (11.30)	37.80[n] (12.60)	35.60[n] (11.10)	41.70[m,o] (10.90)	44.60[p] (11.30)	41.90[o] (11.10)	44.50[p] (10.70)

[a]Nongamers include participants who reported playing games for <3.5 hours a day.

[b]The information on missing data regarding classification variables per profile is presented in Table S6 in Multimedia Appendix 1.

[c]Means that do not share the same superscript letters are significantly different (P<.001).

[d]P=.99.

[e]P=.99.

[f]N/A: not applicable.

[g]P=.28.

[h]P=.46.

[i]P=.48.

[j]P=.13.

[k]GAS: Game Addiction Scale.

[l]WEMWBS: Warwick-Edinburgh Mental Well-being Scale.

[m]P=.02.

[n]P=.16.

[o]P=.81.

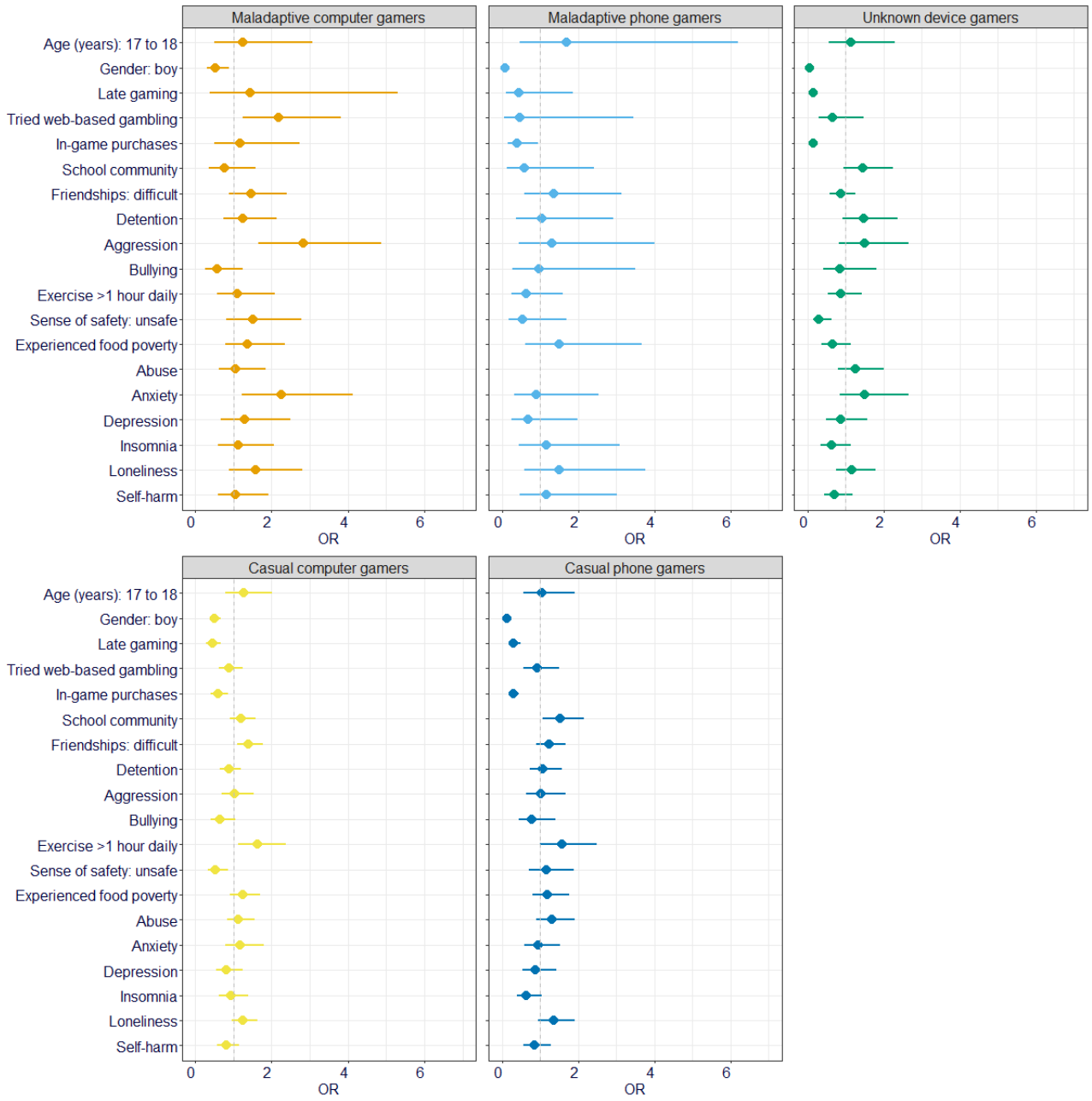
[p]P=.89.

Two further profiles encompassed a relatively small number of participants who only engaged with phone, rather than computer or console, gaming. The smallest profile of *maladaptive phone gamers* characterized 1.74% (69/3970) of the participants, who did not spend any time playing computer games but spent the longest time playing on mobile phones. They were also characterized by high GAS scores and the lowest average well-being in the sample. The other group that reported not playing computer games included 12.04% (478/3970) of the participants, who engaged in some gaming on their mobile phones but had the lowest GAS scores and reported medium well-being. As all participants in the sample previously reported playing games for at least 3.5 hours a day, this group will be referred to as *unknown device gamers*.

The final 2 profiles encompassed more than a third (1450/3970, 36.52%) of the participants, who played some computer games but not as much or as little as the other classes. Most (873/3970, 22%) were characterized by relatively high computer gaming, relatively low phone gaming, GAS scores just below average, and high well-being. This group was named *casual computer gamers*. The rest (577/3970, 14.53%) were defined by relatively low computer gaming scores, medium phone gaming scores, below-average GAS scores, and medium well-being scores and were thus referred to as *casual phone gamers*.

Multinomial logistic regression indicated that the likelihood of being categorized into different gamer profiles could be based on some of the hypothesized predictor variables (Figure 2). For instance, participants in the *maladaptive computer gamers* group, in comparison with the *adaptive computer gamers* group, were less likely to be male (OR 0.51, 95% CI 0.30-0.88) and more likely to have reported anxiety symptoms above the clinical threshold (OR 2.25, 95% CI 1.23-4.12), to have said that they are often aggressive or violent (OR 2.83, 95% CI 1.65-4.88), or to have previously engaged in web-based gambling (OR 2.18, 95% CI 1.24-3.81). *Maladaptive phone gamers*, in comparison with the *adaptive computer gamers*, were even less likely to be male (OR 0.08, 95% CI 0.03-0.21) and less likely to report spending money on in-game purchases (OR 0.40, 95% CI 0.17-0.95) but were more likely to have experienced child abuse, neglect, or domestic violence (OR 3.18, 95% CI 1.34-7.55). Both *casual computer gamers* and *casual phone gamers* were less likely than *adaptive computer gamers* to be male (OR 0.50, 95% CI 0.38-0.67 and OR 0.14, 95% CI 0.10-0.20, respectively), to engage in late night gaming during the hour before sleep (OR 0.45, 95% CI 0.30-0.67 and OR 0.31, 95% CI 0.19-0.50, respectively), or to report spending money on in-game purchases (OR 0.60, 95% CI 0.42-0.86 and OR 0.31, 95% CI 0.21-0.45, respectively). Nevertheless, *casual computer gamers* were also less likely than *adaptive computer gamers* to express feeling unsafe in the place they live (OR 0.53, 95% CI 0.33-0.85) and more likely to say that they find it difficult to make friends (OR 1.39, 95% CI 1.09-1.76) or engage in >1 hour of daily exercise (OR 1.63, 95% CI 1.12-2.37). By contrast, *casual phone gamers* were more likely than *adaptive computer gamers* to state that they identify with their school community (OR 1.52, 95% CI 1.07-2.15). *Unknown device gamers* were least likely to be male (OR 0.04, 95% CI 0.03-0.06), to engage in late night gaming during the hour before sleep (OR 0.14, 95% CI 0.09-0.24), to report spending money on in-game purchases (OR 0.14, 95% CI 0.09-0.21), or to express feeling unsafe in the place they live (OR 0.30, 95% CI 0.14-0.62) compared with the *adaptive computer gamers*. Full characteristics of the 6 profiles are presented in Tables S7 and S8 in Multimedia Appendix 1. An exploratory analysis using the excluded nongamers as a reference category in the multinomial logistic regression is also included in Multimedia Appendix 1 (refer to Supplementary Analysis: Gamer Profiles in Comparison With Nongamers [Figures S1 and S2; Table S9]).

Figure 2. Relative odds ratios (ORs) comparing the likelihood of gaming profiles per hypothesized predictor variable (reference group: adaptive computer gamers). Error bars represent 95% CIs for the ORs. OR and 95% CI >1 (to the right of the dotted line) indicate an increased likelihood of belonging to one of these gamer groups compared with adaptive computer gamers, whereas OR and 95% CI <1 (to the left of the dotted line) indicate a decreased likelihood of belonging to one of these gamer groups compared with adaptive computer gamers.



Discussion

Principal Findings

In this large school survey of the health and well-being of English students, almost one-third (3970/12,725, 31.2%) of the students who answered the questions on time spent on electronic devices said that they were gaming for at least 3.5 hours per day, whereas a fifth (2779/12,725, 21.84%) reported not engaging in any gaming. By examining time spent gaming per device type, GAS scores, and a well-being measure, 6 different gamer profiles emerged among those who were gaming the longest each day. The majority (1728/3970, 43.53%) of the students gaming for at least 3.5 hours fell into adaptive gaming categories with the highest well-being scores. Almost a tenth (314/3970, 8%) of the gamers exhibited maladaptive gaming patterns with the lowest well-being scores. Specifically, *maladaptive phone gamers* were a small group who were mostly female and were more likely to have experienced abuse or neglect. *Maladaptive computer gamers*, who reported gaming on their mobile phones in addition to computer gaming, were mostly male and more likely to report anxiety, aggressive behavior, and engagement in web-based gambling. Generally, those involved in predominantly computer gaming were mostly male, and those involved in predominantly phone gaming were mostly female.

Comparison With Prior Work

Our findings support previous research showing that the amount of time spent playing video games does not necessarily indicate

problematic gaming behavior [16,27,28]. Nearly half (1728/3970, 43.5%) of the gamers in this study engaged in ≥4 hours of computer gaming a day but reported high well-being. Overall, 8% (314/3970) of the adolescent gamers, corresponding to 2.47% (314/12,725) of the full sample, fell into the maladaptive gamer categories, which is also in line with previous estimates [25]. The *maladaptive computer gamers* group was most similar to problematic gamers identified in previous studies [18,26]. Specifically, this group not only spent large amounts of time playing video games daily but also reported low well-being and high GAS scores and were most likely to report aggressive behaviors and anxiety.

These findings expand on previous knowledge by showing that long hours of mobile phone, rather than computer or console, gaming may signal poor functioning. Two of the gamer groups that reported the highest phone gaming in this study also showed the highest GAS and lowest well-being scores. Paik et al [37] have previously found that adults who reported playing games on both their computers and mobile phones, rather than only on their mobile phones, were most likely to score higher on an internet gaming disorder scale and have higher depression and anxiety. Differently from their findings, we identified 2 maladaptive gamer groups that differed on their engagement with computer games, but both were characterized by playing games on their mobile phones for approximately 2.5 hours per day. Given the technological advances and wide availability of smartphones, with 93% of those aged 12 to 15 years in the United Kingdom owning a mobile phone [3], it seems realistic that those with the highest GAS scores would use these portable devices to meet their gaming needs.

In line with previous studies examining phone gaming [37] or smartphone use more generally [36], those engaged in predominantly phone gaming were more likely to be female than those engaged in predominantly computer gaming. Previous reviews highlight how female gamers experience a unique set of obstacles when engaging in video games, such as web-based harassment, hypersexualized female avatars, or aggressive gameplay [61]. It is plausible that gamers in this study who were female were also more likely to have had negative experiences during gameplay that, in turn, either motivated them to engage in phone gaming instead or had an impact on their well-being.

Our findings suggest that long hours spent gaming may be more typical in male adolescents but more likely to indicate problems in well-being for some female adolescents. The *maladaptive phone gamers* were mostly female, whereas the *maladaptive computer gamers* were mostly male. However, although nearly twice as many male gamers than female gamers were categorized into the *maladaptive computer gamers* group, they were still *more likely* to be female than the *adaptive computer gamers*. Female gamers were proportionally least likely to be assigned to the *adaptive computer gamers* group. Instead, they were proportionally most likely to fall into the *unknown device gamers* group that had the lowest GAS score on average but lower well-being than the *adaptive computer gamers* group. This is in line with previous research that found that female adolescents are particularly at risk for mental ill-health and lower well-being [62]. However, it is worth noting that those with previous experience of emotional abuse, neglect, or domestic violence were the most likely to fall into the *maladaptive phone gamers* group. Thus, it is also possible that female gamers who struggle with lower well-being because of previous traumatic experiences may seek out gaming, especially phone gaming, as a coping mechanism. This is partially in line with research showing that extrinsic or escapist motives, rather than playing for fun, are more likely to relate to negative gaming consequences [16,63,64].

A few other personal characteristics and experiences explored in this study predicted the membership of different gamer profiles, revealing a distinction between adaptive heavy gamers and more moderate gaming classes. For instance, *casual computer gamers* were having more difficulty making and keeping friends than adaptive gamers, but they were more likely to exercise. *Casual phone gamers* were most likely to identify with the school community, whereas *unknown device gamers* and *casual computer gamers* were more likely to feel safe at home compared with the adaptive gamers. This pattern of findings partially contradicts the displacement hypothesis [65], which would suggest that replacement of alternative activities such as socializing or exercising with gaming would be associated with lower, rather than higher, well-being. Instead, these findings suggest that gaming may be a potential coping strategy also used by those in, for example, unsafe environments, albeit with different associations for well-being than among those with previous experience of abuse who mostly fell in the *maladaptive phone gamers* group. Taken together, these findings support the theory of compensatory use outlined in the context of internet addiction, according to which negative life situations can give rise to a motivation to go on the web to alleviate negative feelings, the success of which may depend on the level of unmet needs [66]. However, the cross-sectional nature of this study limits our ability to make observations about the direction of effects. Future longitudinal research could disentangle these potential mediation patterns.

Our findings further suggest that some of the gaming-related behaviors that have been previously suggested to indicate risk behaviors for problematic gaming [18,26] may just be part and parcel of heavy daily gaming rather than specific to problematic gaming. For instance, making in-game purchases, although less common in the other groups, seemed to be a common characteristic among those playing extensive computer games and did not distinguish between adaptive and maladaptive gamers. Late night gaming was, not surprisingly, less common among those who engaged in less gaming overall but again did not distinguish between adaptive and maladaptive gamers. Nevertheless, experiences of web-based gambling did distinguish between *adaptive computer gamers* and *maladaptive computer gamers* in line with previous observed risks between gaming addiction and gambling [67].

Practical Implications

Our findings suggest that certain groups of gamers are at greater risk for co-occurring gaming and well-being issues and may require support in dealing with behavioral difficulties and mental ill-health. This study extends previous research by showing that large amounts of time spent gaming on mobile phones,

particularly common in female gamers, may signal poorer functioning, including aggressive behaviors and anxiety as well as experiences of abuse, neglect, or domestic violence. Although further longitudinal and experimental research is needed to understand the causal mechanisms behind this association, our findings highlight a potential avenue for mental health interventions with psychoeducational and therapeutic video (especially mobile phone) games as an opportunity to reach many adolescents struggling with mental ill-health. Indeed, as almost one-third (3970/12,725, 31.2%) of our sample reported playing video games for at least 3.5 hours a day, so did many of those with mental ill-health report heavy gaming (Table 2). This means that a substantial proportion of gamers across all groups, albeit especially in the maladaptive groups, could benefit from interventions for their reported anxiety, depression, insomnia, and self-harm. Certain video games have already been shown to help with symptoms of anxiety and depression [68], as well as be as effective as cognitive behavioral therapy [69] and more effective than second-line medication [70]. Rather than targeting time spent playing video games, using video gaming as a tool presents an opportunity for more affordable and less stigmatizing mental health interventions for adolescent populations and worthy of further investigation.

Limitations and Future Directions

Findings from the study should be considered within its limitations. First, this study uses a cross-sectional design, which curbs our ability to ascertain directionality of the effects; for example, although we found that some (314/3970, 8%) of the adolescents who play video games for at least 3.5 hours also report high GAS scores and low well-being, we are unable to determine whether their well-being is a cause or a consequence of their gaming habits or entirely unrelated. We are also unable to determine what the longer-term effects of heavy gaming may be. Second, although the OxWell student survey is representative of children and adolescents aged 8 to 18 years attending schools or further education colleges in participating counties in England, only a proportion (12,725/20,780, 61.24%) of the full sample was included in this study. A large proportion (8055/20,780, 38.76%) of the participants had to be excluded because they did not answer the question on their gaming habits; these questions were placed toward the end of the survey, and therefore many students might not have been allocated sufficient time to complete all the questions (45 minutes). As only those who played video games for at least 3.5 hours a day were asked further questions on their gaming habits, those who reported playing video games for <3.5 hours were excluded from the main analyses. Therefore, it remains unclear how the gamer profiles or their correlates observed in this study generalize or compare with the gaming patterns of the adolescents reporting spending some, but not as much, time playing video games (5976/12,725, 46.96%). Further studies examining longitudinal patterns in gaming behaviors in adolescent populations will better elucidate how those with poorer well-being or problematic motivation differ in their video game habits. More in-depth clinical assessments could also provide further information on potential well-being and mental health effects not captured in this study.

Moreover, the timing of the data collection could also influence the findings observed. Although the data were collected during the school term, it is plausible that gaming behaviors observed would have been different if measured in autumn or winter; for example, in summer adolescents may be spending more time gaming because of longer daytime hours or less time gaming because they are spending more time outdoors. Similarly, adolescent well-being and mental health scores could also have been seasonally affected [71]. Furthermore, the data analyzed in this study were collected in the context of the COVID-19 pandemic. Both mental ill-health [4] and gaming [5-7] have been reported to have increased in children and adolescents during the pandemic. It is thus possible that our findings represent a time when gaming was used by adolescents more commonly than usual. However, research shows that mental ill-health symptoms were worse in children and adolescents during periods of higher COVID-19–related restrictions [72], and these data were collected in a period (June and July 2021) when restrictions were relatively low, with most students having returned to in-person learning. Nevertheless, the COVID-19 pandemic is likely to have long-term impacts on child and adolescent mental ill-health as well as their engagement with digital technology, potentially explaining inconsistencies between these findings and some of the previous research.

Finally, the screen-based behaviors of the population are rapidly changing, especially in the arena of gaming. The options available at any one time can be dramatically different from one period of time to another; therefore, many of the previous studies and questionnaires developed do not consider the latest innovations in the field, popularity of specific games, and patterns of behavior. In the 2021 OxWell student survey, questions asked students about their own mobile phone use but not about use of mobile phones belonging to their parents or another family member, which may explain the existence of the *unknown device gamers* group. The students were also not asked other gaming-related questions that might have further enhanced our knowledge, such as which games they were playing, the variety of their choice of games, and more specific patterns of use, including whether they played with their friends, with other individuals in web-based gaming communities, or alone. The developments in game variety, device accessibility, and tailored incentives show no signs of abating and are likely to draw more adolescents into gaming, warranting further study.

Conclusions

This is one of the largest studies of adolescent gaming and well-being conducted in England. A substantial number of school-age children are spending at least 3.5 hours gaming each day. Nevertheless, the majority of young people spending much of their time gaming seem to be experiencing few negative effects with regard to their well-being, with <1 in 10 (317/3970, 8%) showing potentially maladaptive patterns of behavior. Our findings highlight how female gamers and those using their mobile phones are potentially at greater risk for co-occurring gaming and well-being issues and are important groups to better understand in order to support them if their difficulties become significant. Although increased time gaming might be changing how adolescents spend their free time and, thus, have public health implications, it does not seem to, at least

cross-sectionally, relate to co-occurring well-being issues or mental ill-health for the majority of adolescent gamers.

Acknowledgments

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Data Availability

All authors had full access to all the data in the study and accept responsibility for submitting the paper for publication. Fully deidentified extracts of the data can be provided to academic research collaborators upon reasonable request after a review process by the research team to ensure that uses of the data fall under the remit of the intended purposes set out in the privacy information and to prevent duplication of analyses. The data are not publicly available because of ethical and information governance restrictions. The full list of questions as well as other details are available on a project-specific *OxWell* Open Science Framework website along with the study protocol [73]. Full data dictionaries can be made available upon approval for access to data extracts.

Authors' Contributions

MF conceived the OxWell student survey with Dr Karen L Mansfield, a member of the OxWell study team, and obtained funds. Both authors worked on conceptualization and methodology. SS designed and performed the analyses. SS wrote the first draft, and MF worked on subsequent drafts. Both authors critically reviewed the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Supplementary tables and analyses.
[DOCX File , 389 KB - pediatrics_v5i4e41480_app1.docx]

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Abbreviations

GAS: Game Addiction Scale
LPA: latent profile analysis
OR: odds ratio
WEMWBS: Warwick-Edinburgh Mental Well-being Scale

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Original Paper

Women's Satisfaction With Telehealth Services During The COVID-19 Pandemic: Cross-sectional Survey Study

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Abstract

Background: Since March 2020, the need to reduce patients' exposure to COVID-19 has resulted in a large-scale pivot to telehealth service delivery. Although studies report that pregnant women have been generally satisfied with their prenatal telehealth experiences during the pandemic, less is known about telehealth satisfaction among postpartum women.

Objective: This study examined telehealth satisfaction among both pregnant and recently pregnant women during the COVID-19 pandemic, to determine whether demographic factors (ie, race, age, marital status, education level, household income, and employment status) are associated with telehealth satisfaction in this population.

Methods: A web-based cross-sectional survey designed to capture data on health-related behaviors and health care experiences of pregnant and recently pregnant women in the United States was disseminated in Spring 2022. Eligible participants were at least 18 years old, identified as a woman, and were currently pregnant or had been pregnant in the last 3 years.

Results: In the final analytic sample of N=403, the mean telehealth satisfaction score was 3.97 (SD 0.66; score range 1-5). In adjusted linear regression models, being aged 35-44 years (vs 18-24 years), having an annual income of ≥ US $100,000 (vs < US $50,000), and being recently (vs currently) pregnant were associated with greater telehealth satisfaction (P≤.049).

Conclusions: Although perinatal women are generally satisfied with telehealth, disparities exist. Specifically, being aged 18-24 years, having an annual income of < US $50,000, and being currently pregnant were associated with lower telehealth satisfaction. It is critical that public health policies or programs consider these factors, especially if the expanded use of telehealth is to persist beyond the pandemic.

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KEYWORDS

telehealth; COVID-19; maternal-child health; Perinatal; pediatrics; telemedicine; pregnancy; women's health; patient outcome

Introduction

The COVID-19 pandemic has profoundly impacted health care service delivery in the United States. Since March 2020, the need to reduce COVID-19 exposure for health care professionals and patients, preserve supplies of personal protective equipment, and reduce burden on health care facilities has resulted in a large-scale pivot to telehealth service delivery [1]. Telehealth is defined by the US Department of Health and Human Services as the delivery of health care services without an in-person office visit and primarily through internet access on a computer, tablet, or smartphone [2]. Before the pandemic, telehealth comprised less than 1% of outpatient visits, but this number rose to 13% in the early months of the pandemic [3]. In fact, telehealth visits increased by 154% in the last week of March 2020, when the pandemic was intensifying in the United States, compared to the same period in 2019 [4]. This surge in the use

of telehealth services continued throughout 2020 with the number of telehealth visits made by Medicare patients increasing 63-fold from 840,000 in 2019 to nearly 52.7 million in 2020 [5]. Although the use of telehealth has receded since its peak in 2020, it remains high comprising 8% of outpatient visits in 2021 [3].

Given the rise in telehealth and the sustained use of these services throughout the pandemic, it is important to examine the experiences of patients using these services in order to understand challenges and address gaps with this health care delivery model. It is especially important to understand the unique experiences of women seeking prenatal and postnatal care through telehealth services because these types of maternal health services are critical to ensuring the health and safety of women and their children. Broadly, patients have reported positive experiences and high satisfaction with telehealth services during the pandemic [6,7]. However, the telehealth experiences among prenatal and postpartum women during the pandemic are not well understood, and women who have been pregnant or recently pregnant during the pandemic and used telehealth services for their routine care may have unique challenges and experiences. Although studies have found that pregnant women are generally satisfied with their prenatal telehealth experiences during the pandemic, less is known about the telehealth satisfaction of postpartum women [8-10]. Given the critical role of prenatal and postpartum health care in preventing adverse pregnancy outcomes, more research is needed to fully understand the factors (eg, age, income, and race) that impact the telehealth experiences of pregnant and recently pregnant women during the pandemic.

Prior work has identified several sociodemographic factors associated with telehealth satisfaction. Recent studies on the relationship between age and telehealth satisfaction during the pandemic have found that older people are generally less satisfied with their telehealth experience [11]. Some reasons for this may include greater challenges with technology and more concerns about privacy among older people. A study of patient satisfaction with telehealth in a rural community during the pandemic found that adults 35 years and older were less satisfied with telehealth compared to younger adults between the ages of 18 and 34 years [12]. Similarly, a study of patients in an urban community found that younger adults had more positive experiences with their telehealth visits compared to older adults [13]. Despite the consistent theme that younger patients report greater telehealth satisfaction, further research is needed to understand whether this relationship is true among women of childbearing age. In focusing on the telehealth satisfaction of pregnant and recently pregnant women, it is possible a different trend may emerge between age and telehealth satisfaction.

Income and education may also be factors related to patient telehealth satisfaction, though less is known about these relationships. A nationally representative survey of US households during the pandemic found that although telehealth use was lowest among households earning less than US $100,000 annually, telehealth satisfaction did not significantly differ by income [7]. Similarly, another study of telehealth patients did not find any significant differences in patient satisfaction by income [11]. Interestingly, a study of low-income pregnant women found that women with a yearly household income less than US $25,000 were significantly more likely to prefer a telehealth visit over an in-person visit compared to those earning more than US $25,000 annually [8]. In addition to income, more research is also needed to understand the role of education in telehealth experiences. One study found no significant differences in telehealth satisfaction by educational attainment [13]. However, another study found that patients with advanced degrees reported significantly fewer technology difficulties during a telehealth visit compared to those who reported lower educational levels [14]. Given the varied findings on how income and education are associated with telehealth satisfaction, more research is needed to elucidate these relationships, especially among pregnant and recently pregnant women of varying socioeconomic status.

Racial minority groups were disproportionately affected during the pandemic and experienced higher rates of COVID-19–related hospitalization and death as well as higher rates of job loss [15]. Given these racial disparities, it is especially important to understand the telehealth experiences of people of color. Although some research has shown greater telehealth satisfaction among non-White patients [11], other studies have found that non-White patients report poorer telehealth satisfaction [16]. Furthermore, other studies have not found any statistically significant differences in telehealth preference by race [7,13]. The lack of consistent findings on the impact of race on patient telehealth satisfaction paired together with the racial health disparities that have long existed in the United States make this a crucial gap to address if telehealth is to become an equitable health care delivery model during the pandemic and beyond.

Since the onset of the COVID-19 pandemic in mid-March 2020, the use of telehealth services has surged to unprecedented levels. Given this surge coupled with the critical role that maternal health services play in preventing adverse pregnancy outcomes for women and their newborns, it is necessary to understand the experiences of women using telehealth during the perinatal period and the different factors that may affect their satisfaction with telehealth. Specifically, it is important to examine the role of age, income, education, and race on women's telehealth experiences, since research in this area is limited and findings are often inconsistent. By understanding the different factors that are at play when women use telehealth services, we may be able to identify and address disparities associated with this health care delivery model. For this reason, this study seeks to examine telehealth satisfaction among pregnant and recently pregnant women during the COVID-19 pandemic and to determine whether demographic factors (eg, race, age, and income) are predictive of telehealth satisfaction in this population.

Methods

Study Design and Sample

A web-based cross-sectional survey, built using Qualtrics software, was conducted from March 22nd to May 19th of 2022. The survey took approximately 10-15 minutes to complete, and all responses were anonymous. Eligibility criteria included

adults ages 18 years and older who identify as a woman and are currently pregnant or have been pregnant in the last 3 years. Survey participants were recruited via Washington, DC prenatal clinic email listserves, social media (ie, Facebook, Instagram, and GroupMe) and Centiment, a web-based survey research company that recruits and pays individuals who meet researcher specified demographic criteria [17]. Individuals recruited by Centiment were living in DC, Maryland, or Virginia at the time of survey participation. Study procedures were approved by the first author's institutional review board. Of the 759 current or previously pregnant participants who completed the survey, 435 (57%) reported using telehealth services since the start of the COVID-19 pandemic. Of those, 17 were missing responses to the telehealth satisfaction scale, and 15 were missing responses to demographic questions. Therefore, the final analytic sample size was N=403.

Measures

Telehealth Satisfaction

Telehealth satisfaction was measured using an 11-item scale. Participants were first asked the following question: "Since the start of the COVID-19 pandemic, have you had a health care appointment using telehealth (provision of health care remotely)?" Those who answered yes were asked to respond to the following prompt: "Please rate your level of agreement with the following statements about your most recent telehealth experience." Statements included the following: "The technology did not work for me," "The technology was helpful in connecting me with my provider," "I felt comfortable using telehealth," "My doctor was attentive to me during the appointment," "I felt my doctor was able to address my needs without a physical examination," "I would like to continue using telehealth," "I was satisfied with the care I received using telehealth," "Telehealth was convenient for me," "Telehealth made it easier for me to receive care," "Telehealth made filling prescriptions easier," and "I was able to receive care quickly using telehealth." Participants responded on a 5-point Likert scale from strongly disagree (1) to strongly agree (5). Item responses were reverse coded as needed, added together, and divided by 11 to produce a total score with the possible range of 1-5.

Demographic Variables

Survey respondents were asked to provide demographic information including age, race, marital status, education level, annual household income, employment status, and pregnancy status (current vs recent).

Analysis

Descriptive statistics were generated for all demographic variables of interest. Demographic characteristics were compared by race (ie, Black or African American, White, and other races) using chi-square tests. Telehealth satisfaction was also compared across demographic characteristics using ANOVA tests. Unadjusted simple regression models predicting telehealth satisfaction score from each demographic variable were tested. Finally adjusted regression models predicting telehealth satisfaction score from all demographic characteristics entered simultaneously into the model were tested. Statistical analyses were conducted using RStudio (version 1.3.1056) [18]. A significance level of <.05 was determined a priori.

Ethics Approval

This study was approved by the George Washington University Institutional Review Board (NCR213844).

Results

The analytical sample (N=403) was majority 25-34 years old, married or in a domestic partnership, employed full-time, and recently (as opposed to currently) pregnant. The mean telehealth satisfaction score was 3.97 (SD 0.66; score range 1-5). Table 1 presents the full demographic information for the analytic sample. Significant differences in demographic characteristics were identified by race (Black or African American, White, and other races), age category, marital status, education level, annual household income, and employment status, with Black or African American mothers tending to be younger, more often single, less educated, having lower annual household incomes, and more often unemployed (Table 1).

Significant differences in telehealth satisfaction score were identified by age category, marital status, education level, annual household income, employment status, and pregnancy status. Specifically, telehealth satisfaction score (mean 4.25, SD 0.54) was highest in participants who were aged 35-44 years, married or in a domestic partnership (mean 4.00, SD 0.62), had a master's degree (mean 4.17, SD 0.56), had a household income of ≥ US $100,000 (mean 4.16, SD 0.50), were employed full-time (mean 4.04, SD 0.63), and were recently pregnant (mean 4.14, SD 0.63; Table 2).

In unadjusted linear regression models, age, marital status, education level, household income, employment status, and pregnancy status were associated with telehealth satisfaction. Specifically, being of older age (vs 18-24 years of age), being married or in a domestic partnership (vs single), having a bachelor's or master's degree (vs high school education or less), having an annual income of ≥ US $100,000 (vs < US $50,000), being employed full-time (vs part-time employment or unemployed), and being recently (vs currently) pregnant were associated with greater telehealth satisfaction (P≤.049; Table 3).

In adjusted linear regression models, being aged 35-44 years (vs 18-24 years), having an annual income of ≥ US $100,000 (vs < US $50,000), and being recently (vs currently) pregnant were associated with greater telehealth satisfaction (P≤.049; Table 3).

Table 1. Descriptive characteristics of the analytic sample. Statistical comparisons are conducted using chi-square tests; italicized *P* values are significant.

Characteristics	Full sample (N=403), n (%)	Black or African American (N=76), n (%)	White (N=194), n (%)	Other races (N=133), n (%)	*P* value
Age (years)					*.001*
18-24	57 (14.14)	22 (28.95)	19 (9.79)	16 (12.03)	
25-34	261 (64.76)	44 (57.89)	130 (67.01)	87 (65.41)	
35-44	85 (21.09)	10 (13.16)	45 (23.20)	30 (22.56)	
Marital status					*<.001*
Married or domestic partnership	366 (90.82)	56 (73.68)	183 (94.33)	127 (95.49)	
Single, divorced, or widowed	37 (9.18)	20 (26.32)	11 (5.67)	6 (4.51)	
Highest education					*<.001*
High school or less	85 (21.09)	28 (36.84)	27 (13.92)	30 (22.56)	
Associate degree or trade school	51 (12.66)	12 (15.79)	25 (12.89)	14 (10.53)	
Bachelor’s degree	126 (31.27)	15 (19.74)	75 (38.66)	36 (27.07)	
Master’s degree	99 (24.57)	12 (15.79)	54 (27.84)	33 (24.81)	
Professional degree or PhD	42 (10.42)	9 (11.84)	13 (6.70)	20 (15.04)	
Annual household income (US $)					*<.001*
<50,000	88 (21.84)	27 (35.53)	28 (14.43)	33 (24.81)	
50,000-99,999	116 (28.78)	26 (34.21)	60 (30.93)	30 (22.56)	
≥100,000	199 (49.38)	23 (30.26)	106 (54.64)	70 (52.63)	
Employment					*.03*
Full-time	250 (62.03)	43 (56.58)	132 (68.04)	75 (56.39)	
Part-time	63 (15.63)	10 (13.16)	32 (16.49)	21 (15.79)	
Unemployed	90 (22.33)	23 (30.26)	30 (15.46)	37 (27.82)	
Pregnancy status					.09
Current	179 (44.42)	33 (43.42)	77 (39.69)	69 (51.88)	
Recent	224 (55.58)	43 (56.58)	117 (60.31)	64 (48.12)	

Table 2. Differences in telehealth satisfaction by demographic variables. Telehealth satisfaction possible range is 1-5; statistical comparisons were conducted using ANOVA; italicized *P* values are significant.

Characteristics	Telehealth satisfaction, mean (SD)	*P* value
Race		.19
White	4.03 (0.59)	
Black or African American	3.89 (0.76)	
Other	3.92 (0.68)	
Age (years)		*<.001*
18-24	3.66 (0.73)	
25-34	3.94 (0.64)	
35-44	4.25 (0.54)	
Marital status		*.005*
Married or domestic partnership	4.00 (0.62)	
Single, divorced, or widowed	3.68 (0.93)	
Highest education		*.001*
High school or less	3.79 (0.76)	
Associate degree or trade school	3.81 (0.79)	
Bachelor's degree	3.99 (0.55)	
Master's degree	4.17 (0.56)	
Professional degree or PhD	3.95 (0.66)	
Annual household income (US $)		*<.001*
<50,000	3.70 (0.74)	
50,000-99,999	3.83 (0.72)	
≥100,000	4.16 (0.50)	
Employment		*.010*
Full-time	4.04 (0.63)	
Part-time	3.79 (0.62)	
Unemployed	3.88 (0.72)	
Pregnancy status		*<.001*
Current	3.74 (0.62)	
Recent	4.14 (0.63)	

Table 3. Linear regression predicting telehealth satisfaction from demographic variables. Italicized *P* values are significant.

Characteristics	Model 1[a]		Model 2[b]	
	β (95% CI)	*P* value	β (95% CI)	*P* value
Race				
White	__[c]	—	—	—
Black or African American	–.13 (–0.31 to 0.04)	.13	.03 (–0.14 to 0.20)	.71
Other	–.11 (–0.25 to 0.04)	.14	–.05 (–0.19 to 0.09)	.49
Age				
18-24	—	—	—	—
25-34	.28 (0.10 to 0.46)	*.003*	.08 (–0.10 to 0.27)	.38
35-44	.59 (0.38 to 0.80)	*<.001*	.23 (0.001 to 0.47)	*.049*
Marital status				
Married or in domestic partnership	—	—	—	—
Single, divorced, or widowed	–.32 (–0.54 to 0.10)	*.005*	–.21 (–0.44 to 0.02)	.08
Highest education				
High school or less	—	—	—	—
Associate degree or trade school	.02 (–0.21 to 0.24)	.88	–.07 (–0.28 to 0.14)	.52
Bachelor's degree	.21 (0.03 to 0.38)	*.024*	–.04 (–0.24 to 0.15)	.66
Master's degree	.38 (0.20 to 0.57)	*<.001*	–.03 (–0.25 to 0.19)	.82
Professional degree or PhD	.17 (–0.07 to 0.41)	.17	–.19 (–0.45 to 0.07)	.15
Annual household income ($ US)				
<50,000	—	—	—	—
50,000-99,999	.14 (–0.04 to 0.31)	.13	.06 (–0.13 to 0.24)	.55
≥100,000	.47 (0.31 to 0.63)	*<.001*	.33 (0.13 to 0.54)	*.001*
Employment				
Full-time	—	—	—	—
Part-time	–.25 (–0.43 to –0.07)	*.007*	–.10 (–0.28 to 0.08)	.28
Unemployed	–.16 (–0.31 to –0.0003)	*.049*	–.02 (–0.18 to 0.13)	.76
Pregnancy status				
Current	—	—	—	—
Recent	.40 (0.28 to 0.52)	*<.001*	.31 (0.19 to 0.44)	*<.001*

[a]Unadjusted; each predictor was entered into a separate model.

[b]All covariates were entered simultaneously.

[c]Not applicable.

Discussion

Principal Findings

In this study, we examined how women's satisfaction with telehealth services during the COVID-19 pandemic differed by demographic factors. Results revealed that several demographic factors were associated with greater telehealth satisfaction, including older age, being married or in a domestic partnership, higher income, having attained a bachelor's or master's degree, and full-time employment. However, telehealth satisfaction did not significantly differ by race, even after adjusting for other demographic factors.

Pregnant and recently pregnant women reported generally positive experiences using telehealth during the pandemic. These findings are consistent with previous literature reporting on patients' positive experiences and high satisfaction with telehealth services during the pandemic [6,7]. Although not surprising, this finding is particularly important because it suggests that pregnant and recently pregnant women are satisfied with using telehealth services, despite the type of care that may be unique to this group, such as prenatal and postpartum care. Given that pregnant and recently pregnant women are satisfied using telehealth, it is important for health care policies and programs to consider sustaining the use of maternal telehealth services beyond the pandemic. For example, providers may

consider replacing routine in-person prenatal visits with prenatal telehealth visits or using telehealth to provide postpartum lactation support and screening for postpartum depression.

Results revealed a significant association between age and telehealth satisfaction, such that older age was associated with greater telehealth satisfaction. This finding is surprising because it is contrary to much of the literature that has consistently found younger age to be associated with more positive telehealth experiences [11-13]. This may be because our sample only included women of childbearing age, which limited the range of ages represented in this study. Furthermore, it is possible that other factors affected the relationship between age and telehealth satisfaction in our sample. For example, older women may have been more likely to have older children that could have assisted them with accessing and using the telehealth platform. Alternatively, younger women may be more inexperienced with the experience of pregnancy, compared to older women, and may need more in-person support during their care [19]. Future research should investigate the relationship between age and telehealth satisfaction among women of childbearing age to identify factors that may be contributing to this unexpected relationship.

Recent studies exploring the impact of income and education on telehealth experiences have produced varied and inconsistent findings [7,8,13,14]. This study found that higher income and higher educational attainment (up to a master's degree) were associated with greater telehealth satisfaction. These data underscore the importance of providing women from underserved communities with additional support when using telehealth services. Ensuring equitable access to telehealth services must be a priority; and public health policies or programs should implement strategies to mitigate the challenges women experience using telehealth services, particularly during the perinatal period. For example, replacing written instructions with graphics or visuals would allow women with lower literacy levels to navigate telehealth platforms more easily. Policy efforts to ensure equitable access to telehealth are crucial to eliminate disparities in patient satisfaction, especially if the current increased use of telehealth sustains beyond the pandemic.

This study did not find any significant differences in telehealth satisfaction by race. This is surprising given the health and health care access disparities that have long persisted in the United States for people of color [20]. This finding suggests that racial minority groups, such as Black women, are just as satisfied with the services they have received through telehealth as White women. However, it is also important to consider women's access to telehealth services and potential barriers. Perhaps, women of color are satisfied with telehealth when they have access to it, but securing that access may be a greater challenge. For example, a recent survey of pregnant women living in rural areas found that although women reported a positive experience with prenatal telehealth visits overall, common barriers included poor internet and phone connectivity, childcare responsibilities, and lack of equipment [21], factors that may disproportionately impact minority groups. Although it is important to understand women's experiences using telehealth, ensuring equitable access to these services is paramount and public health programs or policies are needed to reduce barriers to telehealth access. Given the increases we have seen in maternal morbidity or mortality in the United States [20], access to telehealth for pregnant or postpartum women could expand care and reduce maternal health disparities.

Limitations

Although the findings from this study are important and contribute to the recent literature on patient telehealth experiences during the COVID-19 pandemic, there are certain limitations that should be noted. First, this sample of pregnant and recently pregnant women was highly educated and affluent. Nearly 70% of the sample held at least a bachelor's degree, and almost 50% had an annual household income of at least US $100,000. It is important to note that despite the high educational attainment and income level of our sample, disparities related to income and education still emerged. This underscores the importance of ensuring equitable access to telehealth services, especially in underserved or marginalized communities. A second limitation of this study is that women were asked to report on their most recent telehealth experience and not specifically on their experience receiving prenatal or postpartum care through telehealth. For this reason, we cannot assume these findings are reflective of women's experiences using telehealth for prenatal or postpartum care, specifically, and future research should explore this. Third, another limitation is the potential for recall bias in the sample, especially among women who were not currently pregnant and were asked to recall past telehealth experiences. Finally, this study was cross-sectional, and findings cannot be used to inform causal mechanisms. Future work is needed to identify women's perceptions of telehealth care longitudinally. For example, studies might follow women over the course of their pregnancy to understand how their perceptions change over time.

Conclusions

Given the increase in telehealth services since the start of the COVID-19 pandemic in March 2020, it is important to understand the experiences of women accessing these services and the different factors that impact their satisfaction with these services. Although women are generally satisfied with telehealth, there are also important disparities that exist and it is critical that public health policies or programs consider these factors, especially if the expanded use of telehealth is to persist beyond the pandemic. Ensuring equitable access to telehealth and providing tailored support to women is key to eliminating these disparities. Although patients report high satisfaction with telehealth, future studies should investigate the barriers and challenges related to telehealth access among underserved populations. Future studies should also investigate clinical outcomes related to prenatal and postpartum telehealth services, especially if telehealth is a convenient and well-regarded model for delivering these types of maternal health care services.

Conflicts of Interest

None declared.

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Review

Canadian Resources on Cannabis Use and Fertility, Pregnancy, and Lactation: Scoping Review

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Abstract

Background: Cannabis use among reproductive-aged Canadians is increasing, but our understanding of its impacts on fertility, pregnancy, and breast milk is still evolving. Despite the availability of many web-based resources, informed decision-making and patient counseling are challenging for expectant families and providers alike.

Objective: We aimed to conduct a scoping review of publicly available web-based Canadian resources to provide information on the effects of cannabis on fertility, pregnancy, and breast milk.

Methods: Following PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews), we systematically searched 8 databases between January 1, 2010, and November 30, 2020, and web pages of 71 Canadian obstetrical, government, and public health organizations. We included English resources discussing the effects of cannabis on fertility, pregnancy, breastfeeding, or the exposed fetus and infant. Epidemiological characteristics, readability, and content information were extracted and summarized.

Results: A total of 183 resources met our inclusion criteria. Resources included content for public audiences (163/183, 89.1%) and health care providers (HCPs; 31/183, 16.9%). The resources were authored by national-level (46/183, 25.1%), provincial or territorial (65/183, 35.5%), and regional (72/183, 39.3%) organizations. All provinces and territories had at least one resource attributed to them. The majority (125/183, 68.3%) were written at a >10 grade reading level, and a few (7/183, 3.8%) were available in languages other than English or French. The breadth of content on fertility (55/183, 30.1%), pregnancy (173/183, 94.5%), and breast milk or breastfeeding (133/183, 72.7%) varied across resources. Common themes included citing a need for more research into the effects of cannabis on reproductive health and recommending that patients avoid or discontinue cannabis use. Although resources for providers were consistent in recommending patient counseling, resources targeting the public were less likely to encourage seeking advice from HCPs (23/163, 14.1%).

Conclusions: Canadian resources consistently identify that there is no known safe amount of cannabis that can be consumed in the context of fertility, pregnancy, and breastfeeding. Areas of improvement include increasing readability and language accessibility and encouraging bidirectional communication between HCPs and patients.

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KEYWORDS

cannabis; pregnancy; fertility; breastfeeding; patient education; patient resources; internet; eHealth; digital health

Introduction

Background

The prevalence of cannabis use in North America is increasing across all age groups as more jurisdictions legalize the production, sale, and possession of nonmedical cannabis products [1,2]. Increases in use are most notable among individuals of reproductive age, including pregnant individuals [3-5]. The recreational use of cannabis was nationally legalized in Canada on October 17, 2018 [6]. Before legalization, the prevalence of self-reported cannabis use among pregnant and recently pregnant individuals was increasing at both the national (adjusted odds ratio 1.18, 95% CI 0.98-1.43) [7] and provincial levels (adjusted relative risk 1.61, 95% CI 1.51-1.72) [3]. Although the data after legalization are limited, further increases are expected [1,8].

A growing body of experimental and epidemiological data suggests adverse effects of cannabis use on reproductive and perinatal health, including on fertility, pregnancy, breast milk, and the exposed fetus or infant [9]. However, the availability of scientific data does not necessarily mean that such data are distributed to, consumed by, or accessible to nonacademic audiences. The public increasingly uses internet resources as a primary source for health information and guidance [10]. Perinatal health information accessed via web-based resources may not be evidence based, up to date, or curated by health care professionals. Furthermore, data suggest public dissatisfaction with the quantity and quality of information available on perinatal cannabis use on the web [11]. Despite the availability of clinical guidelines from obstetrical societies [12,13], many health care providers (HCPs) lack the knowledge or confidence in their ability to provide counseling to their patients about cannabis use [14], including topics related to pregnancy [15]. Recent findings from the United States show that many HCPs do not respond to cannabis use disclosures or offer to counsel [16]. When counseling occurs, it frequently does not extend beyond general statements or discussions regarding potential legal or social services implications. A lack of counseling poses a significant challenge. Patients may infer from an absence of discussion that cannabis use is safe, with no impact on fetal development or later child health [11].

Objective

Many Canadian organizations may seek to guide perinatal cannabis use through web-based resources. However, the scope, consistency, and accessibility of available resources have not been previously evaluated. Therefore, the objective of this scoping review was to identify and characterize all publicly available web-based educational resources and clinical guidelines that provide information to the Canadian public and HCPs on the short-term and long-term effects of cannabis use on fertility, during pregnancy, and while breastfeeding.

Methods

Study Design

The protocol for this scoping review was registered a priori in the Open Science Framework [17] and has been published [18]. Protocol deviations are noted in Multimedia Appendix 1. Our methodology followed established frameworks for scoping reviews [19,20] and involved identifying the research question; identifying relevant literature or resources; selecting literature or resource; charting the data; and collating, summarizing, and reporting the results. Findings were reported in keeping with the PRISMA-ScR extension [21].

Search Strategy

Our search strategy was developed by a health sciences librarian (LS), with iterations completed in consultation with the study team and subsequently peer-reviewed by a second information specialist using the Peer Review of Electronic Search Strategies guideline [22].

To identify resources targeting the Canadian public and HCPs, we searched the websites of 71 Canadian organizations known to provide information on pregnancy and breastfeeding (federal and provincial health or public health agencies and national and regional obstetrical and perinatal societies and networks; Multimedia Appendix 2). These websites were identified in consultation with stakeholders in our professional networks. Websites were manually searched using a predefined keyword search strategy described in the published study protocol [18]. Resources with publication dates before 2010 were excluded. Those without publication dates were retained. Website search was completed manually by 2 independent reviewers (KB and AS) and validated by a third independent reviewer (MSQM).

To supplement our search for resources targeting HCPs, we also searched medical databases for professional care guidelines, position statements, and clinical recommendations. The search strategy was developed in MEDLINE and then translated into the other databases (Multimedia Appendix 3). We systematically searched MEDLINE and MEDLINE in Process via Ovid, Embase Classic + Embase via Ovid, ERIC via Ovid, CINAHL via EBSCOHost, and Education Source via EBSCOHost from January 1, 2010, to November 30, 2020, a 10-year contemporary sample encompassing the date of national legalization of the sale of nonmedical cannabis in Canada.

Study Selection

Eligible resources were those that (1) were developed by or on behalf of a Canadian organization; (2) were published in English or French between 2010 and 2020; (3) targeted clinicians or lay public; and (4) provided recommendations, guidance, or reports on the safety or impacts of cannabis use on male or female fertility, pregnancy, the developing fetus, or breast milk and breast milk–fed infants.

There were no limitations on resource formats; thus, eligible resources included web pages, infographics, posters-based

resources, video resources, and clinical guidelines or position statements.

Screening

For records identified via database searching, title, abstract, and full-text screening were conducted using DistillerSR [23] by 2 independent reviewers (KB and AS). Discrepancies arising at each step were discussed until a consensus was reached, and a third reviewer (MSQM) consulted when necessary. Records identified via website searching were assessed against predefined screening criteria as detailed in the published study protocol [18], and the URLs of eligible records were documented. The reference lists of all the included resources were reviewed to identify any relevant records that our search strategy may have missed.

Charting the Data

For resources published in peer-reviewed journals, we extracted the title, journal name, date of publication, name and email of the corresponding author, and the publishing or authoring organization, group, or society that developed the resource. For resources identified through website searches, we extracted the URL, the document title, date of publication (if available), date accessed for extraction, and the organization, group, or society that developed the resource. In addition, the use of visuals, videos, and references has been documented. Additional extracted characteristics included the availability of resources in languages other than English, the perceived target population (HCPs, general public, and both), contributions from patient partners or the general public, contributions from external organizations, cannabis-related terminology, the scope of the information presented on cannabis use, and recommendations made (if any). The accessibility and readability of the web-based resources were also determined. Readability was assessed using the Simple Measure of Gobbledygook [24]. Accessibility was documented as the reviewers' perception of how easy it was to find the resource from the parent website's home page. A resource was subjectively classified as "very easy" or "easy" to find through keyword searches on the parent website. A resource was classified as "not easy" to find if the reviewer was only able to find it after exhausting all possible keyword search strategies or if the resource appeared late in the search result pages (eg, appeared on the 20th search page). As they were not found through manual website searches, resources that were identified via the database search were classified as "not applicable." The extent to which content on fertility, pregnancy, and breastfeeding was mentioned within each resource was subjectively coded as "core to the document," "significantly represented," and "mentioned briefly."

Collating, Summarizing, and Reporting the Results

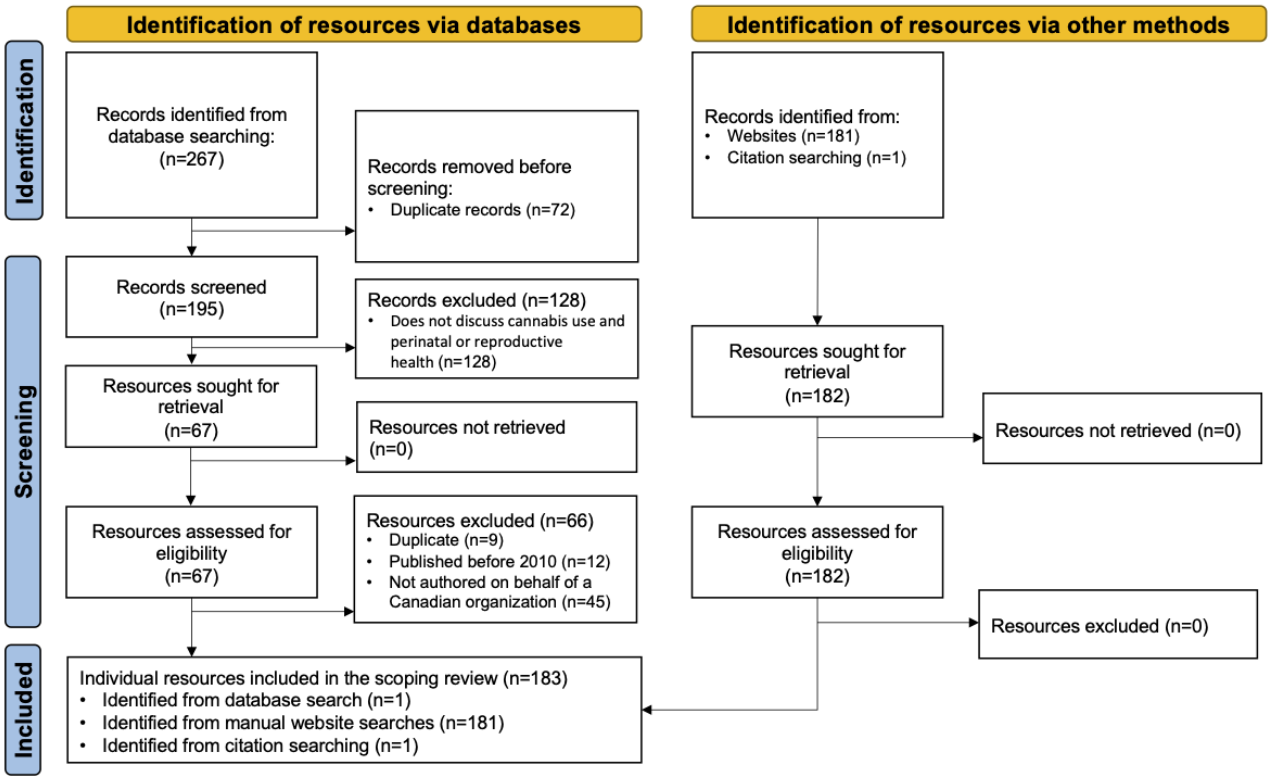
Extracted data were analyzed using quantitative (ie, frequencies and percentages) and qualitative (ie, thematic and exemplar quotes or excerpts) methods. Tables were then created to contextualize the level of jurisdiction of the publishing organization (national, provincial, or regional) and key characteristics and concepts of the included resources. Key characteristics were summarized separately for resources targeting the HCPs and the public. A word cloud was used to visualize the number and frequency of terms used to refer to cannabis and cannabis products [25].

Results

Overview

Our search strategy yielded a total of 377 articles and resources. A total of 267 records were identified from the database search of which 72 were excluded because they were duplicate records; 28 were excluded through title and abstract screening; and 66 were excluded through full-text screening. In total, 181 resources were identified through manual website searching, and 1 resource was identified through a review of reference lists of the included resources. Thus, 183 resources met the eligibility criteria to be included in the study (Figure 1). The individual characteristics of the included resources are shown in Multimedia Appendix 4.

Figure 1. PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) flow diagram.



Distribution of Resources by Canadian Geography

The included resources came from national-level organizations (46/183, 25.1%), provincial- or territorial-level organizations (65/183, 35.5%), and lower-level regional organizations within provinces and territories (eg, community organizations, regional health authorities, or public health units; 72/183, 39.3%). All 13 Canadian provinces and territories had at least one resource attributed to them. The provinces or territories with the greatest number of published resources (including resources from provincial- or regional-level organizations) were Ontario (72/137, 52.6%), British Columbia (28/137, 20.4%), and Alberta and Quebec (6/137, 4.4% for both; Table 1).

Table 1. Summary of educational resources included in this review by the geography of publishing organization.

	Resources, n (%)	Examples of authoring organizations	RefIDs of individual resources[a]
Authoring organization level of jurisdiction (N=183)			
National organization	46 (25.1)	Society of Obstetricians and Gynaecologists of Canada	1, 2, 7-13, 22-24, 26-28, 31, 38-45, 48, 57, 73-76, 84, 137-150, 182
Provincial or territorial organization	65 (35.5)	Centre for Addiction and Mental Health	Summarized below by province or territory
Regional organization[b]	72 (39.3)	Champlain Maternal Newborn Regional Program	Summarized below by province or territory
Authoring organization by home province or territory (n=137)[c]			
Alberta	6 (4.4)	Alberta Health Services	3-6, 21, 69
British Columbia	28 (20.4)	Perinatal services BC	15-17, 33-35, 50, 54, 61-68, 70-72, 111-118, 127
Manitoba	3 (2.2)	Government of Manitoba	77-79
New Brunswick	2 (1.5)	Government of New Brunswick	80, 81
Newfoundland and Labrador	3 (2.2)	Government of Newfoundland and Labrador	82, 83, 85
Northwest Territories	3 (2.2)	Government of Northwest Territories	90-92
Nova Scotia	2 (1.5)	Government of Nova Scotia	86, 87
Nunavut	2 (1.5)	Government of Nunavut	88, 89
Ontario	72 (52.6)	BORN Ontario	14, 18-20, 25, 30, 32, 36, 37, 46, 47, 49, 51-53, 55, 56. 59, 59, 102-110, 119-126, 128-136, 151, 154-156, 159-181, 183
Prince Edward Island	4 (2.9)	PEI Chief Public Health Office	29, 93-95
Quebec	6 (4.4)	Gouvernement du Québec	58, 60, 152, 153, 157, 158
Saskatchewan	5 (3.6)	Government of Saskatchewan	96-100
Yukon	1 (0.7)	Government of Yukon	101

[a]For full citations, see Multimedia Appendix 4.

[b]Includes community organizations, regional health authorities, and public health units.

[c]Excludes resources authored by a national organization.

Characteristics of Resources on Cannabis Use

Overview

Of the 183 resources identified, 15 (8.2%) were published before 2018 (before the national cannabis legalization in Canada), 57 (31.1%) were published in or after 2018, and 111 (60.7%) did not report the year of publication (Table 2). All publication dates were obtained from a manual website search. A total of 16.9% (31/183) of resources included information for HCPs, and 89.1% (163/183) had content specific to the general public. A total of 6% (11/183) of resources included content for both the public and the HCPs. A total of 74.3% (136/183) of resources included references of primary information sources for readers to refer to.

A broad terminology was used to refer to cannabis and its derivative products (n=56). The 4 most-frequently used terms were “cannabis” (n=174 mentions), “THC” (n=107 mentions), “marijuana” (n=63 mentions), and “CBD” (n=62 mentions; Multimedia Appendix 5).

Table 2. Characteristics of educational resources included in this scoping review.

Variables	All records (N=183), n (%)	Targeted audience[a], n (%)	
		Health care providers (n=31)	Public (n=163)
Year of publication			
Before 2018 (year of national legalization)	15 (8.2)	16 (51.6)	10 (6.1)
On or after 2018	57 (31.1)	6 (19.4)	47 (28.8)
Not reported	111 (60.7)	9 (29)	106 (65)
Resource is a clinical guideline	3 (1.6)	3 (9.7)	1 (0.6)
Specified contributions from patient partners or members of the public	8 (4.4)	3 (9.7)	6 (3.7)
Ease of finding the resource[b]			
Very easy	107 (58.5)	14 (45.2)	100 (61.3)
Easy	49 (26.8)	2 (6.5)	41 (25.2)
Not easy	23 (12.6)	5 (16.1)	16 (9.8)
Not applicable	2 (1.1)	2 (6.5)	0 (0)
Available languages			
English	183 (100)	31 (100)	163 (100)
French	80 (43.7)	12 (38.7)	75 (46)
Another language[c]	7 (3.8)	0 (0)	7 (4.3)
Approximate reading grade level[d]			
4-6	5 (2.7)	0 (0)	5 (3.1)
7-9	40 (21.9)	6 (19.4)	35 (21.5)
≥10	125 (68.3)	24 (77.4)	110 (67.5)
Not applicable (<100 words)	11 (6)	1 (3.2)	10 (6.1)
Resource is or includes an infographic	10 (5.5)	0 (0)	10 (6.1)
Resource is or includes a video or videos	29 (15.8)	14 (45.2)	22 (13.5)
Resource includes references	136 (74.3)	14 (45.2)	130 (79.8)

[a]Some records had content targeting both providers and the public and so may be represented in both columns.

[b]Resources were subjectively classified by the reviewer as "very easy," "easy," or "not easy" to find through keyword searches of the parent website. A resource was classified as "not easy" to find if the reviewer was only able to find it after exhausting all possible keyword search strategies or if the resource appeared late in the search result pages (eg, appeared on the 20th search page). Resources identified via the database search were classified as "not applicable."

[c]Other languages included Chinese, Farsi, Korean, Punjabi, Spanish, Vietnamese, Arabic, Farsi, Inuktitut, and Innuinnaqtun.

[d]Measured using the Simple Measure of Gobbledygook [24].

Resources for the Public

Of the 163 resources providing information to the public, only 6 (3.7%) specified contributions from patient partners or the public. On the basis of a subjective measure of difficulty to find the resources using keyword searches on the search engines within the parent-organization websites, of the 163 resources, 141 (86.5%) were "easy" or "very easy" to find, and 16 (9.8%) were "not easy" to find. In addition to English, 75 (46%) resources were available in French (an official language of Canada), and 7 (4.3%) were also available in other languages. Over half of the public-facing resources (110/163, 67.5%) were at an approximate 10th grade reading level or higher. A total of 6.1% (10/163) of resources included one or more infographics, and 13.5% (22/163) included one or more videos.

Resources for HCPs

Of the 31 resources with content for HCPs, 6 (19%) were published on or after 2018, and 9 (29%) did not report the date of publication. A total of 10% (3/31) of resources were clinical guidelines, and 10% (3/31) specified contributions from patient partners or the public. A total of 52% (16/31) of resources were deemed easy or very easy to find, and 16% (5/31) were not easy to find. A total of 39% (12/31) of resources were available in French, and 45% (14/31) included one or more videos.

Scope of Content Specific to Cannabis Use and Fertility, Pregnancy, and Breast Milk

Overview

The extent to which cannabis use and fertility, pregnancy, and breast milk were discussed varied greatly (Table 3). Of the 183 resources, 57 (31.1%) resources were dedicated specifically to providing information on the impact of cannabis use on fertility, pregnancy, and breast milk, but nearly half (87/183, 47.5%) only briefly mentioned the impact of cannabis use on reproductive health.

Table 3. Summary of content covered in the educational resources included in this scoping review.

Content	Included resources, n (%)
Extent to which content on fertility, pregnancy, and breast milk was discussed in the resource[a] (N=183)	
Core to the document	57 (31.1)
Significantly represented	39 (21.3)
Mentioned briefly	87 (47.5)
Content on fertility	55 (30.1)
Female fertility	28 (50.9)
Male fertility	22 (40)
Sex-specific effects not specified	24 (43.6)
Identification of a lack of evidence, data, or information	6 (10.9)
Content on pregnancy	173 (94.5)
Use for nausea in pregnancy	38 (22.0)
Effect on a woman's body during pregnancy	35 (20.2)
Effect on exposure fetus or newborn	117 (67.6)
Identification of a lack of evidence, data, or information	39 (22.5)
Content on breast milk or breastfeeding	133 (72.7)
Effect on mother's breast milk	47 (35.3)
Effect on breastfeeding infant	64 (48.1)
Identification of a lack of evidence, data, or information	34 (25.6)

[a]Subjectively evaluated based on how much content the resource contained on the topics in question relative to the total amount of information presented in the resource.

Content on Fertility

The potential impacts of cannabis use on fertility were identified by 30.1% (55/183) of resources. Of these 55 resources, 28 (51%) and 22 (40%) resources mentioned or discussed the specific impacts on female and male fertility, respectively. The main theme arising from these resources was that cannabis negatively affects the reproductive systems of both males and females. Resources mentioned a correlation between higher cannabis use and decreased testosterone levels and poor sperm quality (including lower sperm count, mobility, and concentration) and warned that cannabis use may be implicated in decreased male fertility and failed pregnancies. Similarly, resources suggested that cannabis use may affect the menstrual cycles of biological females by affecting ovulation, egg quality, and length of the cycle, thereby leading to difficulties in becoming pregnant.

Content on Pregnancy and the Developing Fetus

Cannabis exposure during pregnancy was discussed in 94.5% (173/183) of resources. Of these 173 resources, 38 (22%) included information on cannabis use for the treatment of nausea during pregnancy. The potential effects of cannabis exposure on pregnancy and the exposed fetus or newborn were mentioned or described in 20.2% (35/163) and 67.6% (117/163) of resources, respectively. Common messaging includes the fact that tetrahydrocannabinol (THC) can cross the placenta to the growing fetus and accumulate in the fetal fat and brain cells. Resources have cited varying lengths of time that THC could remain in human tissues, ranging from weeks to months. The indicated short-term effects of cannabis use on the body are also wide-ranging. The following exemplar quotes illustrate the information conveyed:

> *Women who smoke marijuana are at greater risk for a failed pregnancy because the drug can upset the chemical balance necessary for the safe passage of the embryo from the fallopian tube down to the uterus, potentially resulting in an ectopic (tubal) pregnancy or miscarriage.* [Licit and Illicit Drug Use during Pregnancy: Maternal, Neonatal and Early Childhood Consequences; Canadian Centre on Substance Use and Addiction]

> *Using cannabis during pregnancy may affect [the mother's] DNA and genes, which can be passed on to future generations.* [Cannabis and Pregnancy Don't

Mix, Poster #2; Society of Obstetricians and Gynecologists of Canada]

THC exposure to the fetus was linked to adverse outcomes, including preterm birth, low birth weight, stillbirth, growth restrictions, fetal or neonatal mortality, and congenital malformations, including heart abnormalities. Others mentioned long-term implications such as neurodevelopmental impairments, reduced motor development, and behavioral and learning issues as infants age; for example:

> *The effects of cannabis exposure during pregnancy may last a lifetime. Childhood: poor memory function, poor problem solving skills, and an inability to pay attention. Adolescence: Increased risk of depression and /or anxiety. Adulthood: Possible substance use.* [Cannabis, Pregnancy, and Breastfeeding Infographics; Society of Obstetricians and Gynecologists of Canada]

Content on Breast Milk and the Breast Milk–Fed Child

Topics related to breast milk and breastfeeding were mentioned or discussed in 72.7% (133/183) of resources. Among these 133 resources, the specific effects of cannabis use on breast milk were mentioned in 47 (35.3%) resources, and the potential effects on breast milk–fed infants were mentioned in 64 (48.1%) resources. General consensus among the resources was that THC could accumulate in the breast milk of lactating individuals using cannabis, and resources suggested that it could be stored in breast milk for up to 2 months. Consequently, resources conveyed that cannabis use during lactation could affect the quality and quantity of breast milk produced; for example:

> *Marijuana is excreted in your breast milk at levels 8 times higher than your blood marijuana (THC).* [Marijuana; The MotHERS Program]

> *Cannabis use may inhibit the production of prolactin and reduce the rate of milk production.* [Cannabis use during pregnancy and lactation; perinatal services, BC]

> *Cannabis use can affect the quality and quantity of breast milk you produce. THC is stored in your breast milk for long periods of time.* [Cannabis and Your Baby; Chatham-Kent Public Health]

The effects of infant exposure to THC through the consumption of breast milk were described to include slower motor development, reduced muscular tone, poor suckling or difficulty latching (harder to feed the infant), and issues with learning or behavior and mental health; for example:

> *THC (delta-9-tetrahydrocannabinol), the substance in cannabis responsible for the "high", is found in the breastmilk of women who smoke cannabis. If using cannabis affects your mind and body, it may also affect your child's mind and body. Like THC, CBD is likely to accumulate in fatty tissues, such as breast tissue.* [Is cannabis safe during preconception, pregnancy, and breastfeeding? Government of Canada]

Identification of a Lack of Evidence, Data, or Information About Cannabis Use and Reproductive Health

Of the 55 resources with content on fertility, only 6 (11%) identified a lack of evidence regarding the effect of cannabis on male or female fertility. Of the 173 resources with content on pregnancy and the developing fetus, 39 (22.5%) identified a lack of information regarding the effect or safety of cannabis on pregnancy or the developing child. Among the 133 resources mentioning breast milk, 34 (25.6%) identified a lack of information regarding the effect of cannabis on breast milk or breastfeeding infants, which is evident from the following example:

> *Further research is needed to better understand the long-term health effects of cannabis consumption in any form. Further research is needed to allow people to make better informed decisions.* [Cannabis Use During Pregnancy; Canadian Association of Midwives]

Recommendations Made for Cannabis Use and Fertility, Pregnancy, and Breastfeeding

In terms of guidance and recommendations provided by the resources included in this review, the overall theme was that cannabis use should be avoided by individuals who are trying to conceive, those who are pregnant, and those who breastfeed their infants. Therefore, cannabis use for the treatment of nausea and vomiting in pregnancy was not recommended; for example:

> *Cannabis is not recommended to treat nausea and vomiting during pregnancy. Ask a health care provider about safer options to feel better.* [Nausea and Vomiting, KFL&A Public Health]

Pregnant and lactating women or individuals were often grouped together as a single population for the delivery of recommendations; for example:

> *Avoid cannabis completely if you are pregnant or breastfeeding.* [Cannabis and Your Health; Government of Canada]

Of the 163 public-facing resources, only 23 (14.1%) specifically recommended that patients speak to their HCPs about cannabis use in the context of reproductive and perinatal health. One resource recommended that patients speak to their HCPs if using cannabis and planning a pregnancy; 17 suggested speaking to an HCP for further information on using cannabis during pregnancy and 12 for information on using cannabis during lactation; for example:

> *Some women are interested in using cannabis during pregnancy to treat nausea or "morning sickness". There is some research showing that women who use cannabis report relief from these symptoms; however, more research is needed to understand the potential health risks. Talk to your healthcare provider if you have questions about this.* [Women and Cannabis; Centre of Excellence for Women's Health]

In contrast, all the content for HCPs advised counseling patients about the risks of cannabis use; for example:

> *It is prudent to advise pregnant women and women thinking of becoming pregnant of the risks associated with cannabis use during pregnancy. The safest option available to pregnant women is to avoid using cannabis. Experts recommend against using any type of cannabis during pregnancy or breastfeeding.* [Clearing the Smoke on Cannabis, Canadian Centre on Substance Use and Addiction]

> *The relationship between prenatal cannabis use and LBW underscores the need for clinical management of cannabis use during pregnancy and lactation. Patients should be asked about cannabis use and advised to discontinue cannabis use during pregnancy and lactation.* [Alberta Antenatal Pathway; Maternal Newborn Child & Youth SCN]

Discussion

Principal Findings

In this scoping review of Canadian resources on cannabis use and reproductive and perinatal health, we found that resources targeting both HCPs and the public consistently recommend avoiding cannabis while individuals are trying to become pregnant and during pregnancy and lactation. Ontario-based organizations authored most of the public-facing resources; most were published in English only and used language above a 10th grade reading level. Few resources cited patient-partner collaborations as part of the development process, and a minority incorporated visual or audio-visual aids. Although HCP resources consistently identified the importance of patient counseling, resources for the public rarely recommended consultation with HCPs.

Strengths and Limitations

This study provides critical insights into the scope of publicly available information on the effects of cannabis use on fertility, during pregnancy, and while breastfeeding. Our methodology was strengthened by following established frameworks for scoping reviews. In addition, our use of a broad and iterative search strategy developed in collaboration with an information specialist, maternity care experts, and a patient partner further strengthened the yield of possible resources from public health, maternal and child health, and substance use authorities. However, there are relevant limitations that should be acknowledged. First, although our database and gray literature searches were comprehensive, some relevant and contributory resources were missed. For example, although manual searches of target websites were thorough, we may not have identified all eligible resources hosted on a given website. Second, we limited our analysis to Canadian resources; as a result, our observations and recommendations may not be generalizable to resources developed by authorities in other regions. Finally, we were unable to ascertain information on the frequency of use (eg, the number of downloads, web page visits, and sharing on social media) and the date of publication for many web-based resources. Thus, we cannot comment on the extent of resource uptake or how resources were being kept up to date.

Interpretation

The growing popularity of cannabis among individuals of reproductive age, combined with the recent legalization of nonmedical cannabis products in Canada, has necessitated updating or generating clinical recommendations to support HCPs with patient counseling and public resources to guide informed decision-making. However, the development of such resources has proven challenging. Current data on the potential benefits and harms of cannabis use as well as reproductive and perinatal health are still emerging. The volume of published data on these topics has grown exponentially in the last few years, making it challenging to keep resources up to date with reliable information. Although the uptake of health care resources is difficult to ascertain, their usability is greatly influenced by how and in what format they are disseminated. Easy-to-find health care resources that incorporate interactive content where the audience can tailor the information to their personal health care needs and experiences are more likely to be used [26]. Using audio and visual contents alongside plain text and involving or partnering with patients to codevelop resources are also well-recognized strategies for strengthening content, aligning patient and HCP priorities, and improving eHealth literacy [26-28]. Unfortunately, very few resources that we identified incorporated alternative or complementary modes of information sharing, and most did not cite patient involvement in their development. Finally, web-based health information can act as both an enabler and a barrier to shared decision-making [29]—an essential consideration for the development of health care resources and for HCPs when consulting with their patients [30,31]. Although the HCP resources identified in this review were consistent in their recommendation to provide counseling to patients, few public-facing resources examined in this review explicitly recommended that patients consult with HCPs about cannabis use. Failure to identify HCPs as trusted caregivers in patient-facing resources risks perpetuating common barriers to patient counseling in this area [32-34]. Importantly, although not all individuals who use cannabis in pregnancy can have a substance-misuse issue, pregnancy is an optimal opportunity to provide patient education so that informed decisions can be made. To do so necessitates that HCPs stay well informed on general patient-counseling strategies, including counseling strategies specific to perinatal substance use [35].

The resources included in this scoping review represent critical tools for HCPs and the public regarding counseling and decision-making about cannabis use while planning pregnancy, during pregnancy, and lactation. Although the information presented was thematically consistent, we noted common gaps or oversights in existing resources that could be addressed in the future:

1. The authors of educational resources on this topic should regularly update these resources in line with emerging evidence. In line with this, version dates and references should be included for transparency regarding the presented evidence and its recency.
2. Patient-facing resources should clearly and consistently encourage patients to consult with HCPs if they are

considering or continuing cannabis use when planning pregnancy or during pregnancy and lactation.

3. Where resources recommend against cannabis use for the management of specific conditions (eg, nausea, anxiety, and chronic pain), suggestions for alternative options or directions to resources outlining alternative options should be provided.
4. Finally, as web-based resources are widely accessible and are generally the public's first choice to seek information, efforts should be made to increase resource readability and language accessibility. Overall accessibility could be improved by minimizing the use of technical language and text with high reading grade levels, including videos and infographics, and by translating resources to commonly spoken languages in Canada.

Conclusions

Canadian resources provide information to the Canadian public and HCPs on the effects of cannabis use on fertility, pregnancy, and breast milk and consistently communicate that there is no known safe amount of cannabis that can be consumed in pregnancy. Therefore, these resources recommend against using cannabis if planning pregnancy, during pregnancy, and while breastfeeding. Despite the availability of these resources, improvements can still be made to enhance their accessibility and encourage uptake. Notably, public-facing resources discussing cannabis use related to reproductive and perinatal health should always encourage consultation with HCPs. They should be updated regularly to ensure that guidance reflects current information.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Deviations from the published protocol.
[DOCX File , 24 KB - pediatrics_v5i4e37448_app1.docx]

Multimedia Appendix 2
A list of 71 Canadian organizations whose websites were manually searched to identify eligible resources.
[DOCX File , 34 KB - pediatrics_v5i4e37448_app2.docx]

Multimedia Appendix 3
Full database search strategy.
[DOCX File , 36 KB - pediatrics_v5i4e37448_app3.docx]

Multimedia Appendix 4
Full citations and individual characteristics of resources included in this scoping review.
[XLSX File (Microsoft Excel File), 61 KB - pediatrics_v5i4e37448_app4.xlsx]

Multimedia Appendix 5
Word cloud of terminology used to refer to cannabis. The terminology is displayed with the size of the terms in the diagram corresponding to the frequency of their use. Figure generated using "Word It Out" [24].
[PNG File , 396 KB - pediatrics_v5i4e37448_app5.png]

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Abbreviations

HCP: health care provider
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
THC: tetrahydrocannabinol

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Original Paper

Promoting Adolescent Sexual and Reproductive Health in North America Using Free Mobile Apps: Environmental Scan

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Abstract

Background: Neglecting adolescents' sexual and reproductive health (SRH) can affect multiple domains of development. Promoting healthy adolescent SRH is increasingly done using mobile phone apps. Providing SRH information via mobile phones can positively influence SRH outcomes including improving knowledge, reducing sexual risk behavior, and increasing the use of health services. A systematic approach to establishing and evaluating the quality of adolescent SRH mobile apps is urgently needed to rigorously evaluate whether they are a viable and effective strategy for reaching adolescents and improving adolescent SRH knowledge and behaviors in particular.

Objective: This study aimed to conduct an environmental scan to produce an inventory of adolescent SRH–specific mobile apps with descriptions of their purpose, structure, operations, and quality of evidence.

Methods: We used a literature review to develop 15 search terms for adolescent SRH–related apps in the Canadian and US Apple and Google app stores. After generating the search results, inclusion and exclusion criteria were applied. Using the remaining apps, we built an evidence table of app information, and app reviewers assessed each included app using the Mobile App Rating Scale. App assessments were then used to highlight trends between apps and identify gaps in app quality.

Results: In total, 2761 apps were identified by our searches, of which 1515 were duplicates. Of the 1246 remaining apps, 15 met the criteria for further assessment. Across all subdomains, on a scale of 1-5, the mean app score was 3.4/5. The Functionality subdomain had the highest mean score of 4.1/5, whereas the Engagement subdomain had the lowest score of 2.9/5. The top 4 apps were Tia: Female Health Advisor (4.7/5), Under the Stethoscope (4.2/5), Condom Credit Card (4.1/5), and Shnet (3.7/5).

Conclusions: This environmental scan aimed to provide a comprehensive overview of the mobile apps developed to promote adolescent SRH knowledge and outcomes. Of the 15 mobile apps available to provide information related to adolescent SRH, few provided comprehensive, reliable, and evidence-based SRH information. Areas of strength included the apps' gestural design, performance, ease of use, and navigation. Areas of weakness included app goals, evidence base, and app customization options. These results can be used to conduct future studies evaluating the use and efficacy of mobile apps on health knowledge and behaviors and promote adolescent SRH.

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KEYWORDS

mHealth; mobile health; adolescent; sexual and reproductive health; environmental scan; mobile app; sexual health; reproductive health; health; sexual; reproductive; MARS; Mobile App Rating Scale; digital health; adolescents

Introduction

Adolescence is a critical period in the transition from childhood into adulthood, during which young individuals aged 10 to 19 years experience substantial physical, psychological, social, and emotional changes [1]. Adolescents are a vulnerable population because of their age-related psychosocial and biological changes and the challenges associated with navigating these changes [2]. As part of their physical, psychological, and social development, it is common for adolescents to explore their sexual identities and feelings [3]. Neglecting adolescents' sexual and reproductive health (SRH) needs can affect their physical and mental health, future employment, economic well-being, and ability to reach their full potential [4-6].

Interventions to promote adolescent SRH (ASRH) increasingly use mobile phones. Mobile app platforms have the potential to advance SRH. Nearly 90% of young people aged 15 to 24 years in North America use the internet daily or own a smartphone [7,8]. The use of mobile technology for health promotion offers privacy [9-14], access to personalized information [9,11,13,15], and convenience [9,14,16], making it a valuable way to provide accurate information to adolescents about sexual health [9-15]. Furthermore, young people are responsive to and excited about using new technologies for SRH promotion [9,12,17,18]. Offering SRH information via mobile technologies has an emerging evidence base that recommends mobile health (mHealth) as an acceptable, feasible, and promising intervention approach [19-22]. This evidence includes, first, the World Health Organization–led High Impact Practices recommendation that digital technologies be integrated into family planning [19]. This recommendation is supported by a review of SMS text messaging as a digital tool [20] that demonstrates the high acceptability of these interventions among beneficiaries, even though few apps were available with this evaluative component [20]. Echoing these recommendations, a systematic review of mHealth added that the outcomes of these interventions were generally positive but susceptible to threats such as a lack of stable development funding [21]. Although a second systematic review also concluded that these interventions were promising, both reviews end by exhorting the collection of additional evidence [22]. Previous research suggests that providing SRH information via mobile phones is highly appealing to young people and can positively influence SRH outcomes including improving knowledge, reducing sexual risk behavior, and increasing the use of health services [23-27]. The appealing qualities of mHealth interventions (eg, mobile apps) have translated into growing recognition that mobile apps offer a promising platform for reaching large numbers of adolescents across diverse settings with private, essential, high-quality, and comprehensive SRH information and support.

Given the rapid proliferation of smartphone apps, there are several mobile apps that have been developed to promote ASRH. However, to date, no comprehensive attempt has been made to identify and provide information on the quality of these apps. It is increasingly difficult for users, health professionals, and researchers to readily identify and assess high-quality apps [28]. Little information on the quality of these apps is available, beyond the star ratings published on retailers' web pages, whereas app reviews are subjective by nature. An updated systematic approach to establishing and evaluating the quality of ASRH mobile apps is urgently needed to rigorously evaluate whether they are a viable and effective strategy for reaching adolescents and improving ASRH knowledge and behaviors in particular. Although recent reviews have examined digital health solutions to ASRH [9,29-31], none have updated our knowledge by using the same evaluative framework to directly compare the quality of these solutions. The objective of our study was to conduct an environmental scan to produce an inventory of ASRH-specific mobile apps with descriptions of their purpose, structure, operations, and quality of evidence. An understanding of the available ASRH-specific mobile apps that currently exist in North America will help inform (1) the quality and usability of mobile apps to promote ASRH and (2) the potential development of new mobile apps specific to adolescents living in North America.

Methods

Summary

We developed search terms designed to work with Apple and Google's app store search algorithms, and then, using software built for searching both stores, we created an app database based on this search strategy. Subsequently, 2 reviewers applied the inclusion and exclusion criteria to the database and filtered apps based on 9 criteria. Using this list of apps, we built an evidence table of app information, and the app reviewers assessed each included app using a validated health app assessment framework, the Mobile App Rating Scale (MARS) [32,33]. Discrepancies between ratings were addressed through discussion between the app reviewers. Results were then analyzed for trends in SRH-related apps for adolescents, and gaps in app quality that could be used to improve apps in the future were identified.

Search Terms

As we were interested in SRH apps for adolescents in North America, we limited searches to the US and Canadian versions of the Google Play and Apple App stores. There is little formalized knowledge available to researchers about the specifics of how these stores' searches work [34], and our results will be presented in the context that we lack specificity about how these algorithms work. Based on outreach to Google and Apple, as well as available documentation for app developers, results from the Google app store are drawn from app title, publisher, and app description, whereas results from the Apple app store are based on app title, keywords, and primary category (eg, education or lifestyle).

When searching Apple and Google's app stores using a mobile device, we found that apps unavailable in Canada or the United States and apps not compatible with a particular device were not included in search results. In addition, results were personalized, which could have biased the apps examined based on the researchers' search profiles. We addressed this by using custom software built to search the Google Play and Apple App stores that has been previously tested to ensure that personalized results and device compatibility were not influencing search results [35].

We carried out a short literature scan on ASRH using 4 electronic databases (Ovid MEDLINE, PubMed, Cochrane Library, and CINAHL) to identify 15 key terms related to ASRH: sex, sexuality, sexual health, sexual education, sexual health education, reproductive, reproductive health, contraceptive, birth control, pregnancy, safe sex, sex and relationships, sexually transmitted disease (STD), sexually transmitted Infection (STI), and HIV.

Search and Screening

We searched the Apple and Google app stores in Canada and the United States on December 19, 2020, using the 15 terms above. The search returned a maximum of 50 results per search term per country, for each store, for a maximum of 1500 results per app store (750 apps each from the Canadian and US stores). We used custom Python software (Python Software Foundation) that is not susceptible to changes in results from search personalization and device limitations, as confirmed by testing on different computers. Results were automatically organized in a CSV database, which was exported to an Excel spreadsheet (Microsoft Corporation), and paired with an Excel-ready version of the MARS to allow it to be integrated easily into our evidence table.

In total, 6 inclusion criteria and 3 exclusion criteria were used to screen the apps (Textbox 1).

The 2 app reviewers (SLP and SK) independently assessed app titles and metadata (eg, description and paid/free status). Reviewers discussed apps where disagreement on inclusion occurred and used additional information (eg, photos of the app from the Google or Apple store) to reach a consensus. In addition, the 2 app reviewers recorded the reasons why any app was unusable, unavailable, or could otherwise not be assessed using the MARS.

Textbox 1. Inclusion and exclusion criteria.

Inclusion criteria

- Contains content related to sexual health education
- Addressed any component of sexual health or sexuality
- App's intended audience includes adolescents (aged 10-19 years)
- App still exists in the Google Play or Apple App store while being assessed
- Targeted to North American adolescents (app specifically mentions adolescents as users)
- Available in English

Exclusion criteria

- Paid (purchased; these apps, which only account for 5% of all apps [36], are unlikely to be useful to adolescents who cannot access, or are unwilling to access, a credit card)
- Developed for specific event such as a conference
- Targeted to a non–North American context

App Quality Assessment

We used the MARS, a validated tool used for assessing health apps. The MARS was chosen for its high internal consistency and interrater reliability. The MARS contains items related to both the characteristics of an app (eg, rating and time since last update) and app quality assessment. This assessment is divided into 5 subscales: Engagement (eg, how interesting or fun the app is to use); Functionality (eg, how easy the app is to use); Aesthetics (eg, the visual appeal of the app); Information Quality (eg, information quality and relevance); and Subjective Quality (eg, how often the app would be used). Subscales are further divided into items (directed questions). All MARS items are scored on a 5-point, Likert-type scale, with a high score indicating favorability for that item.

The 2 reviewers (SLP and SK) trained on the MARS by reviewing previously rated apps, practiced rating 5 health apps as a group with all authors, and then discussed discrepancies in ratings before carrying out the MARS assessment for all included apps. Differences on item scores were compared and discussed, and a final item score was agreed on by both reviewers. All differences in item scores were resolved following discussion.

To assess each app, reviewers installed the app on an Android or Apple device. If an app was available on both devices, the Apple version was assessed. Once installed, reviewers launched each app and interacted with it for 10 minutes. Reviewers created a log-in or account for apps that required this process to access app content. After interacting with the app, reviewers assessed it with the MARS scale and reaccessed portions of the app ad hoc to determine item scores. To determine whether an app had an evidence base present in scientific literature, reviewers searched Google Scholar and PubMed using the app's name, and the first 50 results were examined for relevance. If a matching paper was found, reviewers examined the nature of that study to determine how to score the MARS item.

Analysis

Once we built an evidence table for all included apps, we calculated subscale scores for each app by averaging items within each subscale and then calculated the MARS score by averaging the MARS items for that app. We converted subscale and MARS scores to a score out of 5 to match the MARS item

score range. The mean score of each item was also calculated to create an item-wise mean score. We rank-ordered apps by MARS score to allow for comparisons of app quality.

We then analyzed apps by comparing scores between each app's MARS score, subscale scores, and item scores. The subscale and item scores of the top 4 apps (with the number of apps arbitrarily chosen post hoc) were compared to the mean app score. Apps were also compared based on duration since the last update (dividing apps into less than or more than 6 months since the last update). To identify gaps in app quality, we compared mean item scores. We also identified areas for quality improvement in the top 4 apps by comparing each app's item scores to the mean app item scores.

Results

Study Characteristics

The search strategy (summarized in Figure 1) [37] identified a total of 2761 mobile apps across 4 searches. After removing 1515 duplicate apps from the results, a total of 1246 mobile apps from the Apple App store (n=751) and Google Play store (n=495) were screened against the inclusion and exclusion criteria. Based on the final inclusion criteria, 15 mobile apps were included in our environment scan. Of the 15 mobile apps included, 5 were only available from the Apple platform (Condom Credit Card; Teenagers with Experience; Tia: Female Health Advisor; TMI Georgia; and Under the Stethoscope), 3 were only available from the Google platform (Adolescent Health Issues; Class 12 Bio Notes; and Sexual Reproductive Health Counsellor), and 7 were available from both Apple and Google platforms (bMOREsafe; It Matters; My Sex Doctor Lite; NeedTayKnow; Shnet; SAUTIplus; and The Sex Talk). Of the 15 mobile apps included, 4 were updated within the last 6 months at the time of analysis (bMOREsafe; NeedTayKnow; Shnet; and Tia: Female Health Advisor), whereas 8 were last updated more than 6 months ago (Adolescent Health Issues; Class 12 Bio Notes; Condom Credit Card; It Matters; My Sex Doctor Lite; SAUTIplus; Sexual Reproductive Health Counsellor; and TMI Georgia). The remaining 3 mobile apps did not provide information on the date of the last update (Teenagers with Experience; The Sex Talk; and Under the Stethoscope). Additionally, 4 mobile apps were targeted specifically for adolescents (Adolescent Health Issues; Class 12 Bio Notes; Teenagers with Experience; and Under the Stethoscope), 8 were targeted for adolescents and young adults (Condom Credit Card; It Matters; NeedTayKnow; SAUTIplus; Sexual Reproductive Health Counsellor; Shnet; The Sex Talk; and TMI Georgia), and 3 were targeted for adolescents, young adults, and adults (bMOREsafe; My Sex Doctor Lite; and Tia: Female Health Advisor). This information is summarized in Table 1.

Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) diagram of the app search and screening process. NA: North America.

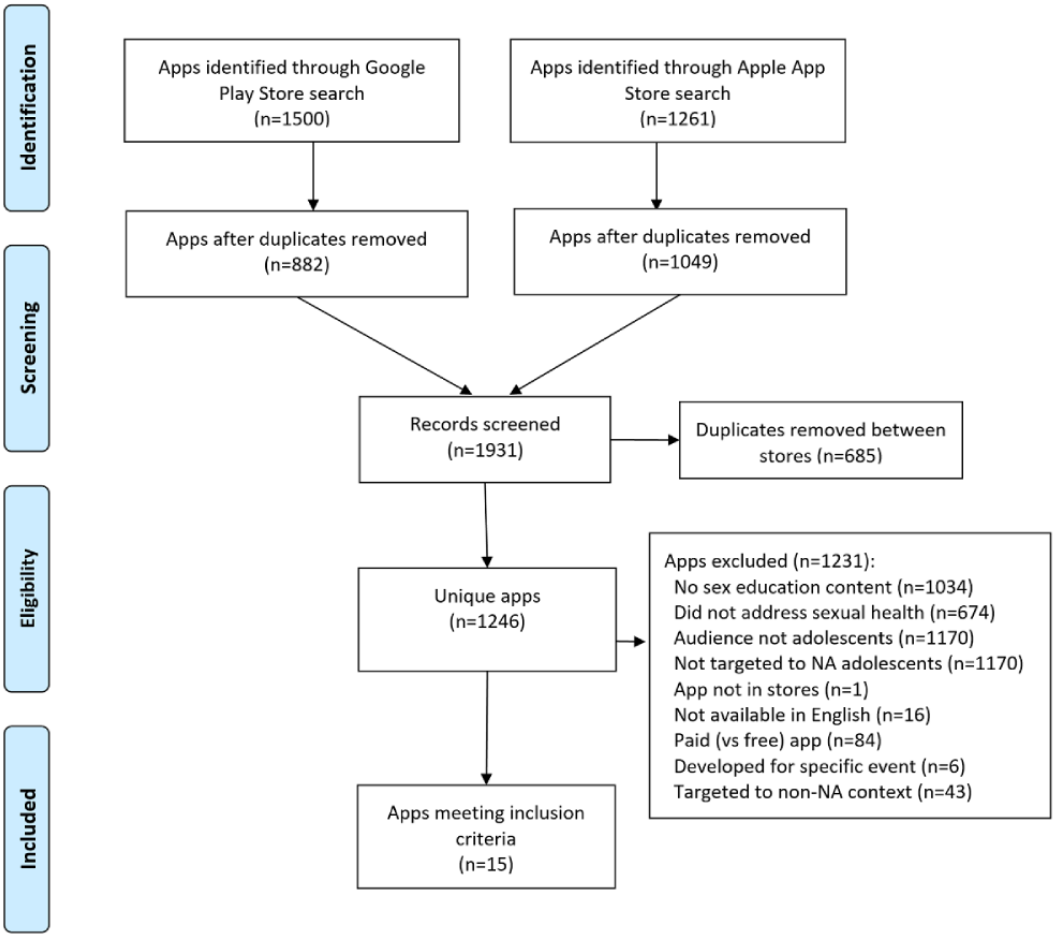


Table 1. Assessed app characteristics.

App name	Availability			Time since update			Target(s)		
	Apple	Google	Both	<6 months	>6 months	No info	Adoles-cents	Adolescents and young adults	Adolescents, young adults, and adults
Sexual Reproductive Health Counsellor		✓			✓			✓	
Adolescent Health Issues		✓			✓		✓		
Class 12 Bio Notes		✓			✓		✓		
My Sex Doctor Lite			✓		✓				✓
NeedTayKnow			✓	✓				✓	
SAUTIplus			✓		✓			✓	
bMOREsafe			✓	✓					✓
Teenagers with Experience	✓					✓	✓		
The Sex Talk			✓			✓		✓	
It Matters			✓		✓			✓	
TMI Georgia	✓				✓			✓	
Shnet			✓	✓				✓	
Condom Credit Card	✓				✓			✓	
Under the Stethoscope	✓					✓	✓		
Tia: Female Health Advisor	✓			✓					✓

Study Findings

The included mobile apps had a mean score of 3.4/5 on the MARS. The included mobile apps scored the highest on the subdomain of Functionality, with a mean score of 4.1/5, whereas the subdomain of Engagement received the lowest mean score of 2.9/5. The overall mobile app mean score was 2.5/5 for the Subjective Quality subdomain, 3.3/5 for the Aesthetics subdomain, and 3.3/5 for the Information subdomain. The scores are summarized in Table 2.

Table 2. Scores by Mobile App Rating Scale (MARS) subdomain and overall 1uality.

	Mean score[a]
Subdomain	
A: Engagement	2.9
B: Functionality	4.1
C: Aesthetics	3.3
D: Information	3.3
E: Subjective Quality	2.5
App quality	
Overall mean (subdomains A to D)	3.4

[a]Mean scores are out of a total of 5.

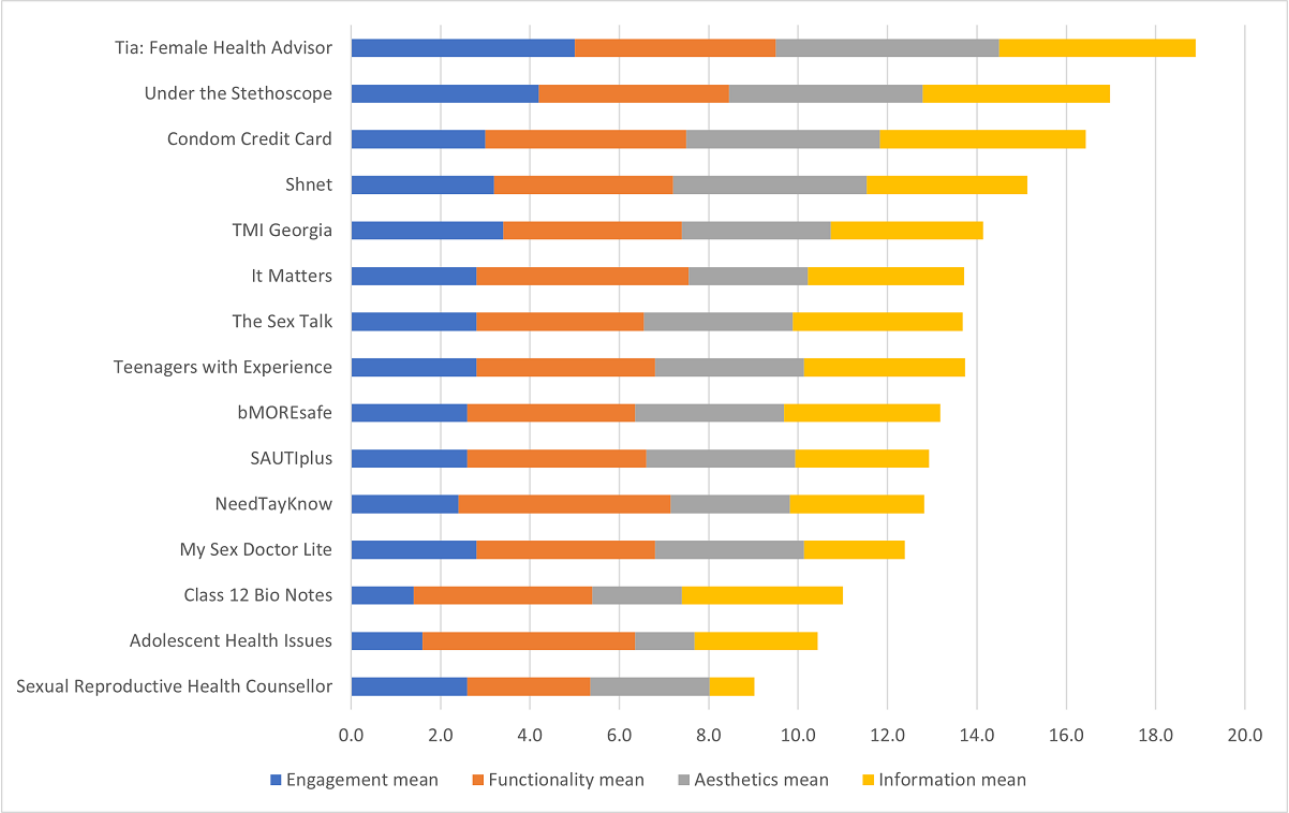
MARS Subdomains

The individual mobile app MARS scores varied between 2.3/5 and 4.7/5 on the MARS tool (Figure 2). Tia: Female Health Advisor was the highest-scoring mobile app, followed by Under the Stethoscope, Condom Credit Card, and Shnet.

For the Engagement subdomain, Tia: Female Health Advisor received the highest mean score of 5/5, whereas Under the Stethoscope received a mean score of 4.2/5. Shnet and Condom Credit Card had lower mean scores of 3.2/5 and 3/5, respectively. For the Functionality subdomain, Tia: Female Health Advisor and Condom Credit Card both received the highest mean score of 4.5/5. Under The Stethoscope followed with a mean score of 4.3/5, whereas Shnet received a Functionality mean score of 4/5. In the Aesthetics subdomain, Tia: Female Health Advisor again received the highest mean score of 5/5. Under the Stethoscope, Condom Credit Card, and Shnet each received a mean score of 4.3/5 in the Aesthetics subdomain. The mean scores in the Information subdomain were 4.6/5 for Condom Credit Card, 4.4/5 for Tia: Female

Health Advisor, 4.2/5 for Under the Stethoscope, and lastly, 3.6/5 for Shnet. For the Subjective Quality mean scores, Tia: Female Health Advisor was rated the highest with a mean score of 4.5/5. Under the Stethoscope and Shnet both received a Subjective Quality mean score of 3.8/5, whereas Condom Credit Card received the lowest Subjective Quality mean score of 3.5/5.

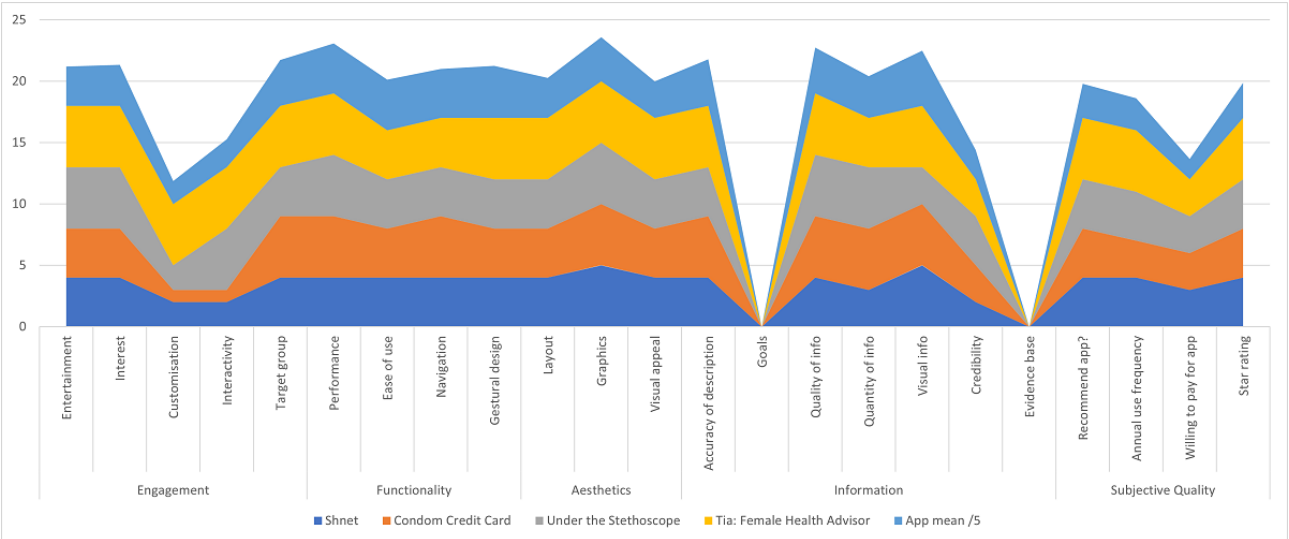
Figure 2. Cumulative score of each app's Mobile App Rating Scale (MARS) subdomains.



Areas of Strength

In a comparison of the top 4 mobile apps against the mean score of all included mobile apps (Figure 3), our study found common areas of strength on the MARS items. Overall, the mobile apps included in our study scored high on the MARS items of *gestural design*, *performance*, *ease of use*, and *navigation* (Figure 3). Although *visual information* was rated highly (4.5/5), only 8 (53%) out of 15 apps contained it, and therefore, this item was not considered a strength. These results suggest that future mobile apps in the area of SRH should continue to consider gestural design, performance, ease of use, and navigation in the development and dissemination of mobile apps. However, our study identified important gaps in the MARS items for current mobile apps being offered in the area of SRH.

Figure 3. Scores of top 4 apps and the mean of all apps by Mobile App Rating Scale (MARS) items.



Areas of Weakness

Primary Areas of Weakness

In a comparison of the top 4 mobile apps against the mean score of all included mobile apps (Figure 3), our study identified primary and secondary areas of weakness on the MARS items for mobile apps currently being offered.

Our study identified 2 major gaps in the MARS items across the included mobile apps. First, the MARS item *goals*—"Does app have specific, measurable and achievable goals (specified in app store description or within the app itself)?" [32]—was absent across mobile apps. Second, the MARS item *evidence base*—"Has the app been trialled/tested; must be verified by evidence (in published scientific literature)?" [32]—was additionally lacking across mobile apps. These findings suggest that researchers should strongly consider incorporating specific goals in the development of SRH mobile apps, in addition to developing a strong evidence base for future mobile apps on SRH. Integrating these MARS items—*goals* and *evidence base*—into future SRH mobile apps may fill the current gap in end-user needs.

Secondary Areas of Weakness

Furthermore, our study identified 2 secondary areas of weakness in a comparison of the top 4 mobile apps against the mean score of all included mobile apps. First, the MARS item *customisation*—"Does it provide/retain all necessary settings/preferences for apps features (e.g. sound, content, notifications, etc.)?" [32]—was lacking. Future development of mobile apps on SRH topics should consider the importance of app customization to comprehensively reach the needs of potential end users. The MARS item *Would you pay for this app?* additionally scored low across the top 4 mobile apps assessed. By addressing the aforementioned gaps of *goals*, *evidence base*, and *customisation*, future SRH mobile apps may increase end-user satisfaction, and thus, increase end users' willingness to pay for the app.

Discussion

Principal Findings

This environmental scan aimed to provide a comprehensive overview of the mobile apps developed to promote ASRH knowledge and outcomes. Research into smartphone apps for ASRH is sparse. Despite the plethora of mobile apps on the market, our literature search identified only 15 apps pertaining to this subject. To our knowledge, our study is one of the first to perform a comprehensive assessment of mobile apps being developed for ASRH that are used during the COVID-19 pandemic. Smartphone apps have immense potential to improve health knowledge, behaviors, and outcomes for young people. We identified 15 mobile apps that we scored across the MARS. These apps differed in terms of their engagement, functionality, aesthetics, information quality, and overall purpose. Most of the apps acquired the highest score in Functionality (mean score of 4.1). This finding shows that most apps prioritize functionality (including concepts such as app performance, the ease of learning the app, and easy navigation between screens) over other features.

The majority of the mobile apps included in this environmental scan are lacking in the MARS items *goals* and *evidence base*. This finding is unsurprising as the mHealth field has been criticized for producing limited evidence about the efficacy and effectiveness of evidence base information [38-40]. Researchers of previous studies that examined youths' perspectives on the use of digital technologies in sexual health education reported that adolescents prefer sexual health education resources that are accessible (ie, a mobile app is a preferred resource because they receive immediate answers to their questions), trustworthy (ie, resources must be credible and have an evidence base), and confidential and private (ie, resources should offer information in a nonthreatening way that will not cause embarrassment) [41,42]. The credibility, quality, and accuracy of information are important factors that encourage young people to use digital platforms for SRH information, and adolescents do not act on digital information if they do not trust its credibility [9,43]. Digital technologies or social media platforms with improved resources that provide evidence-based information on SRH and rights are useful for accessing reliable and confidential information [44], but the availability of this information in some domains (eg, HIV-related apps) has been criticized [45].

Another area of weakness identified is the lack of app customization to comprehensively reach the needs of all potential end users. Consultation with users is essential in the development of mobile apps targeted at young people, as this group can be particularly influenced by the look and feel of an app. Previous research suggests that listening to and meeting young people's desires in terms of mobile app and content is essential in engaging them [46-48].

Strengths and Limitations

The psychometric properties of the MARS tool have been proven to be reliable and valid [32], and the use of this tool lends strength to our study's conclusions. Further, our study provides a comprehensive assessment of all mobile apps available in North America for adolescents' SRH. However, apps in languages other than English could not be assessed, which limits the generalizability of our results and the stores in which we could search for apps. Likewise, paid apps were not included in the search. In addition, the features of the apps examined by us may be different from the updated versions of the app, and these features might have been addressed in apps developed after this review. This possibility is inevitable considering the rapidity with which apps are developed and reformed. Despite the high interrater reliability of this scale [32], the reviewers' subjectivity might have influenced the ratings awarded, and caution must be exercised when interpreting the results portrayed in this study. Finally, only 2 reviewers carried out the MARS assessment of each app, limiting information quality in our analysis.

Conclusions

Digital health tools, such as smartphone-based apps, play an important role in preserving the continuity of SRH services for adolescents and youths. There are numerous mobile apps available to provide information related to ASRH. However, very few mobile apps provide comprehensive, reliable, and evidence-based SRH information to promote ASRH. This review

provides an overview of mobile apps available in North America related to ASRH, summarizes their strengths and limitations through a qualitative assessment, and delineates key functions and features needed for future apps. This information can be used to conduct future studies to evaluate the use and efficacy of mobile apps on health knowledge and behaviors and promote ASRH.

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Conflicts of Interest

None declared.

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Abbreviations

ASRH: adolescent sexual and reproductive health
MARS: Mobile App Rating Scale
mHealth: mobile health
SRH: sexual and reproductive health

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Original Paper

Experiences of Using the Digital Support Tool MeeToo: Mixed Methods Study

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Abstract

Background: Digital peer support is an increasingly used form of mental health support for young people. However, there is a need for more research on the impact of digital peer support and why it has an impact.

Objective: The aim of this research is to examine young people's experiences of using a digital peer support tool: MeeToo. After the time of writing, MeeToo has changed their name to Tellmi. MeeToo is an anonymous, fully moderated peer support tool for young people aged 11-25 years. There were two research questions: (1) What impacts did using MeeToo have on young people? (2) Why did using MeeToo have these impacts on young people?

Methods: A mixed methods study was conducted. It involved secondary analysis of routinely collected feedback questionnaires, which were completed at two time points (T1 and T2) 2-3 months apart. Questionnaires asked about young people's (N=876) experience of using MeeToo, mental health empowerment, and well-being. Primary data were collected from semistructured interviews with 10 young people.

Results: Overall, 398 (45.4%) of 876 young people completed the T1 questionnaire, 559 (63.8%) completed the T2 questionnaire, and 81 (9.2%) completed both. Descriptive statistics from the cross-sectional analysis of the questionnaires identified a range of positive impacts of using MeeToo, which included making it easier to talk about difficult things, being part of a supportive community, providing new ways to help oneself, feeling better, and feeling less alone. Subgroup analysis (paired-sample *t* test) of 58 young females who had completed both T1 and T2 questionnaires showed a small but statistically significant increase in levels of patient activation, one of the subscales of the mental health empowerment scale: time 1 mean=1.83 (95% CI 1.72-1.95), time 2 mean=2.00 (95% CI 1.89-2.11), t_{59}=2.15, and P=.04. Anonymity and the MeeToo sense of community were identified from interviews as possible reasons for why using MeeToo had these impacts. Anonymity helped to create a safe space in which users could express their feelings, thoughts, and experiences freely without the fear of being judged by others. The MeeToo sense of community was described as a valuable form of social connectedness, which in turn had a positive impact on young people's mental health and made them feel less isolated and alone.

Conclusions: The findings of this research showed a range of positive impacts and possible processes for young people using MeeToo. Future research is needed to examine how these impacts and processes can be sustained.

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KEYWORDS

mHealth; mental health; peer support; COVID-19; well-being; young people

Introduction

Evidence suggests that peer support may improve mental health, social functioning, and quality of life [1], particularly during the COVID-19 pandemic [2]. For example, research indicates the effectiveness of using digital resources in peer support work to help young people experiencing psychosis [3]. There is also research illustrating how digital peer support can help people with severe mental health difficulties in their recovery process by encouraging a culture of health and ability [4]. Digital peer support has the potential to reach more young people in need of support than young people being able to access face-to-face peer and other forms of support [5]. This is particularly the case during the periods of quarantine and lockdown due to the COVID-19 pandemic, where digital peer support can be more readily available and accessible to young people [2]. Indeed, research suggests that digital mental health interventions are effective in mitigating psychosocial consequences of social distancing, quarantine, and other restrictions due to the COVID-19 pandemic [6].

In this regard previous studies indicate that the desirable aspects of digital mental health peer support systems are matching peers according to shared interests and identities that they self-identify with, not matching peers according to their mental health diagnosis, and highlighting through social media or other online mediums that discussing mental health is safe in a peer support community [7]. Other important aspects that emerged from previous research on digital peer support platforms were: to educate peers on how to offer support without suggesting unhelpful coping strategies, to guarantee some anonymity and control over how peers present themselves to each other on these platforms, and to provide adequate information to potential peers to facilitate their decision on whether they would like to start befriending their matched peer prior to connecting with them [7].

In addition, Kenny et al's research [8] indicates that young people identified 6 main factors when asked about the development of a mental health app prototype: safety and engagement, functionality and social interaction, awareness, accessibility, gender, and young people in control as important factors. Regarding safety and engagement, the app must be safe in terms of confidentiality, cyberbullying, and stigma and it also must be engaging and user-friendly. Concerning functionality and social interaction, the app must have the useful and relevant function of providing mental health support, as well as allowing young people to interact with one another in an anonymous way. With respect to awareness and accessibility, the app should also be promoted online and offline to raise awareness of mental health among young people and must be easily accessible. Young people also highlighted that there are gender differences among users on the extent to which they would engage with the app. Finally, young people expressed the importance of being in control of how and the extent to which they use the app.

There is also research on digital peer support programs suggesting that these types of interventions encourage young people to self-refer to mental health services and seek help among their social networks, thus effectively combatting mental health stigma among young people [9]. In this respect, evidence suggests that there are 3 kinds of connectedness that are essential for the development of effective digital mental health and well-being tools: professional, self, and peer [10]. Professional connectedness refers to young people's trust in the credibility and authenticity of the tool, similar to the requirements for face-to-face mental health and well-being support. Self-connectedness refers to young people feeling they can share their own experiences appropriately and developing new insights and support strategies. Finally, peer connectedness refers to young people being able to connect with other young people with similar experiences in a safe but meaningful way, often one of the most challenging aspects of digital mental health and well-being support tools.

However, a systematic review suggests a lack of research in digital peer support as it is often used in a supplementary way to face-to-face interventions, and thus the individual effectiveness of digital peer support is not accurately investigated [2]. In addition, research suggests that although there is some evidence of the effectiveness of digital peer support, such as mental health apps, studies remain imprecise on how effective these apps are compared to standard mental health care [11].

MeeToo is a fully moderated anonymous digital peer support tool (app) that is widely used by young people in a range of settings [12]. After the time of writing, MeeToo has changed their name to Tellmi. It is freely available for young people aged 11-25 years [13]. A user is able to see moderated posts from other users who are aged +/–2 years of the user's age, except for users 18-25 years old who are able to see moderated posts from users 18-25 years old. Trained and paid moderators review all posts 24/7 to assess risks and tag posts by theme. Other users can post replies to a post, and these replies are also moderated. Trained "super peers" review posts and make sure no one is left without a response. Super peers are university students from psychology, medicine, and other mental health relevant departments who have completed the structured and monitored MeeToo Super Peer Programme, which is acceptable to be integrated into a degree course as a placement option. The program is offered remotely as super peers do not have to be based in the United Kingdom. In addition, counsellors are available if there are any serious or safeguarding concerns. Posts can be filtered by topic, and there is also a library of mental health resources. Users generally find out about MeeToo through peers, schools, or mental health support services. Apart from research collaboration, the authors of this paper have no other professional or personal involvement in MeeToo.

Indeed, there is a need for more evidence of the impact of digital peer support and how it might achieve this impact. This question is particularly important now because young people face a period of increased social isolation and interruption to regular peer activities due to social distancing [14,15]. In this respect, according to Newlove-Delgado et al [16], examining the mental health of children and young people during the COVID-19 pandemic, 39.2% of 6- to 16-year-olds experienced a deterioration in their mental health since 2017 and 21.8% experienced an improvement. In addition, among 17- to 23-year-olds, 52.5% experienced a worsening of their mental

health and 15.2% experienced progress. This worsening of mental health was greater for young females than for young males, and levels of mental health difficulties were already higher for young females before the COVID-19 pandemic. A recent study examined one-year follow-up data for two groups of young people, one in 2018 (before COVID-19) and one in 2019 (during COVID-19) [17]. They found that young people in the 2019 group had higher levels of depressive symptoms and lower levels of satisfaction, with a greater negative impact on young females than on young males. They estimate that had COVID-19 not occurred, 6% fewer young people would have experienced high levels of depressive symptoms.

In this regard, young people experienced disruptions in their learning because of the closing of schools and the restricted face-to-face interaction with their peers [14]. Indeed, COVID-19 regulations have negatively impacted young people's mental health and well-being, as studies illustrate how many young people experienced COVID-19–related fear as well as depressive and anxious symptoms [15]. These mental health difficulties were prevalent in older adolescents, females, and young people with neurodiversities or chronic physical conditions [15]. It is important that we better understand how to support young people to use digital mental health self-care, given the current global pandemic and corresponding increased stress and adversity.

The aim of this research is to examine young people's experiences of using a digital peer support tool, MeeToo. There were two research questions:

- What impacts did using MeeToo have on young people?
- Why did using MeeToo have these impacts on young people?

Methods

Rationale

A concurrent triangulation design mixed methods study [18] was performed to address the two research questions. During setup, a Logic Model was coproduced by researchers at the Anna Freud Centre and the MeeToo team (see Multimedia Appendix 1) [19] to provide a transparent description of the conceptualization of MeeToo and to identify data collection needs. Quantitative and qualitative data were collected separately, with the quantitative data used to address research question 1 on the impacts of using MeeToo on young people and the qualitative data used to address the related research question 2 on why using MeeToo has these impacts.

Quantitative Methodology

Data Collection

Secondary analysis of anonymized routinely collected feedback questionnaire data was conducted. The questionnaire data were collected over a period of 5 months from January to May 2021. These questionnaires were collected at time point 1 (T1), from January to February, and approximately 2-3 months later at time point 2 (T2), from April to May. As these were routinely collected data, respondents had been using MeeToo for varying amounts of time when they completed the questionnaires (see Table 1). The anonymized data were securely transferred to the research team. The questionnaires asked 7 bespoke questions about the impact of using MeeToo (eg, "Using MeeToo makes it easier for me to talk about difficult things"), with a 6-point response option from "strongly agree" to "strongly disagree" and an additional "I don't know" option. The 17-item Mental Health Empowerment Scale that the authors previously developed asked about young people's levels of mental health patient activation (7 items, eg, "I know how to look after my mental health"), levels of availability of social support (3 items, eg, "I have friends I can talk to when I feel bad"), their access to information and support for their mental health (4 items, eg, "I can find information that I trust if I have questions about my mental health"), and their confidence in said information (3 items, eg, "I will be listened to when getting help about my mental health"). The responses were rated on a 3-point scale from "agree" to "disagree," with higher scores indicating higher levels of mental health empowerment. Finally, well-being was measured using the 4-item Outcome Rating Scale (ORS) [20]. The ORS assessed young people's personal, relational, social, and general well-being (eg, "How are you doing overall?"), and it was rated on 10 cm visual analog scales from "not good" to "doing great." Responses were then scored on a 0-10 scale by centimeter, with higher scores indicating high levels of well-being, and total average scores were then computed. Internal consistency (Cronbach α) for subscales of the Mental Health Empowerment Scale and overall well-being are shown in Table 1.

Table 1. MeeToo usage statistics (how long participants reported they had been using MeeToo).[a]

Period of using MeeToo	T[b]1 participants (n=398), n (%)	T2 participants (n=559), n (%)
Just started	199 (50)	175 (31)
<1 week	32 (8)	35 (6)
2-4 weeks	20 (5)	45 (8)
>1 month	147 (37)	304 (54)

[a]Percentages may not add up to 100% due to rounding.

[b]T: time point.

Analysis

Quantitative data were analyzed using the STATA 16 [21]. The survey data were collected by the MeeToo app at two time points, at T1 and 2-3 months later at T2. Results were analyzed using a cross-sectional sample of those who completed one survey and a longitudinal sample of those who completed both surveys. Analysis of the cross-sectional sample involved descriptive statistics. Analysis of the longitudinal sample involved paired-sample *t* tests to explore changes over time in the four subscales of the Mental Health Empowerment Scale and the ORS. Given the gender imbalance in the data, these analyses were performed for females and males separately as well as together.

Qualitative Methodology

Participants

A qualitative methodology was used involving individual semistructured interviews with 10 young users from four different schools, of which 6 (60%) users identified as female and 4 (40%) as male, and the young people were aged between 14 and 18 years. The sample size enabled us to hear variations in experiences and then close recruitment when there was sufficient consistency in the young people's responses [22]. Participants were recruited from 6 schools in the United Kingdom that used the MeeToo app. In addition, participants came across the opportunity through the app, schools, social media, the Anna Freud Centre website, and the MeeToo website. Participants could express interest by completing a Microsoft Teams online contact form or by directly emailing the research team. The research team then contacted the participants to answer any questions they might have had about the study and their involvement. At this stage, the research team also shared with the participants the information sheet and the Microsoft Teams online consent form.

Ethical Considerations

After the participants' queries were addressed, they provided informed consent by completing the online consent form. Ethical approval was received from the University College London Research Ethics Committee (Ref. 14037/004). Informed consent or assent to take part in the evaluation was obtained by all participants online as was parental consent for all young people under the age of 16 years. The participants were not reimbursed for taking part in the qualitative interviews.

Procedure

The interviews were jointly conducted by the Research Assistant and a Peer Researcher to have a young person's perspective on the research process in order for it to be as inclusive and as representative as possible. Indeed, mental health and health research has highlighted the importance of involving members of the public in research processes in order to be as inclusive and representative as possible [23,24]. The peer researcher is a paid young person, aged 15-25 years, with either direct or indirect experience of mental health difficulties. Indirect experience includes, for example, a young person with a parent or carer with experience of mental health difficulties. Peer Researchers have also an interest or experience in mental health research. Indeed, the Peer Researcher supported us on this project, with the design of the study, data collection, analysis, and write-up. In particular, the Peer Researcher supported us in designing the topic guide for the interviews, which was developed following the Logic Model (see Multimedia Appendix 1) [19]. The topic guide included questions about when and how participants used the app, their experience using the app, whether they experienced any changes after using the app, and any recommendations for improvement. The Peer Researcher also assisted in conducting the interviews as well as providing feedback and input on the interpretation of the coding of the interviews and on identification of themes in the analysis. Interviews lasted from 30 minutes up to an hour and were conducted online on either Microsoft Teams calls or video calls over a period of 3 months between March and May 2021. In addition, interviews were conducted either after participants had used the MeeToo app or while they were still accessing and using the app.

Analysis

All interviews were audio-recorded using an encrypted Dictaphone and transcribed verbatim by an independent transcription service. The transcripts were then reviewed by the research team before being analyzed. In addition, all interviews were anonymized at the point of transcription (eg, names of people and places given by the participants in their interviews). The interview transcriptions were analyzed and coded using thematic analysis through NVivo (QSR International), a qualitative research analysis software program [25]. Thematic analysis was chosen as it can offer insight into people's views and experiences of a certain topic [26], such as digital peer support platforms [27,28].

Results

We first describe the study sample and then present the MeeToo usage data for context. We then present the main results by each research question.

Participants

Overall, 876 young people completed at least one questionnaire. Of these, 317 (36.2%) young people completed the questionnaire at T1 only, 478 (54.6%) completed it at T2 only, and 81 (9.2%) completed it at both T1 and T2. As the matched T1 and T2 questionnaire data were relatively underpowered to detect significant differences, we mainly focused on the young people's responses at T1 (n=398, 45.4%) and at T2 (n=559, 63.8%) separately. Demographic characteristics are shown in Table 2. Across both surveys, almost half of the young people were aged 13-15 years and a third were aged 16-18 years. Smaller numbers of responses were received from 11-12-year-olds or those aged 19 years or older. The majority of respondents were young females (T1 n=256, 64%; T2 n=423, 76%). We used the terms "young females" and "young males" inclusively, reflecting gender self-identity.

Table 2. Demographic characteristics.[a]

Characteristics	T[b]1 participants (n=398), n (%)	T2 participants (n=559), n (%)
Age (years)		
11-12	48 (12)	37 (7)
13-15	187 (47)	260 (47)
16-18	133 (33)	198 (35)
≥19	30 (8)	64 (11)
Gender[c]		
Young females	256 (64)	423 (76)
Young males	104 (26)	71 (13)
Not reported or missing	38 (10)	65 (12)

[a]Percentages may not add up to 100% due to rounding.

[b]T: time point.

[c]The three-response options for gender were "female," "male," and "prefer not to say."

Usage of MeeToo

In this section we discuss some questionnaire and qualitative data on the usage of MeeToo. Usage, acceptability, and engagement were not central to the research questions, and therefore, these data are presented to contextualize the key findings.

Across both questionnaires, most young people had either only just started using MeeToo or had been using it for some time (at least a month). At T1, half of young people (n=199, 50%) had just started and over a third (n=147, 37%) had been using it for at least a month. At T2, the pattern was reversed: over half of young people (n=304, 54%) had been using it for at least a month and less than a third (n=175, 31%) had just started. This possibly suggests greater levels of engagement with MeeToo at the end of the evaluation period.

The qualitative data suggested that young people found the MeeToo app easy to use.

> *I found it very easy to use. It's very simple. It's just simply when you feel something that you need to post, I just go on there and I can feel comfortable enough to post it. It's very simple steps, and I don't think the checking process takes very long either. It takes about 10, 15 minutes and then it's on the app automatically. Yeah, it was very easy to use as well and the support programs on the side, they're very easy to access as well, which I really like.*

> *I found it very simple to get around really, which was very good. And like everything was labeled in a good way, and you could search for keywords.*

This encouraged young people to use the app more.

> *The easiness of the app really encouraged me to pick it up more often. It's more like an automatic response when I'm feeling overwhelmed, I feel very comfortable that I can just immediately pick up my phone and go onto the MeeToo app. Yeah, it's almost like a reflex now for me.*

A few challenges with using MeeToo were reported by young people. Some young people described how an improved ability to filter content, especially on the home page of the app, would enhance usage by making it easier for young people to avoid specific topics that were sensitive to them. Some young people described inadvertently viewing such topics as deterring them from using the app and as resurfacing distressing thoughts and feelings. One young person suggested that there could be a feature on the home page providing users with the option to block sensitive content in order for the users to positively engage with the app. MeeToo is improving the ability to filter content, especially on the home page of the app, but this was not available when young people took part in this study.

> *There were lots of details and words which I would have just felt very uncomfortable to read, if I was back in the situation I was in. And I think just seeing that kind of just put a bad image of the app in my mind. It's such a good idea, and I think it's so good.*

> *It's just there are really just two topics that I really just don't want to read about, more just as a way of…I don't like even always thinking about it.*

What Impacts Did MeeToo Have on Young People?

Descriptive statistics for the bespoke questionnaire data are shown in Table 3. As expected during COVID-19, young people reported low levels of well-being at T1 and T2 in the questionnaire data. Nevertheless, across T1 and T2, the majority of young people (259/398, 65%, to 469/559, 84%) agreed that using MeeToo:

- Made it easier to talk about difficult things
- Connected them to people with similar problems
- Enabled them to feel useful by helping others
- Was a supportive community
- Provided new ways to help oneself
- Helped them feel better
- Helped them feel less alone

Table 3. Descriptive statistics for bespoke questionnaire items.[a,b]

Questionnaire items	T[c]1 participants (n=398), n (%)	T2 participants (n=559), n (%)
Easier to talk about difficult things		
Agree	272 (68)	434 (78)
Disagree	21 (5)	31 (6)
Missing	105 (26)	94 (17)
Connects to people with similar problems		
Agree	309 (78)	456 (82)
Disagree	22 (6)	30 (5)
Missing	67 (17)	73 (13)
I feel useful helping others		
Agree	301 (76)	440 (79)
Disagree	16 (4)	30 (5)
Missing	81 (20)	89 (16)
MeeToo is a supportive community		
Agree	318 (80)	469 (84)
Disagree	10 (3)	13 (2)
Missing	70 (18)	77 (14)
New ways to help myself		
Agree	259 (65)	397 (71)
Disagree	34 (9)	50 (9)
Missing	105 (26)	112 (20)
I feel better when I use MeeToo		
Agree	262 (66)	404 (72)
Disagree	31 (8)	45 (8)
Missing	105 26()	110 (20)
I feel less alone with MeeToo		
Agree	284 (71)	439 (79)
Disagree	26 (7)	34 (6)
Missing	88 (22)	86 (15)

[a]Questionnaire items are paraphrased in the table to facilitate interpretation.

[b]Percentages may not add up to 100% due to rounding.

[c]T: time point.

Descriptive statistics for the scales used in the questionnaire are shown in Table 4. For the 81 young people who completed both T1 and T2 questionnaires, there were no significant differences in well-being in the group and gender subgroup analyses. However, in the subgroup analysis examining young females, overall well-being increased by 0.83 points, from 3.34/10 (95% CI 2.76-3.93) at T1 to 4.17/10 (95% CI 3.54-4.81) at T2, although the difference was not statistically significant: t_{57}=1.97, *P*=.05. Similarly, when looking at change over time in raw patient activation scores, there were no significant differences in the group and subgroup analyses examining young males. However, in the subgroup analysis examining young females, levels of patient activation increased from a mean of 1.83/3 (95% CI 1.72-1.95) to 2.00/3 (95% CI 1.89-2.11), a small but statistically significant increase: t_{59}=2.15, *P*=.04.

We compared age, gender, duration of use, and overall well-being for young people with complete T1 and T2 questionnaires and with only the T1 or T2 questionnaire complete only on baseline characteristics (ie, scores at T1 for those with complete T1 and T2 questionnaires or only the T1 questionnaire and scores at T2 for those with only the T2 questionnaire). There were no significant differences in the distributions of females and males (χ^2_1=0.944, *P*=.33) or age categories (χ^2_3=6.94, *P*=.07). Young people with complete T1 and T2 questionnaires had higher levels of self-reported MeeToo usage than young people with only the T1 or T2 questionnaire

complete (χ^2_3=48.24, *P*<.001). In particular, there were more young people with T1 and T2 questionnaires complete who had been using MeeToo for a month or more (62/81, 77%) than those with only the T1 or T2 questionnaire complete (308/795, 39%). In addition, there were fewer young people with complete T1 and T2 questionnaires who had only just started using MeeToo (8/81, 10%) than those with only the T1 or T2 questionnaire complete (366/795, 46%). Young people with complete T1 and T2 questionnaires had lower levels of well-being than young people with only the T1 or T2 questionnaire complete: t_{830}=2.81, *P*=.01; complete T1 and T2 questionnaire mean=4.01(95% CI 3.55-4.47, n=80); complete T1 or T2 questionnaire mean=4.81 (95% CI 4.63-4.98, n=752). These findings suggest that longitudinal analyses for young people with complete T1 and T2 questionnaires are less likely to generalize to young people who have been using MeeToo for shorter periods or with higher levels of well-being.

Table 4. Internal consistencies and descriptive statistics for questionnaire scales.

Scale	T[a]1			T2		
	N	Cronbach α	Mean (SD)	N	Cronbach α	Mean (SD)
Overall well-being	382	.91	5.07 (2.58)	529	.85	4.44 (2.23)
Patient activation	388	.87	2.11 (0.54)	536	.85	1.97 (0.5)
Social support	388	.73	2.05 (0.68)	536	.67	1.82 (0.63)
Help	388	.79	2.16 (0.62)	536	.76	2.02 (0.6)
Confidence in help	388	.84	2.23 (0.66)	536	.72	2.09 (0.65)

[a]T: time point.

Why Did MeeToo Have These Impacts on Young People?

Two themes were identified in response to this research question: (1) “I don't like talking to people I know, but having an anonymous platform […] is a really good thing” and (2) the MeeToo sense of community. In the interviews, young people described how the anonymity of MeeToo enabled them to authentically share experiences and support other young people as it was a safe space. Connecting with other young people with similar experiences fostered a sense of community, and belonging to this community helped young people feel less alone and feel better.

Theme 1: I Don’t Like Talking to People I Know, but Having an Anonymous Platform […] Is a Really Good Thing

Young people reported in the interviews that anonymity was a central reason why using MeeToo had the aforementioned impacts. Anonymity facilitated their ability to voice their feelings, thoughts, and experiences freely without fear of being judged by others, creating a safe space.

> *I think it's a really good app to use, because sometimes you can't talk to your friends or family about it. And all our usernames are anonymous, which is nice, so you don't know, like, for instance, someone could be my best friend, or whatever, but I don't know that, and they don't know that it's me. I like the anonymous aspect of it.* [All quotes from young people]

Anonymity facilitated this process for young people, particularly if they did not feel comfortable opening up about their difficulties with people they know.

> *I know for me, especially, I don't like talking to people I know, but having an anonymous platform to find people that feel the same way or can give you advice on anything is a really good thing.*

By enabling young people to talk openly, they were able to connect with others who had similar experiences. This then encouraged them to provide support to others in a genuine way, particularly in times of stress during lockdown and school assessment periods. Anonymity also mitigated any concerns about worrying other people by talking about one’s own challenges.

> *I thought it was cool that you get to post anonymously and get to see. My main thing that I really liked about the app is that a lot of people have similar opinions to you. And when I went on it, I saw something someone said and that resonated with me, because I felt the same way. So, I replied, and we had this chat, and it was helpful for me. And I hope that it was helpful for that person as well. But I really just like the fact that it's anonymous and you get to help each other.*

> *I think a lot of people struggle with not wanting to worry others with their own problems. So I think helping people via the app is a very effective way to do so.*

Young people described anonymity as particularly important because of mental health stigma, even causing some to hide that they have the MeeToo app on their phone.

> *I know a lot of people try and hide it. I don't know how people can improve on that, but I just know it's a common thing, where people don't want to talk about mental health, as such, and they literally hide the app on their phone, and hide the notifications.*

The anonymity of interaction in MeeToo enabled young people to connect with one another in a more authentic way, as they were able to be more open.

> *So, it's definitely helped during the app, because it's a good way for people to come and talk to other humans without actually having to go up to the person and not being identified. So, I think it's definitely meant that quite a lot of the stuff on there is very genuine and it's quite good to see that people are making an impact on other people's lives.*

Young people described anonymity as making it easier for them to support others with similar experiences, which in turn built their own confidence.

> *When my family was going through some stuff at the start of lockdown, it was quite nice to scroll down through the family section—I searched it up on the search bar—and it was really nice to scroll down and see that I could talk about how I'd dealt with it with other people, that there were coping mechanisms and breathing techniques that I used to get through those hard times myself. It was nice to share them and see if they actually helped people.*

Theme 2: The MeeToo Sense of Community

The safe space created by the anonymity of MeeToo helped create a sense of community, where young people with similar experiences were sharing with and supporting one another. This sense of community fostered a strong sense of connection, leading to the aforementioned impacts of using MeeToo. Young people explained how the app fostered a sense of community that helped them relate to and connect with their peers experiencing mental health difficulties, particularly during lockdown.

> *I think at the time, because it was in the middle of lockdown, I was definitely struggling with my mental health quite a lot around that time. I tried something else before which didn't really work out, a different application. But MeeToo was definitely a big change because there was more of a community, it was more people sharing their experiences, and I really liked that about it. It was all these people and I actually related with some of the stuff they said.*

> *I search for stuff that I think, if I find a comment that maybe I relate to, I can help someone. You feel very in touch with people on that app, there's definitely some kind of not direct friendship but you feel very connected to people if you're experiencing the same thing.*

Anonymity and the safeguarding in MeeToo encouraged a sense of a connected and also safe community.

> *I felt much more comfortable on there than I did with many other apps because it felt very much like a community. I don't want to compare it to [social media], but it was like that but with a lot more safeguarding around it, which I really like because it felt very safe, it felt very secure.*

Connecting through the MeeToo community was described as a valuable source of social connectedness, which in turn had a positive impact on young people's mental health. It also helped people feel less alone and isolated as other people had similar challenging experiences, empowering young people to talk about mental health more in the app and offline.

> *It's really nice to feel like you can help someone. I've always loved helping people, just telling people how much they mean to me. It makes me happy seeing other people happy. To feel like I've actually helped someone, that really boosts my mood.*

> *And I thought anxiety was like this really ultra, awful mental illness, which happens to very few people, and just reading the repetitiveness of posts around anxiety, I just realized there are so many people must have it or suffer with it.*

> *So I guess when I'm talking to my mates or talking to people who are looking for support, I can tell them quite comfortably, you know: you're not the only one, this happens to quite a few people. So you can relate to it more.*

Discussion

Principal Findings

The aim of this research was to examine young people's experiences of using a digital peer support tool, MeeToo. In so doing, we addressed two research questions: (1) What impacts did using MeeToo have on young people? (2) Why did using MeeToo have these impacts on young people? A mixed methods study was conducted, which involved secondary analysis of routinely collected questionnaire data and interviews with young people.

A range of positive impacts of using MeeToo were reported by young people in the questionnaires, which included making it easier to talk about difficult things, being part of a supportive community, providing new ways to help oneself, feeling better, and feeling less alone. A smaller number of young people completed questionnaires at both T1 and T2. Here, subgroup analysis showed that young females had a significant increase in patient activation over time, suggesting that they felt more knowledgeable and confident to manage their mental health. Nevertheless, without a randomized controlled design, inferences about causation cannot be made. Subgroup analysis was performed by gender as the majority of survey respondents were young females. This is in line with previous research showing that more young females than young males engage with digital support tools and in research on their experiences of these tools [7,9]. It is also not surprising, as previous research has shown higher levels of mental health difficulties in young females than in young males and a greater negative mental health impact of the COVID-19 pandemic on young females [17]. In addition, a few challenges with using MeeToo were reported by young people, such as inadvertently viewing sensitive content on the app. Regarding this, young people suggested that there could be a feature on the home page of MeeToo that could offer users the option to block or filter sensitive content so that they can engage more positively with the app. In this respect, the MeeToo team is now improving the ability of the app to filter content.

Two themes were identified from the interviews about why using MeeToo had these impacts on young people. The first theme was "I don't like talking to people I know, but having an anonymous platform […] is a really good thing." Young people describe anonymity as a central reason why using MeeToo had the aforementioned impacts. Anonymity helped create a safe space in which users could express their feelings, thoughts, and experiences freely without the fear of being judged by others, particularly when they were not comfortable sharing difficulties with people they know. This reflects previous research on digital peer support platforms suggesting that anonymity fosters a sense of separation from pre-existing ties, facilitating users to open up about difficulties [7]. This finding is also in line with previous research identifying self-connectedness (reflecting on one's own feelings, thoughts, and experiences) as important for engagement in digital mental health support [10]. Anonymity enabled young people to connect with others who had similar experiences, as interactions were more authentic. It also helped young people feel confident and empowered to provide support in a genuine way to others, both online and offline, especially about difficulties they had experienced during the COVID-19 pandemic. This relates to previous research highlighting the importance of educating peers on how to offer support online to foster a sense of empowerment among young people to share their difficulties and help one another [7].

The second theme was the MeeToo sense of community, which was created by anonymity and the ability to authentically connect with others. This sense of community helped young people relate to and connect with peers, which was particularly valued during lockdowns. The MeeToo sense of community was described as a valuable form of social connectedness, which in turn had a positive impact on young people's mental health and made them feel less isolated and alone. These findings are in line with research on digital peer support platforms indicating that stigma regarding mental health difficulties within peer support spaces decreases when users share similar experiences and interests [7,9]. This theme is also in line with previous research identifying peer connectedness as important for engagement in digital mental health support [10]. The safeguarding in MeeToo made young people feel like the community was safe. Being supported by others with similar experiences appeared to important for establishing the credibility of MeeToo, as support was provided by experts by experience. Again, these findings are in line with previous research identifying professional connectedness as important for engagement, which in digital support refers to trust in the safety and authenticity of the tool [10].

Limitations

Limitations of this research include the small number of young people with paired T1 and T2 questionnaire data in the secondary analysis, which meant the longitudinal analyses were likely underpowered. The use of routine data and the lack of controlled conditions likely resulted in the small amount of longitudinal data. Still, we do not have data on whether young people who completed the T1 questionnaire but not the T2 questionnaire stopped using MeeToo or continued but did not complete the T2 questionnaire. These findings suggest that longitudinal analyses for young people with complete T1 and T2 questionnaires are less likely to generalize to young people who have been using MeeToo for shorter periods or with higher levels of well-being. As previously mentioned, without a randomized controlled design, inferences about causation cannot be made. Other limitations of routinely collected data also apply to this research [29]. Self-reported usage data were collected from questionnaires and interviews to contextualize the findings. There was not a greater focus, as it was not central to the research questions and MeeToo is already widely used [12]. Nevertheless, future research on MeeToo usage, acceptability, and engagement is recommended, given the challenge of sustained engagement with digital mental health support tools [10]. For example, a randomized controlled design could be used to examine the effectiveness of different engagement strategies in MeeToo, such as regular personalized encouragement messages from super peers. Similarly, future research should also examine the experiences of MeeToo, with a focus on young people from marginalized groups to examine the extent to which it is inclusive of their needs. Indeed, the majority of young people who completed the questionnaires were young females, suggesting that future research with young people with different gender identities is needed. In particular, we cannot say whether young people with different gender identities did not complete the questionnaires, because they were less likely to use MeeToo or because the questionnaires were less inclusive. Regarding the interviews, although the sample size enabled us to hear variations in experiences and then close recruitment when there was sufficient consistency in young people's responses, the sample size was still relatively small. Future research could recruit larger qualitative samples, for example, by offering a range of ways for participants to take part (eg, interviews, free-text questionnaires, photoelicitation). Qualitative research with young people who stopped using MeeToo would be particularly useful to examine the question of sustained engagement.

Conclusion

The aim of this research was to examine young people's experiences of using a digital peer support tool, MeeToo. A range of positive impacts of using MeeToo were reported by young people in questionnaires, which included making it easier to talk about difficult things, being part of a supportive community, providing new ways to help oneself, feeling better, and feeling less alone. Anonymity and the MeeToo sense of community were identified from interviews as possible reasons for why using MeeToo had these impacts. Anonymity helped create a safe space in which users could express their feelings, thoughts, and experiences freely without the fear of being judged by others. The MeeToo sense of community was described as a valuable form of social connectedness, which in turn had a positive impact on young people's mental health and made them feel less isolated and alone. Future research is needed to examine how these impacts and processes can be sustained.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
MeeToo app Logic Model.
[DOCX File , 614 KB - pediatrics_v5i4e37424_app1.docx]

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Abbreviations

ORS: Outcome Rating Scale

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Original Paper

Validation of an Electronic Visual Analog Scale App for Pain Evaluation in Children and Adolescents With Symptomatic Hypermobility: Cross-sectional Study

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Abstract

Background: Rapid advances in mobile apps for clinical data collection for pain evaluation have resulted in more efficient data handling and analysis than traditional paper-based approaches. As paper-based visual analogue scale (p-VAS) scores are commonly used to assess pain levels, new emerging apps need to be validated prior to clinical application with symptomatic children and adolescents.

Objective: This study aimed to assess the validity and reliability of an electronic visual analogue scale (e-VAS) method via a mobile health (mHealth) App in children and adolescents diagnosed with hypermobility spectrum disorder/hypermobile Ehlers-Danlos syndrome (HSD/HEDS) in comparison with the traditional p-VAS.

Methods: Children diagnosed with HSD/HEDS aged 5-18 years were recruited from a sports medicine center in Sydney (New South Wales, Australia). Consenting participants assigned in random order to the e-VAS and p-VAS platforms were asked to indicate their current lower limb pain level and completed pain assessment e-VAS or p-VAS at one time point. Instrument agreement between the 2 methods was determined from the intraclass correlation coefficient (ICC) and through Bland–Altman analysis.

Results: In total, 43 children with HSD/HEDS aged 11 (SD 3.8) years were recruited and completed this study. The difference between the 2 VAS platforms of median values was 0.20. Bland–Altman analysis revealed a difference of 0.19 (SD 0.95) with limits of agreement ranging –1.67 to 2.04. An ICC of 0.87 (95% CI 0.78-0.93) indicated good reliability.

Conclusions: These findings suggest that the e-VAS mHealth App is a validated tool and a feasible method of collecting pain recording scores when compared with the traditional paper format in children and adolescents with HSD/HEDS. The e-VAS App can be reliably used for pediatric pain evaluation, and it could potentially be introduced into daily clinical practice to improve real-time symptom monitoring. Further research is warranted to investigate the usage of the app for remote support in real clinical settings.

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KEYWORDS

hypermobility syndrome; Ehlers-Danlos syndrome; hypermobility; hypermobile; mobile application; mobile app; pain measurement; pain; validation; validate; scale; measure; pain severity; pediatric; validation; visual analogue scale; mHealth; mobile health; mobile app; children; adolescent; youth; child; digital health tool

Introduction

Reliable and validated assessment tools of pain intensity are required to evaluate and implement appropriate and timely therapies. In recent years, digital health advances have led to significant progression in real-time pain-related data collection that may improve pain management [1-4]. A recent meta-analysis of 7977 children and adults reported that pain-related data collected by electronic devices that measured pain intensity mainly using a visual analog scale (VAS) showed equal to or greater reliability than traditional paper collection methods [1]. Furthermore, the study found that patients preferred using the electronic format of data collection to the paper version [1].

The current widely used method to evaluate pain intensity is the VAS instrument, which has been used in clinical and research settings for a number of years to record self-reported pain levels in both adults and children [1,5-7]. This approach is shown to have moderate reliability in children over 5 years of age [8] and validated in children 7 years of age and over [7,9]. Typically, the VAS is a 10-cm–long premeasured horizontal line anchored at either end representing subjective feeling by the extremes of pain level with 0 mm marked as "no pain at all" to 10 cm rated as the "worst possible pain" [6]. Traditionally, the VAS is completed in a paper-based format. Despite the accuracy and extensive clinical application of the paper version, there are a number of limitations of the paper-based VAS (p-VAS), including incomplete or incorrect marking limiting validity of data, inefficient and extensive data handling by clinicians and researchers, and manual processing for each patient with the possibility of introducing error during data measurement and entry [3]. In contrast, an electronic VAS (e-VAS) allows for automatic calculation of the VAS score, preventing possible human errors when using a ruler.

To overcome these potential barriers of the p-VAS version, Escalona-Marfil et al [10] recently developed a novel e-VAS to measure pain level through an "Interactive Clinics" app, which has been since validated for use in healthy children [11]. The electronic VAS method allows the collection of real-time data from patients and direct integration with electronic health records, reducing burden on clinicians and researchers. Furthermore, support for efficient, valid, and reliable approaches in timely assessment of pain severity is critical for evaluating the effectiveness of pain therapies and implementation of early interventions in the pediatric population. Despite emerging evidence on psychometric validation of the digital VAS versions in pediatrics [3,10-13], the feasibility of the application of the e-VAS in children with symptomatic hypermobility conditions has not been reported. Generalized joint hypermobility (GJH) is a connective tissue condition characterized by an excessive range of motions that affects multiple joints [14]. Almost 1 in 5 children with GJH experiences symptoms [15,16], particularly chronic pain [17], with a negative impact on their quality of life [18,19]. Once a young person with GJH has musculoskeletal pain or other symptoms, a diagnosis of hypermobility spectrum disorder/hypermobile Ehlers-Danlos syndrome (HSD/HEDS) is usually made.

This mobile Health (mHealth) tool might prove beneficial for patients living in geographically remote areas, where access to specialists is limited. Patients and parents or caregivers may not always be required to visit the hospital, consequently saving the time and money required to travel long distances from rural areas. Furthermore, health professionals can access the recorded pain-related information digitally without the need to contact the patient. If introduced within different clinics that provide care to children and adolescents affected by HSD/HEDS, the e-VAS can support early pain detection, preventing incidences of unnecessary prolonged pain with a consequent improvement in the patient's quality of life. This possible digital health advancement in pediatric pain management may also lead to a reduction in absenteeism from school. The aim of this study was to determine the validity and feasibility of a newly developed e-VAS app interface in recording pain intensity in children and adolescents with symptomatic hypermobility.

Methods

Study Design

A cross-sectional study design was used to evaluate the validity and reliability of the e-VAS version for pain measurement in children with hypermobility.

Ethics Approval

Ethics approval for this study (H-2020-0387) was granted by Human Research Ethics Committee of University of Newcastle (Callaghan, New South Wales, Australia).

Settings and Participants

Participants were recruited from Narrabeen Sports and Exercise Medicine Centre (Narrabeen, New South Wales, Australia). Eligibility criteria included children and adolescents aged between 5 and 18 years and diagnosed with generalized joint hypermobility (Beighton score of ≥5 for adolescents in or post puberty and ≥6 before puberty) with sufficient English language and cognitive skills to rate the severity of pain. Participants were recruited if they reported lower limb pain of at least 2 out of 10 on the VAS assessment tool in the previous month.

Participants were excluded if they were diagnosed with major cognitive or psychiatric disorders that interfered with rating of pain severity and other medical conditions that may have contributed to chronic or recurrent pain or interfered with their ability to use their hand for documenting p-VAS scores.

Demographic data were collected, including age, sex, height, weight, and BMI. The Beighton Score [20] was used to measure joint hypermobility on a 9-point scale. To prevent bias, the same clinical researcher (MM) completed all data collection.

Measuring Tools

Pain recording data were collected at one time point from each consenting participant using the e-VAS app (version 1.2.4, accessible to both iOS and Android devices, powered by Bit Genoma Digital Solutions Ltd), which was downloaded for free on either the parents' or participants' smartphones. In accordance with the digital health policy outlined by the European Pain Federation [21], e-VAS data collected on the

App were safely stored on the country-based server (Australia). The e-VAS version displays a horizontal gray line on a white background (Figure 1). The traditional p-VAS format displays a 100-mm horizontal line. In both the e-VAS and p-VAS, the end point labels on the left and right sides of the horizontal line indicated "no pain" and "worst possible pain," respectively.

Figure 1. The electronic visual analog scale app technology used to score pain intensity.

Procedure

At the initial appointment, each participant was asked to recall their pain experience during the past month. A researcher who was independent of recruitment and data collection (AC) created the randomization sequence in blocks of 10 each by using a freely available web-based number generator software. Allocation concealment was achieved by AC masking the sequence into consecutively numbered sealed and opaque envelopes. Sealed envelopes were strictly opened by the principal investigator (MM) only on the day of participant's initial consultation to reveal the sequence of the e-VAS and p-VAS. All participants completed assessments on both VAS platforms.

Prior to data collection, a full demonstration was provided to the participant with an opportunity to ask questions. For the e-VAS recording of pain level, the patient's smartphone was placed flat on a table, and each participant was asked to apply single-finger pressure on the horizontal line displayed on the touch screen and to indicate the location corresponding to the pain intensity experienced. The e-VAS mobile app automatically calculated the pain rating from collected results, which were then directly synchronized to the principal investigator's project account on the Interactive Clinics web-based platform that was password protected, thus minimizing data handling and streamlining the processing of data extrapolation. Data from the paper version were extrapolated by the same investigator (MM) using a standard ruler, and results were manually entered into a spreadsheet for statistical analysis.

Statistical Analysis

Descriptive statistics including median, minimum, and maximum as well as mean (SD) values for the e-VAS and p-VAS outcomes were calculated by an independent statistician. The statistician was blinded to both the allocation concealment (p-VAS and e-VAS) and the identity of the participants. All statistical analyses were performed using R (version 4.1.3; R Core Team) [22].

For construct validity and reliability of the e-VAS and agreement between the 2 VAS methods, exploratory Bland–Altman graph analysis and the intraclass correlation coefficient (ICC) were used, respectively [23,24]. For each participant, the difference between e-VAS and p-VAS measurements was plotted against the average of each method. The analysis was performed by calculating the limits of agreement as mean of the difference (SD 1.96) multiplied by the SD of the difference. For comparison, a nonparametric approach to the limits of agreement using 2.5 and 97.5 percentiles was included. For absolute agreement between e-VAS and p-VAS values, the ICC, ICC(3,1), or equivalently ICC(A,1) derived from a 2-way mixed-effects model was used. ICC values of >0.75 indicate good agreement [25].

Results

Participant Characteristics

A total of 43 children and adolescents diagnosed with HSD/HEDS participated in this study. Anthropometric and demographic characteristics at baseline are summarized in Table 1.

Table 1. Clinical and demographic characteristics of the study sample (N=43).

Characteristics of participants	Values
Gender, n (%)	
Female	28 (65)
Male	15 (35)
Age (years), mean (SD)	11.0 (3.8)
Hypermobility (Beighton score), mean (SD)	7.0 (1.3)
Weight (kg), mean (SD)	40 (16)
Height (m), mean (SD)	1.45 (0.2)
BMI (kg/m^2), mean (SD)	18.3 (3.5)
School education level, n (%)	
Primary school	28 (65)
Secondary school	15 (35)

Comparison Between the e-VAS and p-VAS Versions

The summary statistics for the 2 VAS platforms (e-VAS and p-VAS) are presented in Table 2. The difference between the 2 methods of median values is 0.20 among children and adolescents with symptomatic hypermobility.

Table 2. Summary of statistics for visual analog scale (VAS) assessments in children and adolescents with hypermobility spectrum disorder (N=43).

Instrument	Score	
	Median (IQR)	Mean (SD)
Electronic VAS	5.90 (1.40-9.50)	5.89 (1.99)
Paper-based VAS	5.70 (2.00-9.30)	5.70 (1.77)

The scatter plot for the e-VAS compared to that of the p-VAS with a line of equality is presented in Figure 2 for every participant (numbered) with no apparent systematic difference between e-VAS and p-VAS methods. Points that lie on the diagonal line are in complete agreement between the 2 methods. The reliability estimated by ICC for baseline was 0.87 with a 95% CI of 0.78-0.93, indicating good agreement.

The Bland–Altman plot is presented in Figure 3. The mean of the difference between e-VAS and p-VAS was 0.19 (SD 0.95) with limits of agreement ranging –1.67 to 2.04. The 2.5 and 97.5 percentiles of the difference were –1.19 and 2.58, respectively. There was a slight bias toward e-VAS with e-VAS measuring 0.19 higher on average than the p-VAS method.

Figure 2. Scatter plot of data for the electronic visual analog scale (e-VAS) versus paper-based visual analog scale (p-VAS). Points on the graph indicate each participant. VAS: visual analog scale.

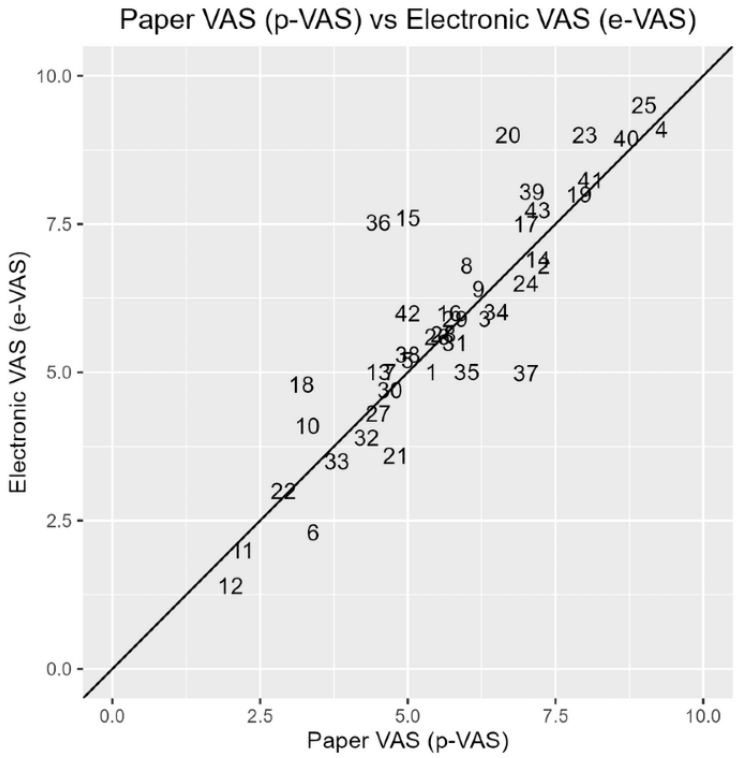
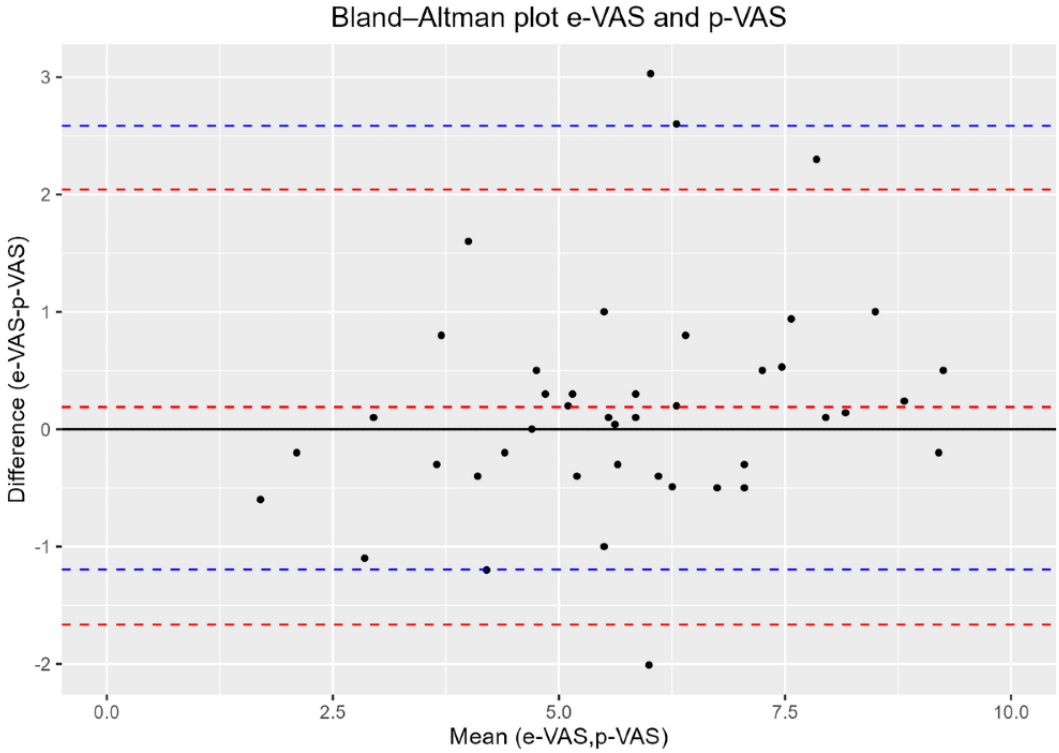


Figure 3. Bland-Altman plot for differences against the mean of scores on the electronic visual analog scale (e-VAS) and paper-based visual analog scale (p-VAS). Dashed red lines indicate the mean difference and limits of agreement. Blue dashed lines indicate the 2.5 and 97.5 percentiles of the difference. The solid black line is the zero reference for the difference.



Discussion

Principal Findings

To our knowledge, this is the first study that investigated the validity and reliability of an e-VAS in children and adolescents with HSD/HEDS for pain evaluation. Our results show that the e-VAS and the p-VAS can be used interchangeably. Instrument agreement was present between the p-VAS and e-VAS methods with good reliability (ICC=0.87) and validity (mean difference 0.19).

These findings are supported by previous reports of good reliability and validity of the e-VAS in healthy children, adolescents, and adult participants without pain on the newly designed Interactive Clinics app compared to that of the paper version [10,11]. In a prospective cross-sectional study, Escalona-Marfil et al [10] reported good reliability of the e-VAS method, as indicated by an ICC of 0.86 (95% CI 0.81-0.90) in healthy adults aged 18-65 years. In addition to evaluating pain in adults, Turnbull et al [11] reported that the e-VAS can be used interchangeability with the p-VAS in the pediatric population by showing moderate-to-good reliability with an ICC of 0.80 (95% CI 0.70-0.87) in healthy children and adolescents aged 10-18 years. Furthermore, there is strong consolidated evidence in support of the e-VAS's comparability with the p-VAS version [26].

Advances in digital health have enabled emerging application of mHealth tools in pain management of children and adolescents by capturing real-time pain-related data, reducing recall bias, and improving responsiveness of health professionals [27]. The findings from a recent meta-analysis revealed a strong correlation between paper methods and electronic capture of pain-related outcomes with respect to completeness of patient-reported data collection, score equivalency, ease of use, and acceptability supporting their use in the clinical setting and in interventional research [1].

Other benefits of electronic data capture methods in the management of patients with pain have been reported to include a significant decrease in the severity of pain, worse pain, and an improved quality of life over time in both adult and adolescent patients (aged 12-68 years) who used a pain management app on a mobile device [28]. A recent meta-analysis of noncancer pain in adult patients further reported that app-based pain interventions were significantly more effective at reducing different types of chronic pain in comparison with control groups [29]. Furthermore, both patients and health care professionals prefer using pain Apps [28] with high compliance (83%) reported in adult patients (aged 19-65 years) completing electronic diaries for pain assessment [30].

Although there are other alternative instruments to the VAS, such as the numeric rating scale and verbal rating scale, the VAS has the greatest clinical utility, is in widespread clinical use, and has been the best measure of self-reported pain in children aged ≥7 years [31]. However, there are certain limitations of the p-VAS. For example, there is potential for drawing the line outside of the 0-10–point scale—or at an angle—and introducing human error while using a ruler [32], whereas the e-VAS allows for automatic calculation of the VAS score, thus preventing invalid responses and increasing consistency as the same measuring method is used, thereby reducing potential for error [33].

Clinical Implications

The growing use of digital health has the potential to improve adherence to pain reporting [34,35], allow real-time data capture [35], and consequently improve communication between clinicians and their patients [36]. Novel mHealth tools, such as the e-VAS App, support efficient capture and recording of patient-reported outcome measures in day-to-day clinical practice, which improves clinicians' insights into the effectiveness of any intervention they provide with the aim of reducing pain.

As part of the daily clinical management of pain in children with HSD/HEDS, the e-VAS app is a useful tool to record pain at a precise time and as frequently as needed. This, in turn, may improve the implementation of more appropriate and timely pain management strategies. The e-VAS app further allows health care professionals to record the time and day of assessment accurately with a lower chance of potential error during clinical data collection. In addition, completion of the VAS assessment is possible remotely as the data can be sent electronically to medical records, allowing for real-time tracking of pain and helping prevent a potential recall bias. Further clinical utility of these digital health advances needs to be explored in geographically remote areas with limited availability of allied health care professionals. Accordingly, further research is warranted to evaluate the efficacy and functional capabilities of these novel apps for clinical pain management in the pediatric population.

Limitations and Strengths

A major methodological advantage of this study was the use of block randomization for the e-VAS and p-VAS sequences when collecting data from children and adolescents with HSD/HEDS. Further strengths of this study include comparison of the digital platform with paper-based assessment and statistical analyses.

The findings of this study need to be considered in light of some limitations. Data were collected from a single center, and two-thirds of the sample consisted of females, which might limit the generalizability of our findings to the whole pediatric population with HSD/HEDS. However, the sample size clearly reflects the higher prevalence of HSD in females [37]. Furthermore, it is important to note that there might be a possible recall bias, especially among the younger children relying on recalling pain intensity the month before. To reduce possible confounding factors, e-VAS and p-VAS recordings were undertaken at the same time, with a maximum gap of only 1 minute between the data collection and rating of pain intensity. While the use of the VAS is generally recommended in children aged ≥7 years, to increase the power for our study, we included children aged 5-6 years in this study since cognitive abilities are more reliable predictors than chronological age in effective use of the VAS [6]. In addition, use of the VAS in 5-6–year-old children has been found to show a moderate-to-strong correlation with the rating of pain intensity level further supporting the application of this instrument in younger children [38]. Therefore, future trials should also have an increased sample size to include the younger pediatric population.

Conclusions

The findings of this study indicate that the e-VAS and p-VAS are interchangeable among children and adolescents diagnosed with HSD/HEDS. This study provides strong support for the clinical application of digital health in pain assessment in this pediatric population. The advancement in easily accessible digital health pain applications may have the potential to facilitate early clinical decision-making and to improve

compliance with pain reporting. In conclusion, emerging digital health platforms may also promote better communication between clinicians and patients by providing more accurate and objective real-time monitoring of symptoms among children and adolescents with HSD/HEDS.

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Conflicts of Interest

None declared.

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Abbreviations

e-VAS: electronic visual analog scale
GJH: generalized joint hypermobility

HEDS: hypermobile Ehlers-Danlos syndrome
HSD: hypermobility spectrum disorder
ICC: intraclass correlation coefficient
mHealth: mobile health
p-VAS: paper-based visual analog scale
VAS: visual analog scale

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Original Paper

Acceptability of Telemedicine Among Parents of Adolescent Patients in an Adolescent Clinic: Cross-sectional Survey Study

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Abstract

Background: Since the beginning of the COVID-19 pandemic, new literature has described the perceptions of adolescent patients on the use of telemedicine for their health care, but less attention has been devoted to parents' and caregivers' perspectives on telemedicine usage for their adolescents. Parents' perspectives are important, as they undoubtedly influence how children learn to make decisions about their health care.

Objective: This study describes the level of acceptability (measured based on accessibility and satisfaction) expressed by caregivers of adolescent patients with regard to telemedicine visits in an urban adolescent medicine practice.

Methods: A cross-sectional survey was sent electronically to parents and guardians of patients aged <18 years who completed outpatient telemedicine visits to an adolescent medicine practice in Chicago, Illinois, from March 2020 to February 2021. The questions focused on accessibility and satisfaction. The data were analyzed to describe response frequencies.

Results: Among a sample of 71 survey respondents, the vast majority reported that telemedicine was very easy to use (58/71, 82%) and was at least as convenient as in-person visits (70/71, 99%). Over 90% of respondents reported that their adolescents' needs were addressed (69/69, 100%) and that they were at least as comfortable with the level of privacy and the confidential conversations between their adolescents and medical providers in telemedicine visits (65/71, 92%) as they were with those in in-person visits.

Conclusions: Our findings suggest that parents and guardians find telemedicine to be an acceptable way for their children and adolescents to receive appropriate health care.

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KEYWORDS

adolescent medicine; telemedicine; acceptability; privacy; confidentiality; satisfaction; caregivers

Introduction

When the SARS-CoV-2 pandemic began in the United States on March 2020, telemedicine services grew exponentially to meet patient care needs. Since then, studies on the utilization of telemedicine by adult and pediatric populations have suggested that telemedicine is an acceptable alternative to in-person visits and that patients are mostly satisfied with the use of telemedicine, largely due to increased convenience [1,2]. Adolescent medicine is a distinct area of pediatrics that involves specialized care with the added complexity of confidentiality and privacy, as it relates to the receipt of care by minors [3].

Studies to date suggest that adolescents are satisfied with the convenience and accessibility of telemedicine visits [4-6] and have few concerns about privacy and confidentiality [7]. Evidence indicates that most adolescents can find a quiet room in which to conduct a telemedicine visit, with few describing a lack of privacy or the fear of being overheard by someone else [6]. These studies however are mainly focused on youth perspectives; less attention is paid to the perceptions of parents and caregivers [4,8,9]. Caregivers are important stakeholders in the care of adolescents, as they make and share health decisions with their adolescents while also allowing confidential health care conversations between their adolescents and medical providers [10,11]. A study published in 2021 delineated adolescent and caregiver perspectives for care in disordered eating and reproductive health care. In that study, adolescents were able to locate a private space to conduct telehealth visits, and caregivers found telehealth to be noninferior to in-person visits with regard to privacy, communication, the discussion of test results, and mood-related issues [12]. Our study aims to add to current literature by describing caregiver perceptions on the acceptability of adolescent telemedicine visits in terms of both perceived accessibility and satisfaction. We hypothesized that caregivers would find telemedicine to be an acceptable means of health care delivery for their adolescents.

Methods

Study Design

In this study, we collected cross-sectional data via a self-administered survey that was sent electronically to caregivers of patients aged <18 years who completed outpatient telemedicine visits via StarLeaf (StarLeaf Ltd)—a teleconferencing application—with the Division of Adolescent Medicine at Lurie Children's Hospital of Chicago between March 2020 and February 2021. Some portions of the visits may have been conducted without the guardians being present (ie, the physician was alone with the adolescent), although the times when this occurred during the visits varied by medical provider. During the data collection period, survey invitations were sent via email to a convenient sample of parents and guardians (ie, those who completed telemedicine visits and had an email address on file) within 72 hours of each visit. Survey invitations were emailed once and remained active until the end of the data collection period. Surveys were completed via REDCap (Research Electronic Data Capture; Vanderbilt University) and included demographic characteristics (eg, race), the reason for the health care visit, a history of the receipt of telemedicine visits (ie, visits for the parent's or guardian's own health care or visits for their adolescent's health care), and questions for assessing the accessibility of and satisfaction with the telemedicine visit (components of acceptability). These questions used a 5-point scale for comparing the accessibility of and satisfaction with telemedicine visits versus in-person visits. The data were summarized by using frequencies of responses and were further dichotomized into the following two groups: respondents who either preferred telemedicine over in-person visits or had no preferences for the type of visit and respondents who preferred in-person visits over telemedicine.

Ethics Approval

The study protocol was reviewed and approved by Lurie Children's institutional review board (reference number: 2020-3737) with a waiver of documentation of consent.

Results

A total of 2442 telemedicine visits occurred between March 2020 and February 2021. A convenient sample of 782 surveys were sent to parents and guardians, and a total of 227 surveys were received—a response rate of 29% (227/782). Of the 81 surveys that were returned completed, 71 were from unique participants (Figure 1). For those who completed more than 1 survey due to multiple encounters, the responses from the first telemedicine encounter were used in the analysis. REDCap software was used for the collection of survey data. SPSS Statistics 27 (IBM Corp) was used for the analysis of data. The demographic data of respondents are provided in Table 1. The majority (61/71, 86%) self-identified as White, while the rest of the respondents self-identified as Black or African American, Native American or Alaskan Native, Native Hawaiian or Other Pacific Islander, Asian, or other. The average age of caregivers was 47 years. Further, 72% (51/71) of parents had used telemedicine previously. Visits were for primary care; sexual, menstrual, or reproductive health; mental health; or gender transition–related care. The most common reason for telemedicine visits was the receipt of gender-affirming care (46/71, 65%). Patients who received gender-affirming care were part of the Gender Development Clinic; they may have been starting pubertal blockade therapy or gender-affirming hormones, or they started these processes and were seeking follow-up care.

With regard to accessibility and satisfaction, survey items and their response frequencies are described in Table 2. All caregivers reported that video visits were somewhat easy to use or very easy to use. The majority (60/71, 85%) reported that if video visits had not been available, they would have waited until in-person appointments were available or until the COVID-19 pandemic ended to receive care (ie, rather than seek immediate care elsewhere or use the emergency department).

Almost all respondents (69/71, 97%) reported that telemedicine was at least equally as convenient as an in-person visit. Further, the vast majority (70/71, 99%) indicated that their adolescents' concerns were addressed at least as well as they would have been in in-person visits, reported that they were at least as comfortable with leaving the room (69/71, 97%; ie, to allow a confidential conversation between the physician and adolescent) as they would have been for an in-person visit, and felt at least as comfortable with the level of privacy (65/71, 92%) as they were with that of an in-person visit. A total of 89% (63/71) of the respondents reported that they would be very likely or extremely likely to recommend telemedicine to others even after the COVID-19 pandemic was over.

Figure 1. Flow of adolescent medicine surveys sent and received.

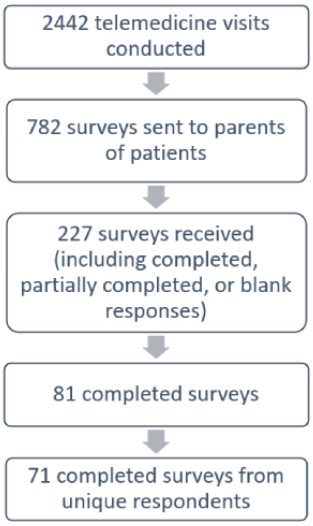

Table 1. Demographic characteristics of caregivers of adolescents (n=71).

Characteristics	Respondents
Race[a], n (%)	
White	61 (86)
Black or African American	6 (9)
Native American or Alaskan Native	0 (0)
Native Hawaiian or Other Pacific Islander	0 (0)
Asian	3 (4)
Other	2 (3)
Hispanic or Latinx, n (%)	
Yes	8 (11)
No	63 (89)
Age (years), mean (range)	47 (34-66)
Reason for visit[a], n (%)	
Sexual, menstrual, or reproductive health	13 (18)
Gender-related care	46 (65)
Mental health	17 (24)
Primary care	5 (7)
Substance use prevention program	0 (0)
"During the video visits, was your child referred for additional services? (Bloodwork, labs, a physical exam, pharmacy BP, etc)," n (%)	
Yes	27 (38)
Sexual, menstrual, or reproductive health	2 (7)
Gender-related care	23 (77)
Mental health	2 (7)
Primary care	3 (10)
Substance use prevention program	0 (0)
No	44 (62)

[a]Respondents checked all response options that applied.

Table 2. Caregiver acceptability of telemedicine for adolescent health visits (n=71).

Survey questions and responses	Respondents, n (%)
Accessibility	
"How easy or difficult was it to use the video visit system?"	
"Very difficult"	0 (0)
"Somewhat difficult"	0 (0)
"Somewhat easy"	11 (15)
"Very easy"	58 (82)
No response	2 (3)
"If a video visit for your child was not available today, what would you have done?"	
"Waited to make an adolescent medicine in-person appointment"	52 (73)
"Gone to the emergency department"	0 (0)
"Looked for a provider outside the Lurie system"	1 (1)
"Waited to seek care after COVID-19"	8 (11)
"I do not know"	10 (14)
Satisfaction	
"The visit was convenient for me."	
"Telehealth much better than in-person"	42 (59)
"Telehealth somewhat better than in-person"	12 (17)
"Telehealth about the same as in-person"	16 (23)
"Telehealth somewhat worse than in-person"	1 (1)
"Telehealth much worse than in person"	0 (0)
"I felt my child's concerns were addressed."	
"Telehealth much better than in-person"	4 (6)
"Telehealth somewhat better than in-person"	1 (1)
"Telehealth about the same as in person"	65 (92)
"Telehealth somewhat worse than in-person"	1 (1)
"Telehealth much worse than in-person"	0 (0)
"I felt comfortable leaving the room."	
"Telehealth much better than in-person"	8 (11)
"Telehealth somewhat better than in-person"	2 (3)
"Telehealth about the same as in person"	59 (83)
"Telehealth somewhat worse than in-person"	0 (0)
"Telehealth much worse than in-person"	2 (3)
"I felt comfortable with the privacy of the video visit."	
"Telehealth much better than in-person"	8 (11)
"Telehealth somewhat better than in-person"	3 (4)
"Telehealth about the same as in person"	54 (76)
"Telehealth somewhat worse than in-person"	4 (6)
"Telehealth much worse than in-person"	2 (3)
"How likely are you to recommend video visits to a family member or friend after the COVID-19 crisis?"	
"Not at all likely"	2 (3)
"Somewhat likely"	6 (8)
"Very likely"	24 (34)

Survey questions and responses	Respondents, n (%)
"Extremely likely"	39 (55)

Discussion

Principal Findings

In this project, we aimed to describe the level of acceptability (measured based on accessibility and satisfaction) expressed by caregivers of adolescent patients with regard to telemedicine use during the first year of the COVID-19 pandemic. Our results show a high level of acceptability for telemedicine among caregivers of adolescent patients receiving predominantly gender-related specialty care. Prior to the COVID-19 pandemic, during an equivalent time period at the Division of Adolescent Medicine at Lurie Children's Hospital, 53.3% (1301/2442) of telemedicine encounters were conducted for gender-related care. Similarly, in this study, gender-related care represented 65% (46/71) of care visits, suggesting that telemedicine is crucial for accessing gender-related care after the pandemic. Prior studies of gender-diverse youth have shown that youth have an interest in receiving care through telehealth [6], and studies of young adult patients and caregivers of youth accessing gender transition–related services have shown preliminary data indicating that telehealth visits are more acceptable and convenient than in-person visits [13]. For all adolescent health–related visits, our results similarly indicate that for many caregivers of adolescent patients, telemedicine is at least equally as acceptable and satisfactory as in-person medical visits. Of the 71 respondents, only 1 felt as if their adolescent's needs were not addressed by their medical provider during the telemedicine visit. There were minimal issues with the use of technology, and all respondents found the video system easy to use.

Confidentiality is a cornerstone of adolescent health issues; the American Academy of Pediatrics has provided guidance on confidentiality for adolescent telehealth visits [14]. All caregivers and families should be reminded that confidential time alone without a parent should be expected for every telemedicine encounter, just as it would for in-person visits. Physicians should discuss the restrictions of confidential care (eg, if the adolescent's safety or someone else's safety is in danger) and ensure that confidential information is housed in the electronic health record appropriately to prevent a parent from accessing information that is not intended to be shared with them [14]. For sexual and gender minority youth in particular, the issue of privacy is critical for improved health care outcomes. Studies related to privacy and telehealth for adolescents have shown mixed results. A survey study conducted at a pediatric center that provides gender-affirming care found no differences in caregiver perceptions of privacy between in-person visits and video visits [13]. However, an adolescent medicine clinic that cares for patients with disordered eating and reproductive health concerns found that 22% of youths believed that the privacy of telehealth visits was inferior to that of in-person visits, whereas only 2.5% of caregivers shared that belief [12]. In our study, the majority of parents (65/71, 92%) did not have concerns about privacy during telehealth visits. Although our study did not elicit adolescents' experiences or their perceptions of privacy, parents' comfort with leaving the room and allowing for private discussions between adolescents and medical providers, as well as the overall privacy of visits, is a critical component of acceptability and high-quality patient care.

Despite the high acceptability of and satisfaction with telemedicine among the group surveyed, there may be some disadvantages. Telemedicine does not allow for thorough physical examinations, the recording of vitals, or blood work, which can be critical parts of adolescent care. Barney et al [15] noted that some reproductive health services cannot be conducted via telemedicine, including sexually transmitted infection screening, the insertion of contraceptive devices, and gynecologic examinations. Of the 13 caregivers in our study who had adolescents with reproductive health concerns, only 2 stated that they were referred for additional services. In many cases, medical providers were able to provide adequate care via the video system that did not require an in-person physical examination. Further, telemedicine can be limited by access to a device or an internet connection, which is necessary for participating in a telemedicine visit. Although many of our respondents did not experience any technical difficulties during the video visits, it is unclear if this would be true for the general population seeking adolescent care or if this was influenced by a lack of demographic diversity within the group of respondents.

Limitations

This study is limited in terms of the small sample size and low responsiveness to the survey invitation. However, the sample size of this study is comparable to those of other studies evaluating telemedicine in adolescent populations. The individuals who completed the survey might not be representative of the larger group of families seeking a variety of adolescent health services via telemedicine, as most respondents self-identified as White (61/71, 86%) and had adolescents who were seeking gender-related health care (46/71, 65%).

Conclusions

In response to the COVID-19 pandemic, telemedicine has undoubtedly been implemented more than ever before. Among parents of adolescents receiving specialty care at our institution, telemedicine is viewed as an acceptable way to receive medical care with minimal concerns for privacy and confidentiality. Further studies are needed to assess telemedicine's acceptability in more diverse populations and its appropriateness for addressing the variety of adolescent health needs.

Implications and Contributions

This paper contributes to the growing body of literature about the acceptability of telehealth by highlighting parent perspectives on the receipt of adolescent-specific telehealth services for their adolescents.

Conflicts of Interest

None declared.

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Abbreviations

REDCap: Research Electronic Data Capture

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Review

Association of Pregnancy With Coronavirus Cytokine Storm: Systematic Review and Meta-analysis

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Abstract

Background: COVID-19 was first identified in Wuhan, China, in December 2019, spreading to the rest of the globe, becoming a pandemic. Some studies have shown an association between pregnancy status and severe COVID-19 with a cytokine storm, whereas others have shown contrasting results.

Objective: The aim of this study was to examine the relationship between pregnancy status and the clinical COVID-19 severity characterized by the cytokine storm through a systematic review and meta-analysis.

Methods: We searched the Google Scholar, PubMed, Scopus, Web of Science, and Embase databases to identify clinical studies suitable for inclusion in this meta-analysis. Studies reporting pregnancy status and comparing the COVID-19 severity cytokine storm outcome were included. COVID-19 severity characterized by a cytokine storm was described using parameters such as intensive care unit admission, invasive mechanical ventilation, mechanical ventilation, hospital admission, pro- and anti-inflammatory cytokine levels, consolidation on chest computed tomography scan, pulmonary infiltration, extreme fevers as characteristic of a cytokine storm, syndromic severity, higher neutrophil count indicative of a cytokine storm, and severe COVID-19 presentation.

Results: A total of 17 articles including data for 840,332 women with COVID-19 were included. This meta-analysis revealed a correlation between positive pregnancy status and severe COVID-19 with a cytokine storm (random-effects model odds ratio [OR] 2.47, 95% CI 1.63-3.73; $P<.001$), with a cumulative incidence of 6432 (14.1%) and 24,352 (3.1%) among pregnant and nonpregnant women with COVID-19, respectively. The fixed-effects model also showed a correlation between pregnancy status and severe COVID-19 with a cytokine storm (OR 7.41, 95% CI 7.02-7.83; $P<.001$). Considerable heterogeneity was found among all pooled studies ($I^2=98\%$, $P<.001$). Furthermore, the updated analysis showed substantially low heterogeneity ($I^2=29\%$, $P=.19$), and the funnel plot revealed no publication bias. The subanalysis between single-center and multicenter studies demonstrated similar heterogeneity ($I^2=72\%$ and 98%, respectively). Sensitivity analysis on each subgroup revealed that pregnancy was significantly related to severe COVID-19 with a cytokine storm from single-center studies (fixed-effects model OR 3.97, 95% CI 2.26-6.95; $P<.001$) with very low heterogeneity ($I^2=2\%$, $P=.42$).

Conclusions: Being pregnant is clearly associated with experiencing a severe course of COVID-19 characterized by a cytokine storm. The COVID-19 pandemic should serve as an impetus for further research on pregnant women diagnosed with COVID-19 to map out the salient risk factors associated with its severity.

Trial Registration: PROSPERO CRD42021242011; https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=242011.

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KEYWORDS

COVID-19; pandemic; pregnancy; maternal health; cytokine; cytokine storm; immune response; infectious disease; coronavirus; respiratory; virus; pregnant

Introduction

Once considered to be an "immunosuppressed" state, pregnancy is associated with an immunological transformation, where the immune system is required to promote and support the pregnancy and growing fetus. When this protection is breached, as in a viral infection, this security is weakened and infection with microorganisms can then propagate and lead to negative outcomes such as preterm labor [1].

Pregnancy is considered a high-risk condition for COVID-19. Pregnant women are more likely to have an asymptomatic infection, accounting for 75% of SARS-CoV-2 infections during the pandemic. Even among those with symptoms, cough and fever are the main symptoms in 40% of cases, with breathing difficulty and myalgia being present in 21% and 19% of pregnant women, respectively. Severe COVID-19 usually occurs with infection in the second half of pregnancy, especially toward the end of the second trimester onward. Those at greatest risk of severe COVID-19 include women who have a higher-than-ideal BMI, those over the age of 35 years, and those who have chronic underlying conditions [2].

COVID-19 is an infectious disease caused by a newly discovered coronavirus (SAR2-CoV-2) that was first identified in Wuhan, China, in December 2019 [3]. COVID-19 subsequently rapidly spread across the world, causing a global pandemic. Between March 2020 and March 2021, this highly contagious disease infected over 25 million people worldwide and killed over 1 million patients, yielding a case fatality rate that varies between 0.7% and 12.7% (average 3.4%) [4].

Most people infected with the SARS-CoV-2 will experience mild to moderate respiratory illness and recover without requiring special treatment. Older people above the age of 58 years and those with underlying medical conditions such as cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more likely to develop serious illnesses [5]. Further, infected patients experiencing cytokine storms present with fevers and shortness of breath, resulting in extreme difficulty breathing that ultimately requires ventilation assistance. Such severe presentations might also be related to pregnancy status [6].

Pregnant women who have COVID-19 appear more likely to develop respiratory complications requiring intensive care than women who are not pregnant [7]. Pregnant women are also more likely to be placed on a ventilator. Some research suggests that pregnant women with COVID-19 are also more likely to have a premature birth and cesarean delivery, and their babies are more likely to be admitted to a neonatal unit [8].

Pregnant women are a potentially highly vulnerable population due to anatomical, physiological, and immunological changes under the COVID-19 pandemic. Issues related to pregnancy with COVID-19 attracted widespread attention from researchers. A large number of articles were published aiming to elaborate on the clinical characteristics and outcomes of pregnant women infected with COVID-19 to provide evidence for management [9,10]. The existing data suggest that the overall prognosis of pregnancy with COVID-19 is promising when compared with that of other previous coronaviruses. However, there are still reports of notable maternal morbidity and mortality related to COVID-19 [9].

There are many unknowns for pregnant women during the COVID-19 pandemic. Clinical experience of pregnancies complicated with infection by other coronaviruses such as severe acute respiratory syndrome (SARS) and Middle Eastern respiratory syndrome (MERS) indicated that pregnant woman should be considered to be particularly vulnerable to severe SARS-CoV-2 infection. Physiological changes during pregnancy have a significant impact on the immune system, respiratory system, cardiovascular function, and coagulation [11].

Given divergent findings in the existing literature, we systematically reviewed English-language studies to investigate whether pregnancy was associated with a more severe clinical course of COVID-19. Specifically, the aim of this study was to establish if pregnancy status is associated with COVID-19 severity characterized by a cytokine storm.

Methods

Design

All guidelines listed in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement were followed in performing this meta-analysis [12]. For this systematic review and meta-analysis, data were pooled from observational studies, including cohort, case-control, cross-sectional, and similar viable case studies. The study is registered in PROSPERO (CRD42021242011).

Search Strategy

We performed a simple search in the Google Scholar, PubMed, Scopus, Web of Science, and Embase databases to identify observational studies suitable for inclusion with the following search terms: "COVID-19" OR "SARS-COV-2" OR "novel coronavirus (CoV)" AND "pregnant" OR "gestation" AND "clinical features" OR "characteristic" AND "severity" OR "severe." Studies were restricted to those published in English from March 2020 to March 2021.

Inclusion and Exclusion Criteria

Inclusion criteria were as follows: (1) studies that examined women within reproductive age and diagnosed with COVID-19 according to World Health Organization (WHO) criteria; (2) observational, cross-sectional, prospective, or retrospective studies; (3) studies that compared pregnant women to nonpregnant women with severe COVID-19 characterized by a cytokine storm; (4) studies evaluating the clinical prognosis in pregnancy and the immunological profile at any gestation

stage, examining the proinflammatory response in COVID-19 and a severe cytokine storm as the hallmark outcome.

Exclusion criteria were as follows: (1) unrelated, duplicated, and missing information answering our research question; (2) non-English-language studies; (3) case reports/series; (4) reviews; (5) editorials; (6) studies lacking a full text (unavailable or not yet published); (7) articles without a DOI; and (8) studies with small sample sizes (<50 patients) because of low statistical power.

Notably, we included preliminary findings published as preprints given that the phenomenon in question remains very grey in the public domain and thus we presumed inclusion of such reports would be of value in converging relevant data and information.

Data Extraction

Both adjusted and nonadjusted data among pregnant versus nonpregnant cases were extracted to identify the most relevant confounding factors to be used in the analysis by subsequent pooling. One reviewer (JM) scanned study titles and abstracts obtained via an initial database search and included relevant articles in a secondary pool. Next, two independent reviewers (MK and KO) evaluated the full texts of these articles to determine whether they met the study inclusion criteria. Any disputes were resolved by discussion and negotiation with a fourth reviewer (EN). Only studies agreed upon by all reviewers were included in the final analysis.

The following data were obtained from all studies: title, first author, publication year, location, sample size, age (median), pregnancy status (pregnant or nonpregnant), and severe COVID-19 cytokine storm presentation. The analysis was then performed to determine whether the pregnant group was more likely to develop severe COVID-19 characterized by a cytokine storm.

Risk of Bias (Quality) Assessment

The National Institutes of Health tool for observational and cross-sectional studies [13] was used for methodological quality assessment. Two to three reviewers independently assessed the quality of the studies, and the scores were added to the data extraction form before inclusion in the analysis to reduce the risk of bias. To evaluate the risk of bias, the reviewers rated each of the 14 items into qualitative variables: yes, no, or not applicable. An overall score was calculated by adding the scores of all items with yes=1 and no or not applicable=0. A score was given for every paper, resulting in a classification of poor (score 0-5), fair (score 6-9), or good (score 10-14). Data were checked by reviewers who did not perform the data extraction or each reviewer was assigned an article that they had not extracted data from in previous steps; however, in rare instances, some reviewers extracted data and performed the quality assessment for the same article.

Statistical Analyses

Review Manager 5.4.1 was used to calculate odds ratios (ORs) with 95% CIs, which are depicted using forest plots. Quantitative variables are summarized in terms total numbers and percentages. The OR of a severe COVID-19 cytokine storm among pregnant and nonpregnant women was calculated. Heterogeneity was evaluated with the Cochran Q statistic and Higgins test. The Higgins test uses a fixed-effects model when the heterogeneity is <50% and a random-effects model when the heterogeneity is >50%. When heterogeneity was detected, a sensitivity adjustment was made to determine its source. This procedure was performed by leaving a study out of the analysis one at a time, with the fixed-effects model applied after excluding heterogeneity. Subgroup, cumulative analyses, and metaregression were used to test whether or not the results are consistent and to investigate the effect of confounders on the outcome (cytokine storm) and elucidate the best predictors in pregnancy status among women with COVID-19. Publication bias was evaluated using the Cochrane Risk of Bias tool.

Results

Included Articles and Quality Assessment

The initial search of international databases using the keywords described above yielded 221 articles. After excluding 70 duplicate articles, 151 articles remained. When article titles and abstracts were evaluated for appropriateness, 29 articles ultimately met the inclusion criteria. In addition, 12 articles not meeting the inclusion criteria were excluded after full-text review. A total of 17 articles met the inclusion criteria [7,14-29]. Multimedia Appendix 1 shows the PRISMA flow diagram of the study selection procedure.

Features of the Included Studies

The 17 included studies provided data for 840,417 women with COVID-19 [7,14-29] (Table 1). According to the Centers for Disease Control and Prevention reporting guidelines for COVID-19 diagnosis [30], 85 patients whose specific parameters related to the severity of COVID-19 defined according to cytokine storm status were reported as “unknown” or not tabulated were excluded from the final analysis, yielding a final group of 840,332 patients with 45,571 (5.42%) pregnant women and 794,761 (94.58%) nonpregnant women. Among the pregnant women, 14.1% (6432/45,571) had cytokine storm events reported, compared to only 3.1% (24,352/794,761) of the nonpregnant women. The cumulative incidence of a cytokine storm from all studies ranged from 0.4% to 90.7% (average 36.26%).

Table 1. Features of the studies included in the meta-analysis.

Reference	Location of patients	Study design	Parameter of comparison on COVID-19 severity with cytokine storm	Events in pregnant women/ total in cohort	Events in non-pregnant women/total in cohort	Cumulative incidence of severe COVID-19 defined by cytokine storm, n (%)
Badr et al [14]	France and Belgium	CC[a], MC[b]	ICU[c] versus no ICU admission	58/83	17/107	75 (39%)
Westgren and Acharya [15]	New York	R[d], O[e], MC	ICU versus no ICU admission	8/82	50/332	58 (14%)
CDC[f] [16]	United States	P[g], C[h], MC	ICU plus mechanical ventilation versus no ICU admission with mechanical ventilation	2583/8200	15,840/316,800	18,423 (5.7%)
Cheng et al [17]	Wuhan, China	R, SC[i]	Higher versus lower level of inflammation markers	0/31	1/80	1 (0.9%)
Collin et al [23]	Sweden	R, MC	Invasive mechanical ventilation versus no invasive mechanical ventilation	7/13	29/40	36 (68%)
Ellington et al [7]	United States	R, O MC	ICU with mechanical ventilation versus no ICU with mechanical ventilation	2587/8207	4840/83,205	7427 (8%)
Liu et al [24]	Wuhan, China	R, CC, SC	Consolidation on chest CT[j] versus no consolidation on chest CT	20/21	16/19	36 (90%)
Martinez-Portilla et al [25]	Mexico	R, MC	ICU/death versus non-ICU/death	752/5183	446/5183	1198 (12%)
Yin et al [26]	China	R, C, SC	Severe or critical COVID-19 characterized by higher levels of inflammatory indices of cytokine storm versus moderate COVID-19	19/31	11/35	30 (46%)
Mohr-Sasson et al [27]	Fuyang, China	R, C, SC	High versus low fevers	3/11	15/25	18 (50%)
Molteni et al [28]	United Kingdom, Sweden, and United States	P, O, MC	Syndromic severity versus nonsyndromic severity	87/140	1508/2515	1595 (60%)
Oakes et al [18]	Wuhan, China	R, C, SC	Hospital admission versus nonadmission	7/22	17/240	24 (9%)
Qiancheng et al [19]	Wuhan, China	R, SC	Nonsevere versus severe	2/28	1/54	3 (9.8%)
Wang et al [20]	Wuhan, China	R, SC	COVID-19 manifestations on chest CT versus no manifestations	22/30	42/42	64 (89%)
Wei et al [21]	Wuhan, China	R, SC	Higher versus lower neutrophil count as indicative of cytokine storm	15/17	24/26	39 (91%)
Xu et al [22]	Wuhan, China	R, SC	Pulmonary infiltration versus no pulmonary infiltration	17/34	3/30	20 (31%)
Zambrano et al [29]	United States	R, MC	Severe COVID-19–associated illness versus mild to moderate illness	245/23,434	1492/386,028	1737 (0.4%)

[a]CC: case-control.

[b]MC: multicenter.

[c]ICU: intensive care unit.

[d]R: retrospective.

[e]O: observational.

[f]CDC: Centers for Disease Control and Prevention.

[g]P: prospective.

[h]C: cross-sectional.

[i]SC: single-center.

[j]CT: computed tomography.

The main outcome of this meta-analysis was the possible association of pregnancy with severe COVID-19 characterized by a cytokine storm, which was indicated by a specific prognosis and event. The parameters used for assessment of COVID-19 severity were intensive care unit (ICU) admission in three studies; ICU plus mechanical ventilation in two studies; higher levels of inflammatory response markers in three studies; severe COVID-19 presentation in two studies; and consolidation on chest computed tomography scan, pulmonary infiltration, extreme fever as a characteristic of a cytokine storm, syndromic severity, hospital admission, invasive mechanical ventilation, and higher neutrophil count indicative of a cytokine storm in one study each. The study designs included retrospective (n=15, 6 multicenter and 9 single-center studies) and prospective (n=2, both multicenter). A summary of the studies included in the meta-analysis is provided in Table 1.

We assessed the quality of the included observational studies based on a modified version of the Newcastle-Ottawa Scale (NOS), which consists of 8 items with 3 subscales, and the total maximum score of these 3 subsets is 9. We considered a study that scored ≥7 to be a high-quality study since a standard criterion for what constitutes a high-quality study has not yet been universally established. The 17 studies assessed generated a mean value of 6.47, indicating that the overall quality was moderate (NOS score range 5-8), as detailed in Table 2.

Table 2. Newcastle-Ottawa scale for quality assessment and risk of bias.

Study	Year	Case selection (maximum 4)	Comparability (maximum 2)	Exposure/outcome (maximum 3)	Total score
Badr et al [14]	2020	3	2	2	7
Westgren and Acharya [15]	2020	3	2	1	6
CDC[a] [16]	2020	4	2	2	8
Cheng et al [17]	2020	3	1	2	6
Collin et al [23]	2020	4	1	2	7
Ellington et al [7]	2020	3	2	3	7
Liu et al [24]	2020	3	1	2	6
Martinez-Portilla et al [25]	2020	3	1	2	6
Yin et al [26]	2020	3	2	2	7
Mohr-Sasson et al [27]	2020	3	1	1	5
Molteni et al [28]	2020	3	1	2	6
Oakes et al [18]	2020	3	2	2	7
Qiancheng et al [19]	2020	3	1	2	6
Wang et al [20]	2020	2	2	2	6
Wei et al [21]	2020	3	1	3	7
Xu et al [22]	2020	3	2	2	6
Zambrano et al [29]	2020	3	1	3	7

[a]CDC: Centers for Disease Control and Prevention.

Pregnancy Status and COVID-19 Severity Characterized by a Cytokine Storm

The meta-analysis revealed a significant association between pregnancy status and severe COVID-19 characterized by a cytokine storm (Table 3). A sensitivity analysis was performed to explore the impact of excluding or including studies in the meta-analysis based on sample size, methodological quality, and variance. After removing eight studies (n=748,058 patients) [7,15,16,23,25,27,28,31] accounting for major causes of heterogeneity, a total of 92,274 patients were left for analysis in the remaining studies. Figure 1 and Figure 2 respectively show a shift from the random-effects model (OR 2.47, 95% CI 1.63-3.73; $P<.001$) to the fixed-effects model (OR 7.41, 95% CI 7.02-7.83; $P<.001$), revealing that pregnancy was significantly associated with severe COVID-19 characterized by a cytokine storm. Furthermore, this updated analysis showed substantially low heterogeneity ($I^2=29\%$, $P=.19$). Figure 3 shows a funnel plot evaluating publication bias, which revealed considerable heterogeneity between all pooled studies ($I^2=98\%$, $P<.001$). Figure 4 shows a funnel plot revealing no publication bias for the updated analysis.

Table 3. Events (cytokine storm) in pregnant and nonpregnant women.

Studies	Pregnant with COVID-19		Nonpregnant with COVID-19	
	Patients, N	Events, n (%)	Patients, N	Events, n (%)
Badr et al [14]	87	58 (66.7)	107	17 (15.9)
Westgren and Acharya [15]	82	8 (9.8)	332	50 (15.1)
CDC [16]	8200	2583 (31.5)	316,800	15,840 (5.0)
Cheng et al [17]	31	0 (0)	80	1 (1.3)
Collin et al [23]	13	7 (53.8)	40	29 (72.5)
Ellington et al [7]	8207	2587 (31.5)	83205	4840 (5.9)
Liu et al [24]	21	20 (95.3)	19	16 (84.2)
Martinez-Portilla et al [25]	5183	752 (14.5)	5183	446 (8.6)
Yin et al [26]	31	19 (61.3)	35	11 (31.4)
Mohr-Sasson et al [27]	11	3 (27.2)	25	15 (60.0)
Molteni et al [28]	140	87 (62.1)	2515	1508 (59.9)
Oakes et al [18]	22	7 (31.8)	240	17 (7.1)
Qiancheng et al [19]	28	2 (7.14)	54	1 (1.9)
Wang et al [20]	30	22 (73.3)	42	42 (100.0)
Wei et al [21]	17	15 (88.2)	26	24 (92.3)
Xu et al [22]	34	17 (50.0)	30	3 (10.0)
Zambrano et al [29]	23,434	245 (1.1)	386,028	1492 (0.4)

Figure 1. A forest plot of meta-analysis between pregnancy status and severe COVID-19 with cytokine storm.

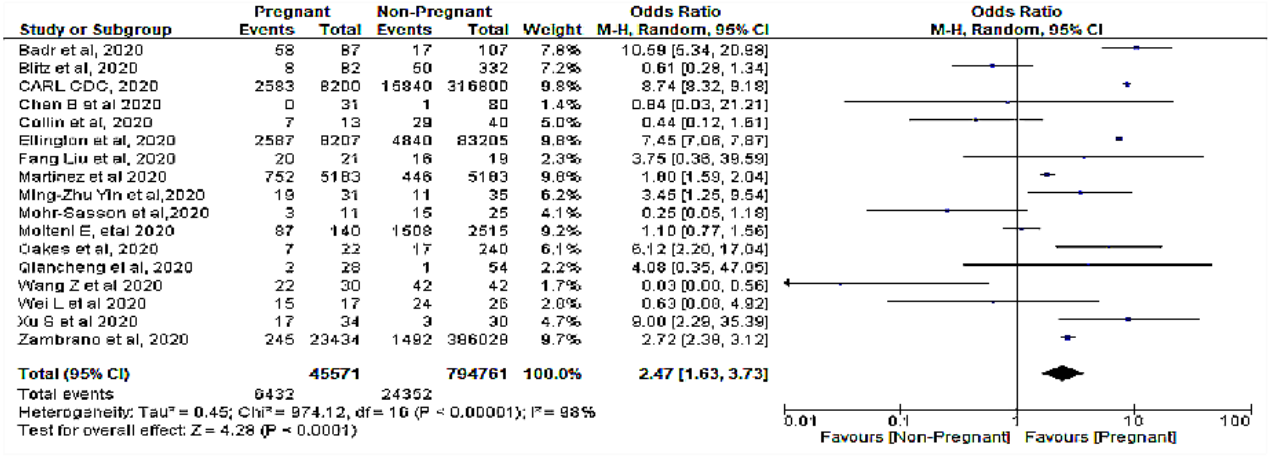


Figure 2. Forest plot of the association of pregnancy with severe COVID-19 characterized by a cytokine storm with the fixed-effects model.

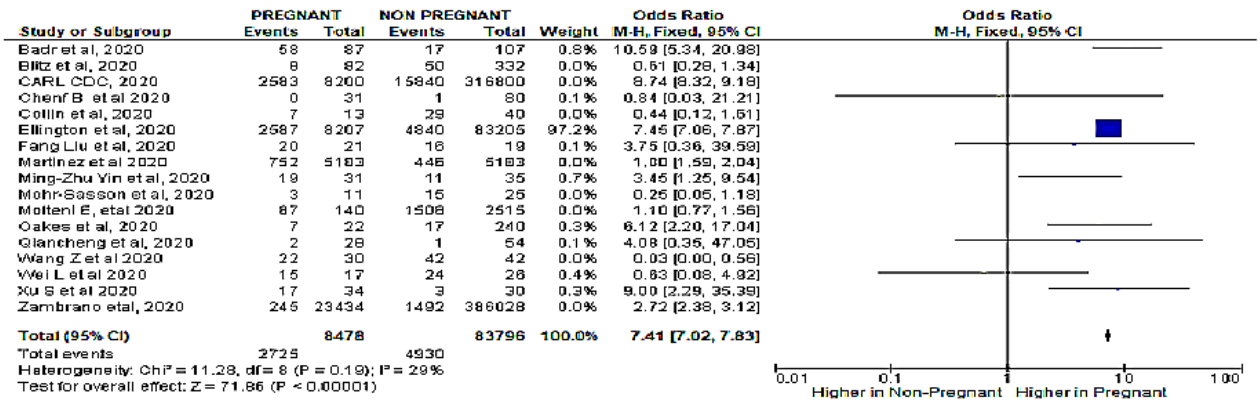


Figure 3. Funnel plot evaluating publication bias. OR: odds ratio.

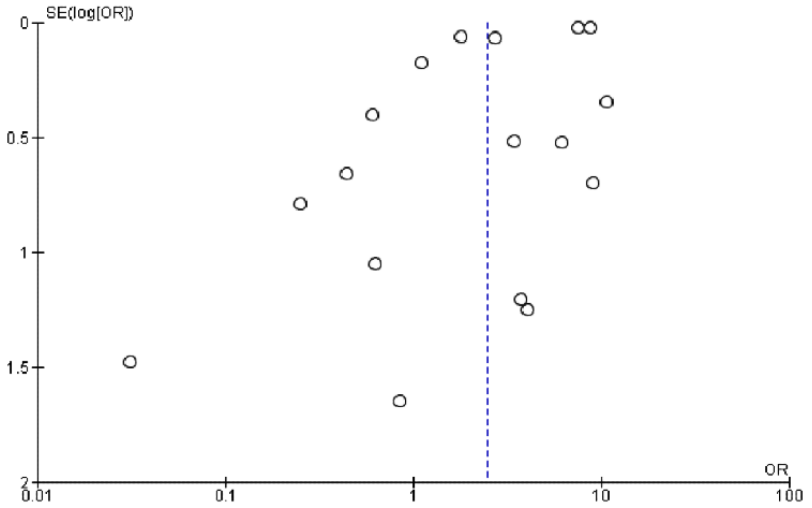
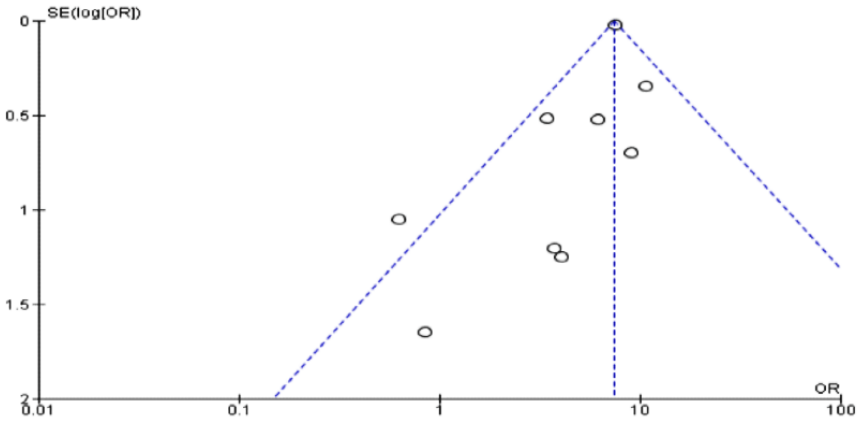


Figure 4. Funnel plot revealing no publication bias in the updated analysis. OR: odds ratio.



Subgroup Analysis and Investigation of Heterogeneity

Heterogeneity in the pooled effect estimates was considerably high for all 17 studies, contributed by 748,058 out of 840,332 (89.02%) evaluated subjects, and thus it was necessary to perform subgroup analyses to identify possible variables or characteristics moderating the results obtained. Subgroup analysis was performed according to whether it was a multicenter study, including 879,556 patients, or a single-center study with 776 patients. Figures 5 and 6 show that subgroup analysis still showed high heterogeneity (I^2=72%). The test for the overall effect for single-center studies (Z=0.91, P=.36; I^2=98) and multicenter studies (Z=3.97, P<.001) showed no significance difference (χ_1^2=0.67, P=.41; I^2=0%). This prompted further sensitivity analysis on each subgroup to ascertain the group that was most strongly associated with heterogeneity.

Figure 7 shows the sensitivity analysis on independent subgroups. In single-center studies, elimination of studies that caused the major heterogeneity ([27] and [31]; n=108) revealed that pregnancy was significantly related to severe COVID-19 with a cytokine storm represented by 668 patients (fixed-effects model OR 3.97, 95% CI 2.26-6.95; P<.001), with this updated analysis showing substantially low heterogeneity (I^2=2%, P=.42). In multicenter studies, subsequent removal of any one study did not change the heterogeneity from its original value (χ^2_7=928.90, P<.001; I^2=99%), demonstrating that multicenter studies were the main cause of heterogeneity and this was similar to the overall heterogeneity of the combined groups (fixed-effects model heterogeneity χ^2_{14}=938.26, P<.001; I^2=99%), with the test for subgroup differences being insignificant (χ^2_1=1.9, P=.17; I^2=47.4%). Figure 8 shows a funnel plot similarly demonstrating that multicenter studies were associated with heterogeneity with only one study demonstrating homogeneity.

Figure 5. Subgroup analysis according to single-center or multicenter study designs showing similarly high heterogeneity as the full meta-analysis.

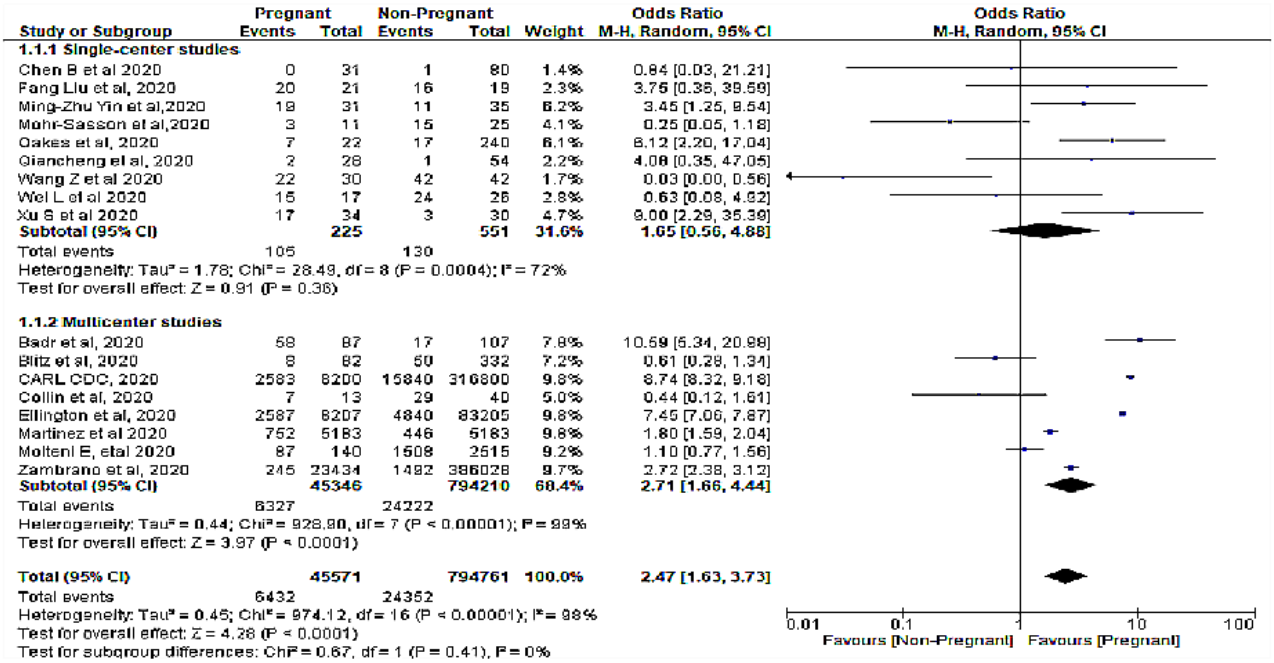


Figure 6. Funnel plot of the subgroup analysis-single-center and multicenter studies.

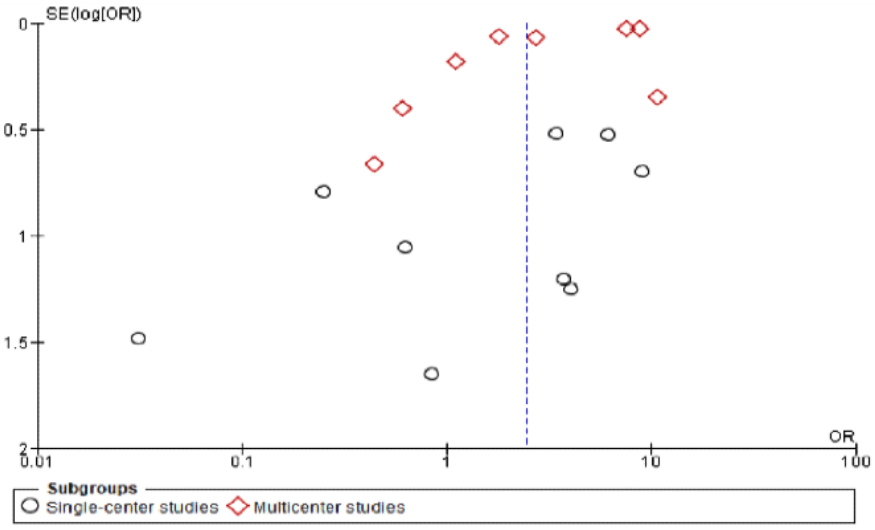


Figure 7. Sensitivity analysis on independent subgroups.

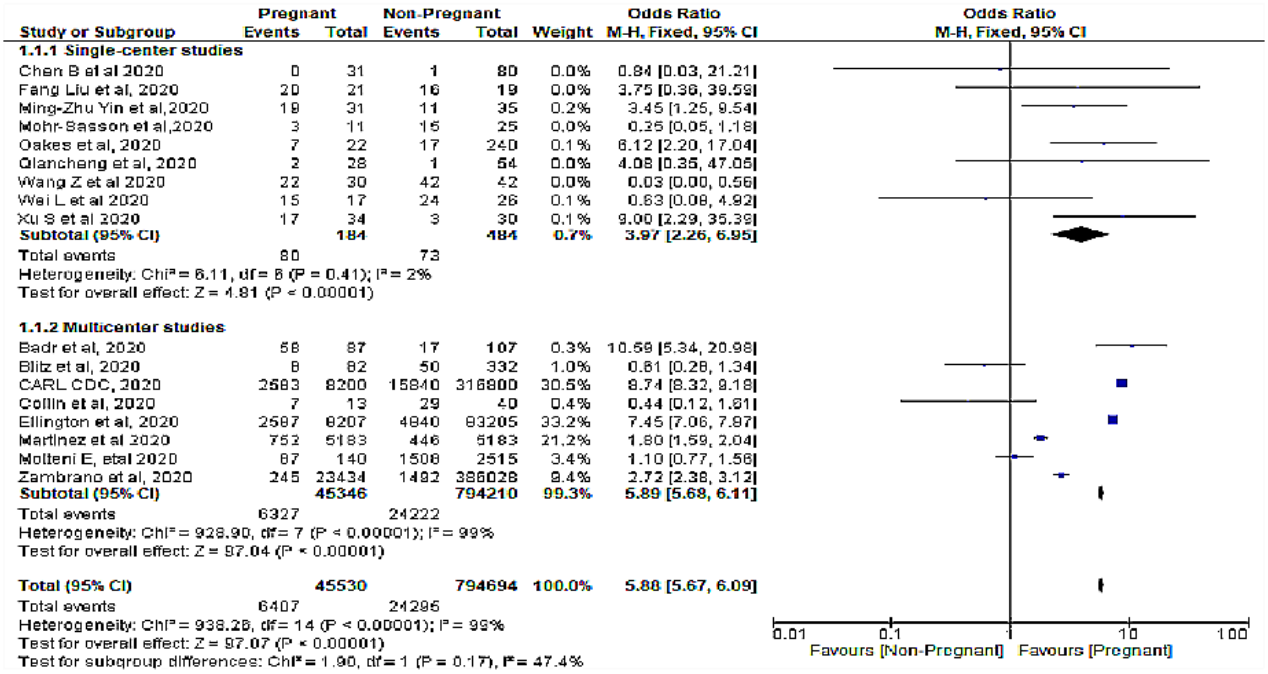
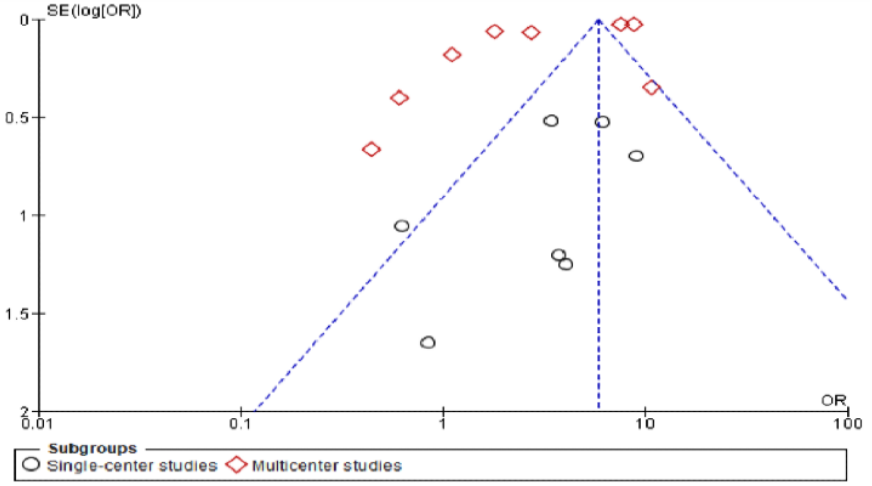


Figure 8. Funnel plot of sensitivity analysis on independent subgroups (single-center and multicenter) to evaluate publication bias.



Discussion

This review established that pregnancy is associated with an experience of severe COVID-19 characterized by a cytokine storm. Heterogeneity analysis revealed that the pooled effect estimate was considerably high considering all 17 included studies, contributed by 89% of the total patients evaluated. Further, sensitivity analysis on each subgroup indicated that single-center studies were more homogeneous in comparison to multicenter studies.

This meta-analysis included 17 studies and revealed that pregnant women had a significantly increased risk for severe COVID-19 characterized by a cytokine storm. Previous research has indicated a similar association [32,33]. Additionally, another meta-analysis reported the outcome of coronavirus spectrum infections (SARS, MERS, and COVID-19) during pregnancy, showing that COVID-19 disease severity increased during gestation [34]. This analysis adds to the extensive consensus in the literature, which should motivate more studies examining pregnancy status as a possible predictor of severe COVID-19 characterized by a cytokine storm.

Prior studies have reported results that contrast with those presented here, namely a lack of significant difference between pregnant and nonpregnant women diagnosed with COVID-19 in terms of disease severity [35,36]. In addition, a previous meta-analysis [37] failed to find a relationship between being pregnant and severe COVID-19 in 24 studies including pregnant women, and another meta-analysis indicated that COVID-19 infection during pregnancy most likely had a clinical presentation and severity resembling those in nonpregnant adults [38]. Moreover, a meta-analysis demonstrated similar trends in disease severity between pregnant people and the general population [39]. Further, two more studies showed no feasible differences in the clinical presentation of COVID-19 between pregnant and nonpregnant women [40,41]. Of concern, neither of the meta-analyses mentioned above [37,38] included an

assessment of publication bias or study quality. As such, these studies should be considered as only a preliminary quest. Hence, the present systematic meta-analysis offers a more detailed view as it covers 17 studies from diverse regions capturing both single and multiple centers. The heterogeneity was high, and after sensitivity adjustments to eliminate studies largely responsible for the heterogeneity, the association of COVID-19 severity with pregnancy was revealed with substantially low heterogeneity. Furthermore, the subgroup analysis after performing the sensitivity test in each specified subgroup (multicenter or single-center studies) showed a clear significant association between being pregnant and developing severe COVID-19 characterized by any specific parameter of a cytokine storm in single-center studies. Therefore, severe COVID-19 was observed to be almost 4 times (OR 3.97, 95% CI 2.26-6.95; $P<.001$) more frequent in pregnant women. Some previous studies, including some meta-analyses [39,42-46], support the current findings.

A recent meta-analysis revealed that SARS-CoV-2 infection may not manifest as mild symptoms during pregnancy [47]. Interestingly, this meta-analysis showed that 40 patients developed pneumonia, bilateral in most cases, with a 46.2% rate of hospitalization and 4 patients required ICU admission. The same study found a higher rate of severe forms of COVID-19, even when compared to nonpregnant women with the same baseline characteristics [47]. This appears to be because, during the gestation period, pregnant women face proinflammatory episodes that mimic the trends of a cytokine storm in the case of severe COVID-19. This has been demonstrated in recent studies where specific immune cells, especially neutrophils, and other biomarkers have been highlighted as essential effector cells in the development of COVID-19 [48-51]. In addition, pregnancy has been reported to increase the progression of COVID-19 [52]. There is growing evidence to support the WHO's statements that pregnant women are at a higher risk of developing severe COVID-19–related symptoms and possible mortality [53-56]. Indeed, pregnancy has been found to worsen the morbidity of COVID-19, and this effect becomes more prominent as pregnancy advances [57].

The association between pregnancy and illness severity due to other respiratory viruses such as MERS has been investigated previously. In one study, the case fatality (25%), ICU admission (50%), and mechanical ventilation (33%) rates were increased in the pregnant population compared with those of the nonpregnant population (20%) [58], which may be related to abnormal immune responses in pregnancy. Additionally, pregnancy may propagate respiratory infections and increase the risk of hospitalization [59]. Another study demonstrated that complications of severity with other acute respiratory distress syndromes are enhanced in pregnancy [11]. As a result, adverse effects on the pregnant woman's lungs may aggravate the symptom severity of viral infections.

The novel SARS-CoV-2 virus uses angiotensin-converting enzyme 2 (ACE2) receptor in the lungs to enter cells and cause infection. ACE2 expression and activity are enhanced during pregnancy, and transient ACE2 overexpression and its increased activity during pregnancy may be important in modulating systemic as well as local hemodynamics in the uteroplacental unit [60,61]. ACE2 upregulation may increase infectiousness and therefore infection severity risk, as the SARS-CoV-2 virus uses this receptor for host entry. Paradoxically, ACE2 upregulation has also been reported to be a protective factor against acute lung injury [62].

In one recent study, *ACE2* gene expression was found to be upregulated in cells specific to the maternal-fetal interface [63], thereby suggesting a mechanism by which the risk for severe COVID-19 increases in pregnancy. A role of ACE2 in COVID-19 pathophysiology has also been demonstrated, including factors influencing ACE2 expression and activity in relation to COVID-19 severity [64]. Thus, the potential impact of ACE2 expression and thus SARS-CoV-2 entry into the host in pregnancy should be further investigated [65].

The cytokine storm phenomenon has received substantial research attention recently because of the COVID-19 pandemic. Although more and more information is accumulating daily, the cytokine storm seems to be at least part of the reason that some people develop life-threatening symptoms from COVID-19. Hyperinflammatory cytokine storms in many patients with severe symptomatic cases of COVID-19 may be rooted in an atypical response to SARS-CoV-2 by dysfunctional mast cells, in a condition known as mast cell activation syndrome, rather than the typical response by normal mast cells [66]. This may be explained by systemic and chronic inflammation, diminished respiratory function and capacity, and chronic obstructive pulmonary disease–related respiratory failure in some patients. Some findings indicated an association of pro- and anti-inflammatory cytokines that play crucial roles in the development and function of preeclampsia [67]. Given this, pregnancy itself and pro- and anti-inflammatory cytokines should be considered together as a single risk factor for severe COVID-19 among pregnant women diagnosed with the novel coronavirus.

Another critical area of concern is that the cytokine storm is a critical contributor to mortality in some patients with severe COVID-19. In these patients, the levels of proinflammatory cytokines such as interleukin (IL)-1, IL-2, IL-6, IL-8, IL-17, interferon (IFN)-γ, and tumor necrosis factor (TNF)-α are elevated, which affect the patient's clinical symptoms and severity in the general population [68]. In pregnancy, IFNs and cytokines play important roles in the immune responses promoting healthy pregnancy as well as congenital disorders and complications [69], similar to those activated during a COVID-19 cytokine storm, including TNF-α [70]. Increased levels of INF-γ, luteinizing hormone, and prolactin have been identified as the underlying cause for recurrent pregnancy losses; thus, these factors not only amplify the severity of the cytokine storm in COVID-19 but also consequentially result in adverse pregnancy outcomes [70]. This potential interaction should be clarified with future clinical research.

Several factors limit the interpretation of the present study. First, the vast majority of studies included in the meta-analysis were retrospective epidemiological studies conducted in the United States and China, with limited studies from other regions. Second, some of the included studies did not distinguish the age range of the participants as well as the stage of the gestation

period. Third, COVID-19 severity as assumed to be characterized by a cytokine storm relied on different parameters of clinical implications such as the levels of inflammatory cytokines, invasive mechanical ventilation, and ICU admission. Given these limitations, caution should be exercised when interpreting the current findings for more valid clinical practice. Future studies may respond to these issues by defining disease severity more clearly and by obtaining more detailed information on the associated inflammatory cytokines defining the COVID-19 cytokine storm.

Multiple factors are responsible for recurrent pregnancy loss, although an altered cytokine profile is known to be a major contributor, especially in the early stages of gestation. Similarly, exposure to high maternal proinflammatory cytokine concentrations in early pregnancy might play a role in several adverse effects for either the woman or infant. Thus, women expecting a pregnancy should be screened to assess the cytokine profile even prior to conception whenever possible to avoid pregnancy loss and to improve their health and social well-being, as abnormal cytokine levels could aggravate COVID-19 severity.

Finally, the interactions between the inherent inflammatory cytokines and cytokine storm due to COVID-19 should also be further examined and clarified. In addition, clinicians should pay more attention to the history of pregnancy-related altered immune responses of COVID-19 patients. Further research may aim to determine the mechanisms that drive or decrease this risk of severity by a within–pregnant population study approach.

This meta-analysis revealed that pregnancy is significantly associated with increased COVID-19 symptom severity defined by a cytokine storm. The SARS-CoV-2 epidemic should serve as an impetus for further research on pregnant women diagnosed with COVID-19, and to map out salient risk factors associated with its severity with an aim of maintaining a good pregnancy outcome and possibly evading an adverse COVID-19 clinical prognosis.

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Authors' Contributions

JM conceptualized the study, and was responsible for data collection, collation, and retrieval; design of tables, images, and figures; major analysis and interpretation of data; and writing and drafting of the manuscript. KO performed the data collection and quality assessment. JMN played a key role in data analysis, quality assessment procedure and general review of the write-up. EMN participated in acquisition of data, quality analysis, and writing and revision of the manuscript. MK played a major role in reviewing and revising the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
PRISMA (Preferred Items for Systematic Reviews and Meta-Analyses) flow diagram.
[PDF File (Adobe PDF File), 195 KB - pediatrics_v5i4e31579_app1.pdf]

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Abbreviations

ACE2: angiotensin-converting enzyme 2
ICU: intensive care unit
IFN: interferon
IL: interleukin
MERS: Middle East respiratory syndrome
NOS: Newcastle-Ottawa Scale
OR: odds ratio
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SARS: severe acute respiratory syndrome
TNF: tumor necrosis factor
WHO: World Health Organization

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Original Paper

An Internet-Based Parent Training With Telephone Coaching on Managing Disruptive Behavior in Children at Special Family Counseling Centers During the COVID-19 Pandemic: Feasibility Study

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Abstract

Background: There is growing concern about the short- and long-term impacts that the COVID-19 pandemic will have on the mental health and psychosocial well-being of children and families. There are no existing studies about feasibility and outcomes using internet-based parent training programs with telephone coaching for disruptive behavioral problems in childhood during the COVID-19 pandemic in clinical settings.

Objective: This study explored how the Strongest Families Smart Website (SFSW) parent training program, with telephone coaching, provided support during the COVID-19 pandemic at specialist family counseling centers in Helsinki, Finland, when restrictions made face-to-face counseling impossible. This study followed the success of a randomized controlled trial (RCT) and its implementation study of the SFSW parent training program by primary care child health clinics. The aim was to improve parenting skills, so that parents could tackle disruptive behavior by developing positive parent-child relationships. It started in May 2020, when the COVID-19 pandemic was at its height in Finland.

Methods: In total, 8 family counseling centers in Helsinki identified 50 referrals aged 3-8 years with high levels of parent-reported disruptive behavioral problems. Child psychopathology and functioning and parental skills and well-being were measured at baseline, posttreatment, and 6 months later using a range of tools. The data were extracted from questionnaires completed by the parents.

Results: We found that 44 (88%) of the 50 families completed the whole 11-session parent training program. Most of the children (n=48, 96%) had definitive or severe behavioral problems when they were initially screened by the centers, but with those assessed at the 6-month follow-up (n=45, 90%), this dropped to 58% (n=26). There were significant changes from baseline to 6-month follow-up in most of the child psychopathology measures, including the Child Behavior Checklist-Parent Report Form (CBCL) total score (mean change 16.3, SE 3.0, 95% CI 10.2-22.3; P<.001) and externalizing score (mean change 7.0, SE 1.0, 95% CI 4.9-9.0; P<.001). When parenting skills were measured with the Parenting Scale (PS), they showed significant changes from baseline to 6-month follow-up in total scores (mean change 0.5, SE 0.1, 95% CI 0.4-0.7; P<.001). Parents showed significant change in the stress subscore (mean change 3.9, SE 0.8, 95% CI 2.2-5.6; P<.001). Of the parents who filled in the

satisfaction questionnaire (n=45, 90%), 42 (93%) reported high satisfaction in the skills and 44 (98%) in the professionalism of the family coaches.

Conclusions: The program proved to be an effective method for improving parenting skills and child psychopathology and functioning. The parents were satisfied with the program, and the dropout rate was exceptionally low. The study shows that the training program could be implemented in specialist clinical settings and during crisis conditions, such as the COVID-19 pandemic.

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KEYWORDS

parent training; disruptive behavior; child psychopathology; child functioning; internet-based; COVID-19 pandemic; COVID-19; mental health; psychological well-being; digital health; parenting; telehealth; behavioral problem; psychopathology

Introduction

There is growing concern about the possible short- and long-term impacts that the COVID-19 pandemic is having on the mental health and psychosocial well-being of children and their families [1]. Studies have shown that the use of mental health services by children and adolescents was lower during the initial phase of the COVID-19 pandemic than before the pandemic [2]. However, some time-trend studies have shown that mental health problems have increased during the COVID-19 pandemic [3-5]. This has resulted in a higher level of unmet needs in children with mental health problems. These findings have underlined the need for low-threshold and remote services to address the psychosocial problems affecting children and their families. It is crucial that we be able to demonstrate the feasibility and outcomes of such programs in real-world settings during the COVID-19 pandemic because they are likely to prove invaluable during both current and future crises.

Disruptive behavior and conduct problems are common among children and can lead to negative outcomes in later life [6-9]. Children with disruptive behavior and conduct problems have higher risks of encountering lifelong disorders in relation to conduct, impulse control, mood, anxiety, suicidality, and substance abuse [7-10]. It is likely that several risk factors linked to the COVID-19 pandemic will have detrimental effects on children, and these are particularly expected to affect vulnerable children, such as those with disruptive behavior problems. These risk factors could include isolation due to school closures, parental stress about the virus and job security, increases in undetected child abuse, greater levels of cyberbullying due to increased online activities, and the trauma or threat of losing family members [1,11-13].

Parent training has been found to be the most effective way to prevent and treat disruptive behavioral problems among children. There is growing evidence from randomized controlled trials (RCTs) that such initiatives reduce problems and improve parenting skills [14-17]. Parent training has been shown to be 1 of the best-validated therapeutic techniques in child mental health [18]. Interventions that encourage positive behavior, and include video demonstrations, practical exercises, and homework, have helped parents reduce their children's aggressive behavior. The goal of these interventions is to teach parents to identify, define, and observe their children's problem behaviors in new ways. They also teach parents strategies that help them prevent their child's oppositional behavior and react to any episodes in a positive way [15]. Parent training should be the first choice when it comes to tackling children's disruptive behavior [19]. Despite this, only a small percentage of families who are struggling with these problems receive evidence-based treatment programs [20]. The biggest barriers to such programs include the stigma related to receiving mental health treatment and the difficulties in accessing, and engaging with, treatment programs, because of time, cost, and location [16,17]. Providing traditional parent training programs has been challenging during the COVID-19 pandemic restrictions, particularly as they are usually based on group treatments and face-to-face contact. Problems have been exacerbated by lockdowns and other social distancing measures, together with fears of getting infected by the virus during face-to-face contact and a possible decrease in seeking help when problems arise. One consequence of the COVID-19 pandemic could be the decreased availability of evidence-based parent training interventions for children with disruptive behavior. Delaying these interventions, or not being able to provide them, could lead to further deterioration in the children's problems and functioning levels. There are also concerns that steps taken to impede the spread of the pandemic may have also led to increased risk family dysfunction, which may have had a particular impact on vulnerable children, including those with disruptive behavior problems [21,22].

A number of studies have found that many digital and digital-assisted parent training programs offer many benefits over traditional interventions, such as high levels of support, higher fidelity, greater accessibility, and convenience [23-26]. They can also reduce health care costs and time.

Our pioneering Strongest Families Smart Website (SFSW) study was the first RCT to use an internet-based intervention, with telephone coaching, to train the parents of Finnish preschool children with disruptive behavior [27]. They were identified by public health nurses at routine 4-year child health clinic health check-up visits [28]. The 11-week internet-based parent training intervention comprises parent training material delivered via an interactive online platform, which is backed up by regular telephone contact with specially trained coaches. This intervention has been shown to improve the preschool children's psychiatric symptoms and the parents' skills in handling their disruptive behavior. The RCT showed that improvements were maintained 24 months after the program, when the families who received the intervention were compared with a control group that only received basic information on the subject [29-32].

This paper is the first to report the feasibility and outcomes of providing the SFSW program in a clinical setting during the COVID-19 pandemic. The first aim was to report changes in the children's functioning and psychopathology levels at baseline, posttreatment, and 6 months after baseline. The second aim was to report changes in parenting skills and parent well-being at the same time points. The third aim was to shed light on the feasibility of providing an internet-based training program in specialist clinical settings during exceptional circumstances, namely family counseling centers and the COVID-19 pandemic. Based on using the SFSW in primary health care settings, we hypothesized that the parent training program could show significant reductions in a wide range of child psychopathology problems, increase parenting skills, and reduce parental stress. We also expected a high satisfaction level and a low dropout level during the program.

Methods

Study Environment

The study focused on clients from each of the 8 family counseling centers in Helsinki, the capital of Finland, where social workers, psychologists, and doctors offer low-threshold services that are based on openness and confidentiality. The centers are administratively part of social services and support the child's development by strengthening parenting skills and relationships between the child, parents, and other family members. Families can themselves contact the centers, or they can be referred by child health centers or other health care professionals. The centers work as part of a network with other organizations, such as schools, social services, and child protection. This means that families benefit from multiprofessional support that is integrated into any other support plans they have.

The family counseling centers provide specialist support for children and adolescents aged 0-17 years when basic services are not enough for them and their family. Direct support is offered at the centers, and center staff can also provide advice to other services who are helping the families. The centers can also refer children and families to other specialist services, such as child protection and child psychiatry.

Family counseling centers typically offer parent training as individual face-to-face meetings or in group sessions, and these cover areas such as problems raising children or crisis situations. During the COVID-19 pandemic, there were lockdowns and these face-to-face services were impossible to arrange. It was not possible to offer face-to-face or group-based guidance, and this highlighted the importance of providing parental support in other ways, including our SFSW internet-based parent training program with telephone coaching.

Study Design

This study had a single-group design with repeated measurements. The parents were asked to fill in questionnaires at baseline, posttreatment, and 6 months after starting the parent training program. The baseline questionnaires were filled in before the program started, the posttreatment questionnaires right after the program ended, and the baseline questionnaires 6 months later. The study population comprised 50 families. The study was conducted between May 2020 and September 2021. When the study started, the COVID-19 pandemic situation was at its height in Helsinki and a state of emergency had been declared across Finland. There were strict social distancing restrictions in the Helsinki area to try to halt the spread of the virus, and these had a big impact on families living in the area. Schools and leisure facilities were closed, social contact was strictly limited, and most parents who were able to work from home did so.

Study Population

This study focused on children aged 3-8 years who displayed high levels of disruptive behavior when they were screened by 8 family counseling centers. The study population comprised 50 families, and 37 (74%) of the 50 children aged 3-8 years were boys. Staff from the 8 counseling centers identified the families they felt would benefit from the SFSW internet-based parent training program, with telephone coaching, for children with disruptive behavioral problems.

Recruitment

The screening measures and enrollment criteria were identical for the implementation study carried out at the counseling centers, the previous child health care clinic implementation study, and the original RCT [29-32]. The screening was mainly carried out using the conduct scale of the Strengths and Difficulties Questionnaire (SDQ) [33,34]. Parents who were already attending the counseling center before the pandemic started were asked whether their child had mild, moderate, or severe problems. This was based on a single question about whether the child had difficulties in 1 or more of the following areas: emotions, behavior, or getting on with other people. If they replied yes, then they met the first inclusion criterion. They were also asked whether they felt that their child had at least minor difficulties when it came to emotions, behavior, or social interactions. To take part in the study, at least 1 parent had to speak native Finnish or Swedish and they needed access to a telephone and a device with an internet connection. The exclusion criteria included children who had been diagnosed with autism; Down syndrome; fetal alcohol syndrome; an intellectual disability; a severe mental disorder, such as psychosis or depression; or genetic-based mental retardation. We also excluded children who were unable to speak, had difficult hearing, or had visual impairments that were not corrected by wearing glasses.

Procedure

Families were approached about the study if they met the eligibility criteria and would derive the most benefit from the SFSW parent training program by clinical evaluation at the family counseling center. The whole parent training program and data collection were carried out from 1 center, the Research Centre for Child Psychiatry, University of Turku, Finland. If parents agreed, they were provided with password-protected access to the internet site and allocated a family coach for the duration of the program. They started the program by completing a series of questionnaires (at baseline) and then worked through the 11 sessions, with weekly guidance from the family coach

(Table 1). When they completed the program, they were asked to fill up the posttreatment questionnaires and provide feedback on the program. The data collected at baseline were compared with the data collected after the program and 6 months after the program started to measure the impact of the program on the parents and the children.

Table 1. Themes of the 11-session SFSW[a] internet-based parent training program for children with behavioral problems.

Session	Key training elements	Goals
1. Notice the good.	Positive, active parenting	Boost the child's self-esteem, boost the parent's self-esteem, and change the parent's view of their child.
2. Spread attention around.	Positive, impartial parenting	Strengthen the child's empathy skills.
3. Ignore whining and complaining.	Positive, self-controlled parenting	Teach parents self-regulation.
4. Prepare for changes.	Positive, proactive parenting	Reinforce good daily routines.
5. Plan ahead at home.	Positive, proactive parenting	Boost the self-esteem of the child and the parent and involve the child in planning.
6. Chart and stickers.	Positive, active parenting	Involve the child in planning and reinforce good daily routines.
7. Plan ahead outside the home.	Positive, proactive parenting	Boost the self-esteem of the child and the parent and involve the child in planning.
8. Working with day care.	Positive cooperation and communication between parent and day care	Help the child manage and succeed.
9. Time out.	Positive, self-controlled parenting	Teach self-regulation and consistency.
10. and 11. Revise problem solving and future application of skills.	Positive daily parenting in the future	Teach parents skills to support child development and prepare for future challenges.

[a]SFSW: Strongest Families Smart Website.

Intervention

The intervention was originally developed from the Canadian version of the Strongest Families intervention, which was provided through handbooks, videos, and weekly telephone calls from the coach [35]. In our study, the participants received the intervention, which was the internet-based SFSW parent training program. The SFSW parent training program comprised material delivered via an interactive online platform and telephone coaching. Although it was based on 11 weekly themes, some parents needed longer to progress to each new stage. The program focused on improving skills to strengthen parent-child relationships, together with a series of weekly telephone sessions with specially trained coaches. The family coaches were licensed health care professionals, such as nurses and public health nurses. Each family coach received a training for the internet-based program held by experienced coach supervisors. The training included theoretical information (eg, mental health prevention methods and information about conduct problems in childhood) and rehearsal phone calls [31]. After receiving the training, the family coach was ready to start carrying out the program with the families.

All the coaching calls were recorded, and the recorded calls were audited by the coach supervisor randomly. After each coaching call, the family coach assessed their own performance on a scale from 4 to 10. If self-assessment was equal to 6 or less, the coach supervisor received a message from the digital platform and subsequently discussed the issue with the family coach. There were also systematic supervision meetings with each family coach, if needed, and weekly group case meetings, where all family coaches reviewed and discussed the families they were coaching [31]. A rough estimate of the direct costs, including coaching, supervision, IT support, contacts with the family counseling centers, and administrative, postage, and material costs, were approximately €1500 (US $ 1468.42) per family.

The program started by discussing and on agreeing personalized goals for the program based on the child's behavior problems. The sessions were divided into 3 sections: basic positive parenting skills, practical parenting skills and reinforcing the skills they had acquired, and sustaining their approach to positive parenting. During the first 7 weeks, parents learned positive and practical problem-solving skills and were encouraged to develop an understanding of their child's emotional development.

The primary aim was that the parent would notice the child's positive behavior and react with a positive response. The second aim was to apply the skills they had learned in everyday situations and use positive methods to reinforce the child's positive behavior. The last 2 weekly themes focused on reinforcing the use of their new positive parenting skills in everyday life in order to support their child's positive behavior. The parents practiced their positive parenting skills with their child and discussed their progress during the weekly telephone calls with their coach. The goal was to ensure that the parents were able to sustain the skills they had learned when the program finished. The weekly themes are depicted in Table 1.

Measurements

The parents completed online questionnaires at baseline, after the parent training program, and 6 months after they had started the program. The timing of each questionnaire is described in Table S1 in Multimedia Appendix 1.

Demographic and Family Information

Demographic information was obtained at the screening phase and included the child's sex, the family structure, and the parents' birth year, native language, educational level, and employment status. The demographic and family information are depicted in the Results section.

Child Psychopathology and Functioning

Psychopathology was measured using the SDQ [33,34], a brief behavioral screening questionnaire that examines positive and negative behaviors in subjects aged 3-16 years. The 25 items of the SDQ are divided into 5 subscales of 5 questions: emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems, and prosocial behavior. Perceived difficulties were assessed with a single question about whether the child had difficulties in at least 1 of these areas: emotions, behavior, or being able to get on with other people. The possible answers were no, minor difficulties, definite difficulties, and severe difficulties. One study reported that the SDQ had an internal consistency score of 0.58 when it was used by the parents of preschool children [36].

Child irritability was measured by the Affective Reactivity Index (ARI) scale, which comprises 6 irritability symptom items and 1 impairment item [37]. The ARI scale examines 3 aspects of irritability: the threshold for an angry reaction, the frequency of angry feelings/behaviors, and the duration of such behaviors/feelings. Parents were asked to assess their child's behavior over the past 6 months compared to peers of the same age. They were presented with 6 statements about behaviors and feelings related to irritability and were asked to say whether they were not true (0 points), somewhat true (1 point), or certainly true (2 points). The ARI scale also includes 1 question about whether the child's irritability impairs them, with the same possible responses.

Disruptive behavior was measured by the externalizing subscale of the Child Behavior Checklist-Parent Report Form (CBCL) for ages 1.5-5 years. The CBCL 1.5-5 [38] comprises 99 problem items, and the subscales are emotionally reactive, anxious/depressed, somatic complaints, withdrawn, sleep problems, attention problems, and aggressive behavior. These can be combined to provide internalizing, externalizing, and total problem scores. This study focused on the externalizing subscale, which comprises 24 items on behavioral problems, including attention issues and aggressive behavior, and the total score of the CBCL. The parents were asked to evaluate their child's behavior during the past 2 months using a 3-point scale for each item: 0 (not true), 1 (somewhat true), and 2 (very true/often true). The CBCL has good test-retest reliability (eg, 0.81) and criterion validity (eg, 0.56-0.87) [38].

The 24-item Inventory of Callous-Unemotional Traits (ICU) [39] is used to evaluate 3 precursors of psychopathy: callousness, uncaring, and unemotional traits. It has been shown to be an important measure for identifying subgroups of antisocial and aggressive children and adolescents [40,41]. The ICU comprises 24 statements with a 4-point Likert scale: 0 (not at all true), 1 (somewhat true), 2 (very true), and 3 (definitely true). Larger scores indicate higher callous and emotional traits.

A 17-item questionnaire, based on the Barkleys' Home situation Questionnaire [42], was created to measure parents' experiences of their child's functioning and behavior during daily situations and routines. The questionnaire included questions about how the child behaved at home; in transition situations, such as when they were getting dressed; and while eating. The questionnaire asked parents about how their child behaved on a 5-point scale ranging from 1 point if the child's behavior was easy to 5 points if it was awkward.

Parenting, Parental Mental Health, and Satisfaction

The 30-item Parenting Scale (PS) is used to measure parenting and discipline styles for children aged 1-12 years, particularly those related to the development or maintenance of child disruptive behavior [43,44]. The scale focuses on 3 dysfunctional discipline styles: laxness, overreactivity, and verbosity. Laxness comprises 11 items about how parents fail to enforce rules. Overreactivity has 10 items on mistakes, such as displays of anger or irritability. Verbosity has 7 items that reflect lengthy verbal responses to situations. The 7-point scale ranges from ineffective to effective responses and is often used to evaluate parent training programs. The parents were asked to evaluate their parenting skills during the preceding 2 months.

The parents' stress, anxiety, and depression symptoms during the past week were evaluated with the shorter 21-item Depression, Anxiety, and Stress Scale (DASS-21) [45]. The 3 DASS-21 scales contain 7 items, divided into subscales with similar content. For example, the depression scale assesses dysphoria, hopelessness, and lack of interest, and the anxiety scale assesses situational anxiety, autonomic arousal, and skeletal muscle effects. The stress scale is sensitive to levels of chronic nonspecific arousal, such as being easily upset and having difficulty relaxing. Responses are based on a 4-point Likert scale: 0 (did not apply to me at all), 1 (applied to me to some degree or some of the time), 2 (applied to me to a considerable degree or a good part of the time), and 3 (applied to me very much or most of the time).

Parents were also asked about their satisfaction with the parent training program when they completed the program. The same satisfaction questionnaire was used in our previous studies [31]. The satisfaction questionnaire included parents' general experiences of the program, how it had affected their parenting skills, and their views on the website, the content of the program, and working with the telephone coach. The questionnaire also included questions about where they had gone through the program (eg, at home or work) and whether they had input from the other parent when they used the website. Each statement on the program was rated using a 5-point scale: completely disagree, disagree, not agree or disagree, agree, and totally agree (see Table S2 in Multimedia Appendix 2).

Statistical Analysis

All participating families (N=50) were included in the intent-to-treat analyses. Categorical demographic variables, including child, parent, and family characteristics, are presented as numbers and percentages. Continuous demographic variables

including the parents' age are presented as means and SDs. The outcome variables were analyzed with linear mixed-effect models for repeated measurements with time as the within factor: at baseline, after the program (posttreatment), and at 6 months after starting the program. We used linear contrasts to estimate the changes from baseline to 6 months and, if feasible, from baseline to posttreatment and from posttreatment to 6 months. Statistical significance was judged at $P<.05$. The statistical analyses were performed using SAS statistical software, version 9.4 (SAS Institute Inc).

Ethical Considerations

Ethical approval for the study was received from the University of Turku (statement 25/2018), and the study had a research permit from the city of Helsinki. The parents provided written informed consent and were advised that participation in the study was voluntary and they had the right to withdraw at any time.

Results

Participant Characteristics

The study comprised 50 families, and 44 (88%) completed the whole SFSW program, including the assessment after the program. In addition, 45 (90%) of the 50 families completed the assessment 6 months after baseline data were collected. The children were 3-8 years old, and 37 (74%) of the 50 children were boys. The baseline data showed that 38 (76%) of the 50 children lived with both their biological parents. Table 2 provides the demographics of the families included in this study and shows that 48 (96%) of the 50 children had definitive or severe behavioral problems at baseline. Only 2 (4%) of the 50 children had minor problems.

As shown in Table 2, the average time spent on the program website for each of the 11 themes was 48.0 (SD 25.6) minutes and the mean duration of telephone coaching was 35.3 (SD 8.8) minutes per call. The parents spent approximately 8-9 hours on the whole program. The average total time for 11-week phone coaching per family was 352.5 (SD 113.3) minutes. In addition, the family coaches spent time in reviewing the case; taking notes and possible remarks, if needed, after the calls; and writing the feedback, which was sent to the family counseling center and home to the family after the program. In some cases, family coaches had to be in contact with the family counseling centers. The estimated time spent by the family coach per family was approximately 9 hours total in completed programs.

Baseline, posttreatment, and 6-month follow-up scores of all child and parent outcome measures are presented in Tables 3-8. Table 4 shows the change in overall perceived behavior problems based on the single SDQ question about whether the child had overall problems in 1 or more of the following areas: emotions, behavior, or getting on with other people. This showed that 18 (36%) of the 50 children had severe problems and 30 (60%) of the 50 children had definite problems at baseline. At the 6-month follow-up, 5 (11%) of 45 children had severe problems and 21 (47%) of 45 children had definite problems. Only 2 (4%) of the 50 children had minor problems at baseline, and this increased to 19 (42%) of 45 children at the 6-month follow-up, which was a significant decrease in severity levels.

Additional analysis for those 45 (90%) of the 50 parents who completed the 6-month follow-up questionnaires showed that 35 (78%) of the 45 children had an SDQ total score above the 90th percentile (ie, abnormal range) at baseline, while only 12 (27%) remained in the abnormal range at the 6-month follow-up ($P<.001$, McNemar test) based on the population sample of 4-16-year-old children [33]. When using the 80th percentile cut-off point (ie, abnormal or borderline range), 42 (93%) children were above the cut-off point at baseline, while the respective figure at the 6-month follow-up was 23 (51%) children, indicating a highly significant change ($P<.001$).

As shown in Table 6, there were significant improvements in most of the child psychopathology measures between baseline, before the program started, and 6 months after baseline. The only exception was the unemotional score in the ICU scale, which did not show a significant improvement. The improvements in externalizing, internalizing, hyperactivity and peer problems, irritability, and prosocial behavior measured by the SDQ, ARI, and CBCL scales were significant between baseline and 6 months. As shown in Tables 6-7, similar significant improvements were shown in the SDQ impact scale and parents' experiences of their child's functioning and behavior during daily situations and routines. Changes to key outcomes, namely the SDQ total, conduct, and irritability scores are visualized in Figure 1.

As shown in Table 8, when parenting skills were measured with the PS, it showed significant improvements between baseline and the 6-month follow-up. Parental mental health, which was measured with the DASS-21, showed significant improvement in the total scores and subscore measuring stress between baseline and 6 months. However, there were no significant changes in depression and anxiety.

The satisfaction questionnaire was completed by 45 (90%) of the 50 parents once they had completed the program. As shown in Table S2 in Multimedia Appendix 2, there were high levels of satisfaction with how the program had improved their parenting skills, matching their expectations and needs. More than 90% (n=42-44, 93%-98%) reported high satisfaction in the skills and professionalism of the family coaches. These findings were similar to the original RCT and child health clinic center implementation study [29-32].

Only 6 (12%) of the 50 parents failed to complete the whole program: 3 (6%) dropped out during the first few weeks, and the other 3 (6%) completed the first 7 weeks of the program, which comprise the key elements. This meant that those 3 families missed out on weeks 8-11, which focused on putting the skills and techniques they had learned into action (Table 1). In addition, 1 (17%) of these 6 families took part in the 6-month follow-up assessments. Meta-analysis shows that online parenting programs are effective in reducing children's disruptive behavior compared to a control group and seem to have the same effectiveness as face-to-face programs [46,47]. The explaining factor for the good completion rates included highly structured and manualized content, the implementation strategy, remote delivery using phone coaching and a digitalized

platform, and fidelity assurance. Special attention was given to motivate the parents to complete the program using, for example, attributional questions. To achieve good completion rates, it was important to collaborate closely with the family counseling centers.

Table 2. Demographic characteristics and treatment factors (N=50).

Participant and program characteristics	Participants
Family structure, n (%)	
Biological parents	38 (76)
One biological parent	11 (22)
Other	1 (2)
Age of the parent (years), mean (SD)	
Maternal	31.9 (4.3)
Paternal	32.8 (3.7)
Maternal educational level[a], n (%)	
Secondary education	11 (22)
College or university degree	37 (76)
Other	1 (2)
Paternal educational level[b], n (%)	
Elementary school or less	3 (7)
Secondary education	11 (24)
College or university degree	31 (7)
Other	1 (2)
Native language of the participating parent[c], n (%)	
Finnish	43 (88)
Swedish	5 (10)
Other	1 (2)
Sex of the child, n (%)	
Female	13 (26)
Male	37 (74)
Age of the child (years), n (%)	
3-4	15 (30)
5-6	27 (54)
7-8	8 (16)
Child's behavioral problems, n (%)	
Minor	2 (4)
Definite	30 (60)
Severe	18 (36)
Program characteristics , mean (SD)	
Mean duration of calls for the 11 themes (minutes)	35.3 (8.8)
Mean duration of website access per theme (minutes)	48.0 (25.6)
Total mean duration of program per theme (minutes)	83.3 (28.0)

[a]1 missing observation.

[b]4 missing observations.

[c]1 missing observation.

Table 3. Child psychopathology at baseline, posttreatment, and 6 months after baseline.

Variable	Baseline[a] (N=50), mean (SE)	Posttreatment[b] (n=44), mean (SE)	Follow-up after 6 months[c] (n=45), mean (SE)
SDQ[d]			
Total	19.8 (0.7)	15.0 (0.7)	14.2 (0.7)
Emotional symptoms	3.5 (0.3)	1.9 (0.2)	2.2 (0.3)
Conduct problems	7.5 (0.2)	5.8 (0.3)	5.3 (0.2)
Hyperactivity	6.0 (0.3)	5.3 (0.3)	4.7 (0.3)
Peer problems	2.8 (0.3)	2.1 (0.2)	2.1 (0.2)
Prosocial behavior	5.2 (0.3)	5.6 (0.3)	6.0 (0.3)
Impact	3.0 (0.3)	1.9 (0.3)	1.7 (0.3)
Questionnaire for irritability			
Irritability	8.6 (0.4)	5.9 (0.5)	4.8 (0.4)
CBCL[e] for preschool children [f]			
Externalizing	25.7 (1.0)	N/A[g]	18.8 (1.2)
Total	62.1 (3.1)	N/A	45.8 (3.3)
ICU[f,h]			
Total	27.4 (0.4)	N/A	23.3 (1.2)
Callousness	8.9 (0.5)	N/A	6.8 (0.5)
Uncaring	14.5 (0.5)	N/A	12.5 (0.6)
Unemotional	4.1 (0.4)	N/A	4.1 (0.4)

[a]Measurements before the program started.

[b]Measurements after completing the program.

[c]Measurements 6 months after starting the program.

[d]SDQ: Strengths and Difficulties Questionnaire.

[e]CBCL: Child Behavior Checklist-Parent Report Form.

[f]The CBCL externalizing scores and total scores and the ICU were measured only at baseline and 6 months after baseline.

[g]N/A: not applicable.

[h]ICU: Inventory of Callous-Unemotional Traits.

Table 4. Child function level at baseline, posttreatment, and 6 months after baseline.

Variable	Baseline[a] (N=50)	Posttreatment[b] (n=44)	Follow-up after 6 months[c] (n=45)
Everyday situations, mean (SE)			
Child behavior total	43.0 (1.6)	36.8 (1.4)	33.5 (1.9)
Transition situations	14.7 (0.6)	12.8 (0.6)	11.4 (0.6)
Dining situations	7.8 (0.4)	6.6 (0.3)	6.0 (0.4)
Situations outside home	10.4 (0.5)	8.8 (0.4)	8.1 (0.6)
Home situations	10.0 (0.4)	8.6 (0.4)	8.0 (0.6)
Behavior problems, n (%)			
No or minor problems	2 (4.0)	12 (27.3)	19 (42.2)
Definite	30 (60.0)	24 (54.5)	21 (46.7)
Severe	18 (36.0)	8 (18.2)	5 (11.1)

[a]Measurements before the program started.

[b]Measurements after completing the program.

[c]Measurements 6 months after starting the program.

Table 5. Parental skills and parental mental health at baseline, posttreatment, and 6 months after baseline.

Variable	Baseline[a] (N=50), mean (SE)	Posttreatment[b] (n=44), mean (SE)	Follow-up after 6 months[c] (n=45), mean (SE)
PS[d,e]			
Total	3.5 (0.1)	N/A[f]	2.9 (0.1)
Laxness	2.8 (0.1)	N/A	2.5 (0.1)
Overreactivity	4.3 (0.2)	N/A	3.4 (0.2)
Hostility	1.9 (0.1)	N/A	1.6 (0.1)
DASS-21[e,g]			
Total	22.6 (2.1)	N/A	16.8 (2.1)
Depression	6.6 (1.0)	N/A	4.9 (0.8)
Anxiety	2.8 (0.6)	N/A	2.7 (0.7)
Stress	13.2 (0.9)	N/A	9.3 (0.9)

[a]Measurements before the program started.

[b]Measurements after completing the program.

[c]Measurements 6 months after starting the program.

[d]PS: Parenting Scale.

[e]The PS and DASS-21 were measured only at baseline and 6 months after baseline.

[f]N/A: not applicable.

[g]DASS-21: 21-item Depression, Anxiety, and Stress Scale.

Table 6. Treatment comparisons of child psychopathology at baseline, posttreatment, and 6 months after baseline.

Variable	Baseline[a] to posttreatment[b]		Baseline to 6-month follow-up[c]		Posttreatment to 6-month follow-up	
	Mean (95% CI)	*P* value	Mean (95% CI)	*P* value	Mean (95% CI)	*P* value
SDQ[d]						
Total	4.8 (3.3 to 6.2)	<.001	5.5 (4.2 to 6.9)	<.001	0.8 (–0.5 to 2.0)	.21
Emotional	1.6 (1.0 to 2.2)	<.001	1.3 (0.7 to 1.9)	<.001	–0.3 (–0.8 to 0.2)	.21
Conduct	1.7 (1.1 to 2.3)	<.001	2.2 (1.7 to 2.7)	<.001	0.5 (–0.1 to 1.0)	.08
Hyperactivity	0.7 (0.1 to 1.3)	.02	1.3 (0.7 to 1.9)	<.001	0.6 (0.2 to 1.0)	.01
Peer	0.7 (0.3 to 1.2)	.002	0.7 (0.3 to 1.1)	.001	0.0 (–0.4 to 0.4)	.99
Prosocial	–0.5 (–1.0 to 0.1)	.08	–0.8 (–1.3 to –0.3)	.001	–0.4 (–0.7 to 0.0)	.05
Impact	1.0 (0.5 to 1.6)	.001	1.2 (0.7 to 1.8)	<.001	0.2 (–0.3 to 0.7)	.47
Questionnaire for irritability						
Irritability	2.8 (1.8 to 3.7)	<.001	3.9 (3.0 to 4.8)	<.001	1.1 (0.4 to 1.9)	.003
CBCL[e,f] for preschool children						
Externalizing	N/A[g]	N/A	7.0 (4.9 to 9.0)	<.001	N/A	N/A
Total	N/A	N/A	16.3 (10.2 to 22.3)	<.001	N/A	N/A
ICU[h]						
Total	N/A	N/A	4.1 (2.1 to 6.1)	<.001	N/A	N/A
Callousness	N/A	N/A	2.1 (1.0 to 3.1)	<.001	N/A	N/A
Uncaring	N/A	N/A	2.0 (1.0 to 3.0)	<.001	N/A	N/A
Unemotional	N/A	N/A	0.1 (–0.6 to 0.7)	.88	N/A	N/A

[a]Measurement before the program started.

[b]Measurement after the program ended.

[c]Measurements 6 months after starting the program.

[d]SDQ: Strengths and Difficulties Questionnaire.

[e]CBCL: Child Behavior Checklist-Parent Report Form.

[f]The CBCL externalizing scores and total scores and the ICU were measured only at baseline and 6 months after baseline.

[g]N/A: not applicable.

[h]ICU: Inventory of Callous-Unemotional Traits.

Table 7. Treatment comparisons of child function level (everyday situations: child behavior) at baseline, posttreatment, and 6 months after baseline.

Variable	Baseline[a] to posttreatment[b]		Baseline to 6-month follow-up[c]		Posttreatment to 6-month follow-up	
	Mean (95% CI)	*P* value	Mean (95% CI)	*P* value	Mean (95% CI)	*P* value
Child behavior total	6.1 (3.0 to 9.2)	<.001	9.4 (5.0 to 13.8)	<.001	3.3 (–0.3 to 6.9)	.07
Transition situations	1.9 (0.6 to 3.1)	.004	3.3 (1.8 to 4.8)	<.001	1.4 (0.2 to 2.7)	.03
Dining situations	1.2 (0.4 to 2.1)	.006	1.8 (0.9 to 2.7)	<.001	0.6 (–0.2 to 1.3)	.12
Situations outside home	1.6 (0.8 to 2.5)	<.001	2.3 (1.0 to 3.6)	.001	0.7 (–0.4 to 1.8)	.20
Home situations	1.3 (0.4 to 2.2)	.005	1.9 (0.7 to 3.2)	.004	0.6 (–0.4 to 1.6)	.25

[a]Measurement before the program started.

[b]Measurement after the program ended.

[c]Measurements 6 months after starting the program.

Table 8. Treatment comparisons of parental skills and parental mental health at baseline, posttreatment, and 6 months after baseline.

Variable	Baseline[a] to posttreatment[b]		Baseline to 6-month follow-up[c]		Posttreatment to 6-month follow-up	
	Mean (95% CI)	*P* value	Mean (95% CI)	*P* value	Mean (95% CI)	*P* value
PS[d,e]						
Total	N/A[f]	N/A	0.5 (0.4 to 0.7)	<.001	N/A	N/A
Laxness	N/A	N/A	0.3 (0.1 to 0.6)	.02	N/A	N/A
Overreactivity	N/A	N/A	0.8 (0.6 to 1.1)	<.001	N/A	N/A
Hostility	N/A	N/A	0.3 (0.1 to 0.5)	.004	N/A	N/A
DASS-21[e,g]						
Total	N/A	N/A	5.8 (1.4 to 10.3)	.01	N/A	N/A
Depression	N/A	N/A	1.8 (–0.2 to 3.7)	.07	N/A	N/A
Anxiety	N/A	N/A	0.1 (–1.6 to 1.7)	.93	N/A	N/A
Stress	N/A	N/A	3.9 (2.2 to 5.6)	<.001	N/A	N/A

[a]Measurement before the program started.

[b]Measurement after the program ended.

[c]Measurements 6 months after starting the program.

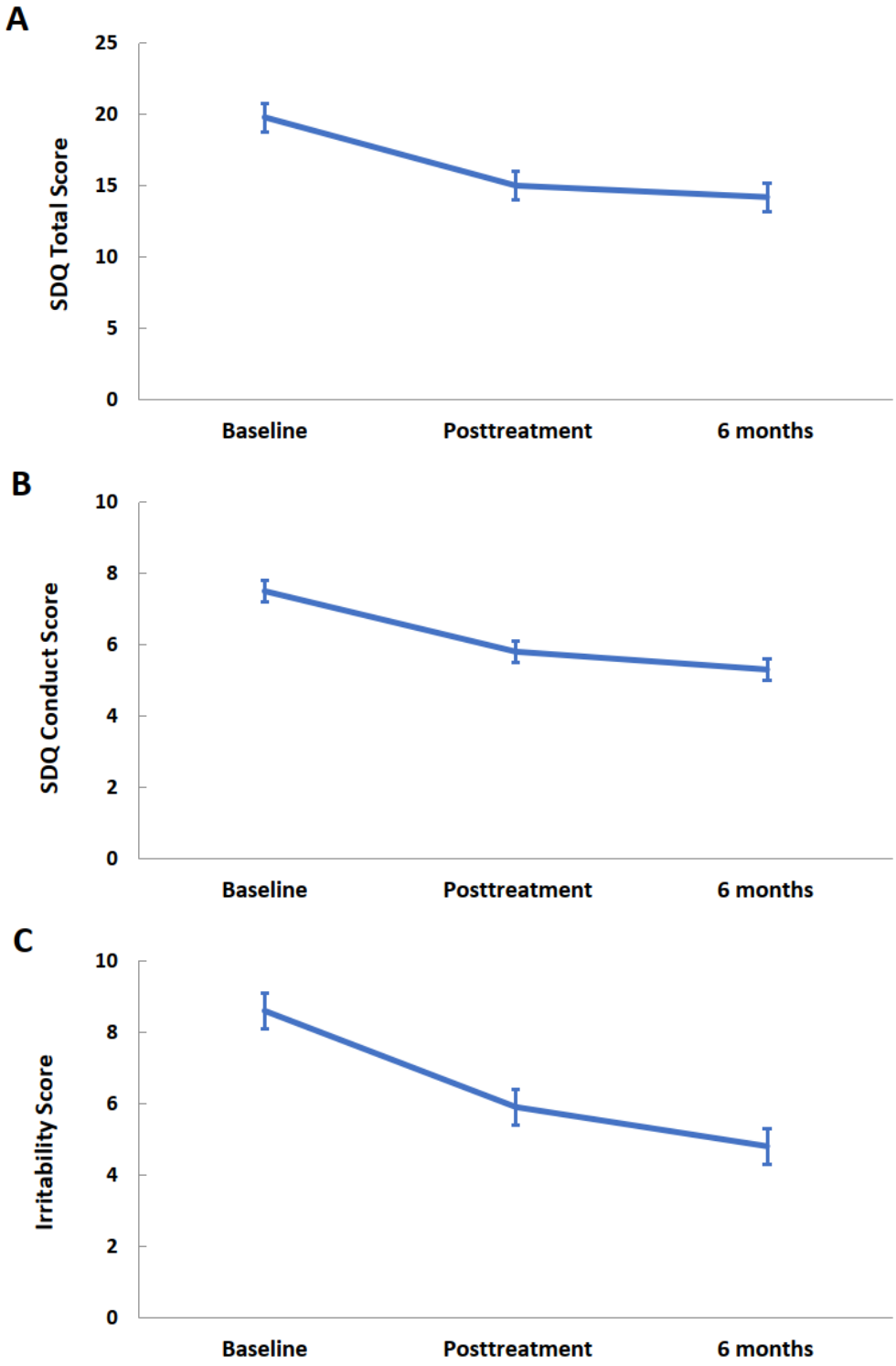
[d]PS: Parenting Scale.

[e]The PS and DASS-21 were measured only at baseline and 6 months after baseline.

[f]N/A: not applicable.

[g]DASS-21: 21-item Depression, Anxiety, and Stress Anxiety Stress Scale.

Figure 1. Mean curves of SDQ total and conduct scores as well as irritability score. (A) SDQ total scores over time (model-based least-squares means [SE]). (B) SDQ conduct scores over time (model-based least-squares means [SE]). (C) Irritability score over time (model-based least-squares means [SE]). SDQ: Strengths and Difficulties Questionnaire.



Discussion

Principal Findings

The study showed that the parent training program was effective when it was used in a specialist clinical setting during the COVID-19 pandemic. The program led to significant improvements in children's externalizing symptoms 6 months after baseline. It improved most of the psychopathology symptom domains we measured, including parent-reported externalizing, internalizing, hyperactivity and peer problems, irritability, and prosocial behavior. The changes in the children's psychopathology and functioning were fairly similar to the population-based RCT and the child health clinic implementation study [29-32]. It is often assumed that digital

interventions are best suitable for those who have minor behavioral problems. However, this study showed that internet-based interventions with telephone coaching are effective for children who have more severe behavioral problems. In the population-based implementation study [32], the mean change for the CBCL total score between baseline and the 6-month follow-up was 15.2 points, while in this study, the mean change was 16.3 points.

The results showed that the program provides parents with feasible parenting skills that they are able to sustain, even after the program ends. The impact that the program had on the children's social development was remarkable, as the intervention had positive effects on daily transitions and activities, such as getting dressed, behavior when eating, and activities inside and outside the home. The self-reported parenting skills significantly improved, and parents expressed less distress at the 6-month follow up in relation to dealing with their child. This was despite the fact that the intervention was conducted during the COVID-19 pandemic, which was bound to be a stressful time. It is noteworthy that although the effects were maintained at 6 months, according to most of the child psychopathology measures we used, the intervention did not have a long-lasting effect on callous-unemotional traits, which have been associated with poorer treatment outcomes [48].

The number of parents who failed to complete the program was low, and the parents who did were highly satisfied with the program. These findings show that the program was feasible during the height of the COVID-19 pandemic in Finland. One of the keys to successful parent training interventions is the ability to engage and retain parents in the program [49-51]. High dropout rates have been reported by digital interventions, and these have been particularly associated with unguided interventions [50,52-55]. The 12% dropout rate in our study, which included telephone coaching sessions, was much lower than the 30%-50% reported by previous studies on digital parent training interventions [56-60]. There are a number of possible reasons for the low dropout rate, including the fact that the program had a strong background of research-based evidence. The context of the program was well defined, and there were clear inclusion and exclusion criteria. In addition, the parents voluntarily sought help to address their children's challenges from the family counseling center and the program included weekly telephone coaching on the weekly themes. The program also had a clear structure, and the parents received weekly feedback and support from the family coach. Digital interventions that include guidance and support, such as regular phone calls, have been shown to have a larger effect size on mental health outcomes than smartphone interventions without any personal support [61].

Comparison With Previous Works

Even though there has been a lot of research published about parent training, none of this has addressed how an internet-based parent training program was implemented during exceptional circumstances, such as the COVID-19 pandemic. It was possible to implement the program during the pandemic because it did not require face-to-face meetings and the parents were not required to leave home. The findings of this study are also relevant for other types of crises, where the providing face-face services is not feasible.

Strengths and Limitations

The strengths of the study were that the SFSW is an established program that has already been the subject of an RCT and has been successfully implemented in primary care child health clinics in Finland [29-32]. The study was carried out at a time of international crisis, during the height of the pandemic in Finland, which meant that it was tested during stressful and rigorous social distancing conditions. Despite this, it had a good retention rate, high parental satisfaction, and engagement. The 6-month follow-up assessment provided good data on how feasible and sustainable the program was.

Some limitations should also be noted. First, the COVID-19 pandemic meant that treatment and family counseling services could not be provided in the usual way, and this meant that it was not possible and ethical to conduct the study as an RCT. The study design did not make it possible to draw direct conclusions about the effectiveness of the parent training program, because the study did not have an intervention-control group design, but parental satisfaction was positive. However, in previous studies, we have been able to show the long-term effectiveness of the program. In the RCT intervention group, the changes in children's conduct problems and parents' parenting skills were maintained at the 2-year follow-up [29,30]. In addition, we compared a large implementation sample with the RCT sample [32]. The RCT intervention group and the implementation group did not differ at the 6-month follow-up. This means that the program was effective and may have benefits over traditional group-based treatment approaches when the goal is to identify children at risk in the community at an early stage.

Another limitation was that only parental reports of child behavior were used in the analyses. Direct observations of parenting, and clinical observations or teacher ratings, would have helped validate the reported changes, but social distancing, including school closure, meant this was not possible. This also made it impossible to obtain pretest and posttest data, for example, from teachers. The study also covered children aged 3-8 years, so self-reports were not really feasible. Finally, the participants were limited to those who could speak, read, and write Finnish or Swedish and had access to a computer or smartphone.

Conclusion

The internet-based parent training program with telephone coaching (SFSW) was successful in helping parents tackle child behavioral problems in children aged 3-8 years. The participants reported significant improvements in parenting skills and child psychopathology and functioning. Satisfaction was high, and dropout rates were low. These findings are remarkable because the study was conducted during the COVID-19 pandemic, when health care services and schools were in lockdown and parents were told to work at home if they could.

Providing sustainable key services during crises is a major challenge for society. Social distancing during the height of the pandemic meant that the face-to-face services that have

traditionally proved successful in addressing disruptive child behavior were simply not possible. The COVID-19 pandemic has highlighted the importance of exploring remote, digital, or digitally assisted solutions for ensuring that young children, and their families, are provided with prompt support for mental health problems. This study demonstrated that technology can provide effective alternatives to traditional face-to-face interventions and can overcome a number of barriers during crises. Technology can be used to provide the right treatment at the right time, with high levels of support and fidelity, greater access, convenience, and reduced costs and time.

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Conflicts of Interest

AS is the founder and director of Digifamilies, which provides evidence-based treatments to Finnish public health services. The other authors have no conflicts of interest to declare.

Multimedia Appendix 1
Schedule of questionnaires filled by parents during the program.
[DOCX File , 16 KB - pediatrics_v5i4e40614_app1.docx]

Multimedia Appendix 2
Satisfaction-related questions in the parent training program.
[DOCX File , 17 KB - pediatrics_v5i4e40614_app2.docx]

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Abbreviations

ARI: Affective Reactivity Index
CBCL: Child Behavior Checklist-Parent Report Form
DASS-21: 21-item Depression, Anxiety, and Stress Scale
ICU: Inventory of Callous-Unemotional Traits
PS: Parenting Scale
RCT: randomized controlled trail
SDQ: Strengths and Difficulties Questionnaire
SFSW: Strongest Families Smart Website

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Original Paper

Evaluating the Effectiveness of a Family-Based Virtual Childhood Obesity Management Program Delivered During the COVID-19 Pandemic in Canada: Prospective Study

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Abstract

Background: Generation Health (GH) is a 10-week family-based lifestyle program designed to promote a healthy lifestyle for families with children who are off the healthy weight trajectory in British Columbia, Canada. GH uses a blended delivery format that involves 10 weekly in-person sessions, and self-guided lessons and activities on a web portal. The blended program was adapted to be delivered virtually due to the COVID-19 pandemic. Currently, the effectiveness of the virtual GH program compared with that of the blended GH program remains unclear.

Objective: We aimed to (1) compare the effectiveness of the virtual GH program delivered during the COVID-19 pandemic with that of the blended GH program delivered prior to the pandemic for changing child physical activity, sedentary and dietary behaviors, screen time, and parental support–related behaviors for child physical activity and healthy eating, and (2) explore virtual GH program engagement and satisfaction.

Methods: This study used a single-arm pre-post design. The blended GH program (n=102) was delivered from January 2019 to February 2020, and the virtual GH program (n=90) was delivered during the COVID-19 pandemic from April 2020 to March 2021. Families with children aged 8-12 years and considered overweight or obese (BMI ≥85th percentile according to age and sex) were recruited. Participants completed preintervention and postintervention questionnaires to assess the children's physical activity, dietary and sedentary behaviors, and screen time, and the parent's support behaviors. Intervention feedback was obtained by interviews. Repeated measures ANOVA was used to evaluate the difference between the virtual and blended GH programs over time. Qualitative interviews were analyzed using thematic analyses.

Results: Both the virtual and blended GH programs improved children's moderate-to-vigorous physical activity ($F_{1,380}$=18.37; P<.001; ηp^2=0.07) and reduced screen time ($F_{1,380}$=9.17; P=.003; ηp^2=0.06). However, vegetable intake was significantly greater in the virtual GH group than in the blended GH group at the 10-week follow-up ($F_{1,380}$=15.19; P<.001; ηp^2=0.004). Parents in both groups showed significant improvements in support behaviors for children's physical activity ($F_{1,380}$=5.55; P=.02; ηp^2=0.002) and healthy eating ($F_{1,380}$=3.91; P<.001; ηp^2=0.01), as well as self-regulation of parental support for children's physical activity ($F_{1,380}$=49.20; P<.001; ηp^2=0.16) and healthy eating ($F_{1,380}$=91.13; P<.001; ηp^2=0.28). Families in both groups were satisfied with program delivery. There were no significant differences in attendance for the weekly in-person or group video chat sessions; however, portal usage was significantly greater in the virtual GH group (mean 50, SD 55.82 minutes) than in the blended GH group (mean 17, SD 15.3 minutes; P<.001).

Conclusions: The study findings suggested that the virtual GH program was as effective as the blended program for improving child lifestyle behaviors and parental support–related behaviors. The virtual program has the potential to improve the flexibility and scalability of family-based childhood obesity management interventions.

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KEYWORDS

childhood obesity management; virtual intervention; COVID-19 pandemic; COVID-19; children; healthy lifestyle; health promotion; virtual health; digital health intervention; parenting; obesity; childhood obesity

Introduction

Children who are off the healthy weight trajectory have increased risks of chronic diseases, psychological distress, and lower quality of life [1]. The prevalence of children who are overweight or obese (BMI ≥85th percentile according to age and sex) has increased from 23% in the late 1970s to 35% in 2004 in Canada [2]. A similar trend was seen in the United States, where the prevalence of obesity in children and youth tripled between the late 1970s and 2016 from 5% to 18.5% [3]. A recent study reported that the rate of BMI increase almost doubled during the COVID-19 pandemic compared to the prepandemic period among children aged 2 to 19 years [4]. Consequently, there is an urgent need to develop innovative solutions to help families with children who are off the healthy weight trajectory.

Physical inactivity, increased screen time, and unhealthy food choices have all contributed to overweight or obesity among children [1,5]. The lockdown imposed during the COVID-19 pandemic has further exacerbated these unhealthy lifestyle behaviors. Recent studies have shown that physical activity significantly reduced, while screen time significantly increased among Canadian children [6]. There was also a significant increase in the consumption of unhealthy foods and beverages, such as sugary drinks, among children during the COVID-19 pandemic [7]. Therefore, lifestyle interventions aimed at promoting physical activity and a healthy diet, and reducing screen time are desperately needed for families with children who are off the healthy weight trajectory.

Family-based lifestyle interventions have been shown to be effective for managing childhood obesity [8-11]. Family-based interventions encourage the whole family to make lifestyle behavior changes and remove the focus from the child with overweight or obesity. Engagement with the entire family is important to improve a child's lifestyle behaviors, since family-level attitudes and behaviors play critical roles in shaping a child's lifestyle behaviors [11]. Based on the evidence supporting family-based interventions in combatting childhood obesity, our team collaborated with stakeholders, the Childhood Obesity Foundation, and the British Columbia Ministry of Health to develop a 10-week early intervention program, which was rebranded as "Generation Health" (GH) for families with children (8-12 years of age) who were off the healthy weight trajectory (BMI ≥85th percentile according to age and sex). Childhood obesity management interventions for children aged 8 to 12 years can be particularly effective as prepubertal children are more likely to return to a normal course of growth [12,13]. GH was designed to meet the needs of families living in British Columbia, Canada. GH used a blended in-person and online delivery model to provide program delivery flexibility for families. In our previous trial, this program was shown to be effective relative to a control in improving a child's days of moderate-to-vigorous physical activity (MVPA), and parental support behaviors and self-regulation support for child physical activity and healthy eating [14]. Unfortunately, physical distancing restrictions and the temporary closure of recreation centers as a result of the COVID-19 pandemic did not allow in-person GH component delivery in March 2020. Consequently, our team rapidly adapted GH to be delivered completely virtually starting in April 2020. The overall curriculum of the virtual GH program remained the same as the blended GH program. However, the 10 weekly in-person sessions were adapted to be delivered using online group video sessions, and the online portal was updated to incorporate additional COVID-19–related interactive content (eg, video and audio lessons). The effectiveness of the virtual GH program delivered during the COVID-19 pandemic has not been previously evaluated. Thus, the study objectives were (1) to compare the effectiveness of the virtual GH program delivered during the COVID-19 pandemic with that of the blended GH program delivered prior to the COVID-19 pandemic for changing children's physical activity, sedentary behaviors, dietary behaviors, and screen time, and parental support–related behaviors for child physical activity and healthy eating; and (2) to explore virtual GH program engagement and satisfaction. We hypothesized that (1) the virtual GH program would be as effective as the blended GH program in improving a child's lifestyle behaviors and parental support–related behaviors and (2) families in the virtual GH program would have similar engagement and program satisfaction as those in the blended GH program.

Methods

Study Design

This study used a single-arm pre-post comparison design. Eligible families participated in study assessments at baseline and following the 10-week intervention. Families were invited for an exit interview at the end of the study to collect qualitative program feedback data. The blended GH program was delivered and evaluated from January 2019 to February 2020. The virtual GH program was delivered and evaluated during the COVID-19 pandemic from April 2020 to March 2021. All participants enrolled in the blended and virtual GH programs were included in this analysis. Families were recruited using social media; email mailouts to provincial networks; and posters displayed in recreation centers, medical offices, and schools.

Ethics Approval

This study was approved by the research ethics board at the University of Victoria (H20-00564).

Participants

Families with at least one child between the ages of 8 and 12 years and considered overweight or obese (BMI ≥85th percentile according to age and sex) were included. At least one parent/caregiver was required to participate in the program. Children with one or more comorbidities were excluded and referred to the Shapedown British Columbia clinical program.

Program

Blended GH

The blended GH program was delivered at the following local community centers in British Columbia, Canada: Prince George (YMCA of Northern British Columbia), Kelowna (YMCA of Okanagan), Surrey (Tong Louie Family YMCA), Surrey (City of Surrey), Burnaby (City of Burnaby), and Greater Victoria (West Shore Parks and Recreation Society). The program was theoretically informed by the multi-process action control (M-PAC) framework, which emphasizes social cognitive approaches to facilitate intention formation, adoption of action control through self-regulation, and an action control maintenance phase where behavior becomes habitual and self-identified [15]. The in-person component consisted of 10 weekly 120-minute group sessions delivered by trained facilitators at local community centers and community-based activities (eg, family grocery store tour led by a registered dietitian). The weekly in-person sessions included specific child activities (eg, physical activity games developing basic physical literacy skills such as throwing, kicking, and catching), parent activities (eg, facilitator-led discussion about using behavior change techniques as tools for modifying families' dietary or physical activity behaviors, reducing screen time, and developing parental support behaviors for child dietary and physical activity behaviors), and family activities (eg, family goal setting, physical activities, and recipes). The online component consisted of self-guided lessons for healthy living, which included a variety of physical activities, healthy eating activities, positive mental health family activities, and additional resources for parents. The online component complemented the weekly in-person group sessions. These online resources could be accessed via a mobile-friendly web portal. See Multimedia Appendix 1 for session activities and intervention details.

Virtual GH

The virtual GH program contained the same curriculum and used the same theoretical framework (M-PAC) as the blended GH program; however, the content of the program was adapted to be delivered online over a group video call (Zoom, Zoom Video Communications). Family activities were modified to accommodate this new delivery format. Program modifications included (1) reformatting the layout of each session (eg, front-loading all family time, replacing child-only physical activity time with family physical activity time, and ending with parent-only discussion time); (2) modifying activities and games for at-home delivery; and (3) replacing the additional community-based activities with virtual expert sessions (eg, virtual cooking classes with a registered dietitian, and virtual question and answer sessions with a physical activity or mental health expert). The self-guided component of the online portal was enhanced to include additional interactive videos and content to help families achieve a healthy lifestyle during the COVID-19 pandemic lockdown (eg, in-home fun family activities, screen time management tips, and resources for parents to support child dietary and physical activity behaviors). See Multimedia Appendix 1 for session activities and intervention details.

Procedure

Study data were collected from the parents and children using an online questionnaire at baseline and at follow-up. Demographic data, including the child's age and ethnicity, parents' education, annual household income, number of people in the household, and family structure status (ie, single parent), were collected at baseline. Child BMI was collected by a research assistant at the delivery sites for the blended program. However, child BMI was self-reported by parents for the virtual program owing to physical distancing measures.

Child Measures

Children's MVPA

The Physical Activity Questionnaire for older children (PAQ-C) was used to evaluate the number of days in the past week that children engaged in 60 minutes of MVPA [16]. Specifically, the question stated, "During the past week (7 days), on how many days were you physically active for a total of at least 60 minutes per day? Count all the time you spent doing activities that increased your heart rate or made you breathe hard." The response options were 0 to 7 days. The PAQ-C has been previously validated to assess MVPA among Canadian children and has a moderate correlation to the objective measures of MVPA (r=0.34, 95% CI 0.29-0.39) [17].

Children's Screen Time and Sedentary Behaviors

The Physician-based Assessment & Counseling for Exercise (PACE) adolescent psychosocial instrument was used to measure screen time and sedentary behavior [18]. The validity of the questionnaire has been previously demonstrated (ρ=0.4) [19-21]. The questionnaire assessed the number of hours on a school day and a weekend day that children engaged in sedentary behaviors (ie, sitting on the couch) and screen time behaviors (ie, using a smartphone, television, iPad, or computer). The responses ranged from 0 hours to 6 or more hours.

Children's Dietary Behaviors

Child dietary behaviors (ie, fruit and vegetable intake and sugary beverage intake) were assessed using questions drawn from the Centre for Disease Control and Prevention Behavioral Risk Factor Surveillance System (BRFSS) 7-day recall (intraclass correlation=0.50) [22]. The BRFSS survey included a 7-day recall with questions, such as, "in the last 7 days, how many times did you eat a green leafy or lettuce salad, with or without other vegetables?" and "in the last 7 days, how many times did you eat doughnuts, brownies, pies, or cakes?" The responses represented the number of times in the past week that the child consumed the items (1: none, 2: 1-3 times, 3: 4-6 times, 4: 1

time per day, 5: 2 times per day, 6: 3 time per day, and 7: 4 or more times per day).

Parental Support Behaviors

Parental Support for Healthy Eating and Physical Activity

A subscale drawn from the Family Life, Activity, Sun, Health, and Eating (FLASHE)-EAT survey (α=.77) [23] and the Parent Physical Activity Support survey (α=.72) [24,25] were used. The FLASHE-EAT survey and healthy eating items (5-point Likert Scale; 1, strongly disagree to 5, strongly agree) were "I have to make sure that my child eats enough fruits and vegetables," "I encourage my child to try different kinds of fruits and vegetables," and "Bought fruit or vegetables you know your child likes." The parental support for physical activity items (5-point Likert Scale; 1, strongly disagree to 5, strongly agree) were "I go out of my way to enroll my child in sports and other activities that get him/her to be physically active (eg after school programs and programs at the YMCA)," "I often watch my child participate in sporting activities (eg, watch your child perform at a softball game or dance recital)," and "I take my child to places where he/she can be active."

Self-regulation for Parental Support of Child Healthy Eating and Physical Activity

The Parent Support of Child Physical Activity Questionnaire was adapted from previous research [25-27] for measuring self-regulation for eating (α=.86) and physical activity (α=.89). This subscale assessed parents' regulation of their children's physical activity and healthy eating behaviors by measuring parents' goals and plans to support their children's behaviors over the next month. Specifically, the items were "I set short-term (daily or weekly) goals for how I could support my child's healthy eating/leisure-time physical activity behaviors last month" and "If I did not reach my goal/one of my goals for supporting my child's healthy eating/physical activity last month, I analyzed what went wrong," "I made plans regarding what to do if something made it difficult to support my child's healthy eating/physical activity last month," and "I made regular plans concerning when, where, how, and what kind of support I could provide for my child's eating behaviors and food choices/physical activity last month."

GH Engagement

Weekly GH program attendance for the in-person and virtual group video sessions was recorded by facilitators using a tracking form. Web analytics captured the total minutes spent interacting with the web portal content. The average minutes per week a family spent logged into the portal was calculated by dividing the total time by 10 (the length in weeks of the GH program).

Program Satisfaction

Program feedback questionnaires for participants were administered at the end of the interventions. The surveys prompted participants to (1) rate the weekly sessions (eg, please select whether you "liked" this session on a scale of 1 ["not at all"] to 5 ["a lot"]), (2) rate the level of satisfaction with intervention components (ie, family classroom, child physical activity, parent classroom, online portal, etc), and (3) rate the information given in weekly sessions (ie, was the information given in weekly sessions easy to understand, culturally suitable for your family, etc, with answers on a 5-point Likert scale ranging from 1 ["not at all"] to 5 ["a lot"]). Parents were also invited for a phone interview to provide further program feedback.

Statistical Analysis

All statistical analyses were conducted using R statistical software version 4.1.0 (R Foundation for Statistical Computing). We determined that the data were missing at random and performed mean imputation for missing outcome variables [28]. Independent samples *t* tests and chi-square tests were conducted to compare continuous and categorical demographic variables between groups, respectively. A repeated measures ANOVA was conducted to examine the main effects of time (baseline and follow-up), as well as the group (blended GH vs virtual GH) by time (baseline and follow-up) interaction for all outcome variables. Independent *t* tests were used to evaluate program satisfaction and engagement for the blended and virtual GH programs. All quantitative statistical techniques used in this study to generate the results had established a significance set at $P<.05$. Qualitative data from postprogram interviews on program feedback were transcribed using Transcriptive software (Digital Anarchy, Inc) and analyzed using NVivo 12 (QSR International). General categories and themes were identified using a framework analysis approach [29]. Themes were then summarized into areas of program improvements.

Results

Participant Characteristics

Overall, 192 participants were enrolled in the GH program and completed baseline surveys. Participants' demographic data are shown in Table 1. There was no significant difference between the blended and virtual GH groups in terms of children's age and ethnicity, household income, and the number of single parents. The mean child age was 10.10 (SD 1.63) years, and 50.0% (96/192) of the children who attended the GH programs were female. The GH programs reached a demographic representing the British Columbia population [30], whereby 45.8% (88/192) of the children were white, 6.3% (12/192) were indigenous, 12.0% (23/192) were Asian (South Asian, West Asian, Chinese, and Southeast Asian), and 7.3% (14/192) were black or Latin American. Of the 192 participants, 102 (53.1%) were in the blended GH program and 90 (46.9%) were in the virtual GH program. Of the 102 participants in the blended GH program, 71 (69.6%) completed the program and provided follow-up responses. Meanwhile, of the 90 participants in the virtual GH program, 62 (68.9%) completed the program. Demographic characteristics of the completers and noncompleters of the GH programs are shown in Multimedia Appendix 2. We found that the percentage of completion was significantly higher for nonsingle parents than for single parents in both the blended and virtual GH programs (χ^2_6 [N=192]=18.03; P=.01).

Table 1. Demographic information of participants in the blended and virtual Generation Health programs.

Characteristic	Blended GH[a] group (n=102)	Virtual GH group (n=90)	*P* value
Child age (years), mean (SD)	10.24 (1.53)	9.82 (1.82)	.11
Child BMI (>85th to ≤97th percentile), n (%)	41 (40)	41 (46)	.12
Child BMI (>97th percentile), n (%)	61 (61)	49 (54)	.14
Female child, n (%)	52 (51)	44 (49)	.97
Adults in household, mean (SD)	2.19 (1.07)	1.89 (0.64)	.02
Children in household, mean (SD)	1.94 (0.88)	1.94 (0.84)	.98
Child ethnicity, n (%)			
Indigenous	8 (7.8)	4 (4.4)	.23
White	43 (42.2)	45 (50.0)	.15
Asian (South Asian, West Asian, Chinese, and Southeast Asian)	15 (14.7)	8 (8.8)	.37
Black	6 (5.9)	2 (2.2)	.37
Latin American	2 (2.0)	4 (4.4)	.57
Arab	2 (2.0)	2 (2.0)	>.99
Other	17 (16.7)	12 (13.3)	.66
Missing values	8 (7.8)	7 (7.8)	>.99
Household income (CAD$[b])			
<$28,000	9 (8.8)	8 (8.9)	>.99
$28,000 to <$34,000	5 (4.9)	1 (1.1)	.27
$34,000 to <$41,000	6 (5.9)	4 (4.4)	.90
$41,000 to <$47,000	5 (4.9)	6 (6.7)	.83
$47,000 to <$53,000	6 (5.9)	6 (6.7)	>.99
$53,000 to <$59,000	5 (4.9)	3 (8.9)	.86
≥$59,000	42 (41.2)	44 (48.9)	.35
Prefer not to answer	16 (15.7)	11 (13.9)	.63
Missing values	16 (7.8)	14 (7.8)	>.99
Single parent			
Yes	25 (24.5)	15 (16.7)	.34
No	64 (62.7)	66 (73.3)	.16
Prefer not to answer	5 (4.9)	2 (2.2)	.55
Missing values	8 (7.8)	7 (7.8)	>.99

[a]GH: Generation Health.

[b]A currency exchange rate of CAD $1=US $0.73 is applicable.

Children's Physical Activity, Sedentary Behavior, Screen Time, and Dietary Outcomes

There was a main effect of time for days of MVPA and screen time (Table 2), suggesting that children in both groups reported significantly more days of reaching 60 minutes of MVPA ($F_{1,380}$=18.37; P<.001; ηp^2=0.07) and significantly lower screen time ($F_{1,380}$=9.17; P=.003; ηp^2=0.06). We also observed a significant interaction between group and time for vegetable intake among children. Specifically, participants in the virtual GH group reported significantly greater vegetable intake than those in the blended GH group at the 10-week follow-up ($F_{1,380}$=15.19; P<.001; ηp^2=0.004). No significant main effect of time or a group-by-time interaction was observed for fruit intake, sugary drink intake, or sedentary time (P>.05).

Table 2. Children's dietary, physical activity, sedentary behavior, and screen time data before and after the blended and virtual Generation Health programs.

Variable	Blended GH[a] group, mean (SD)		Virtual GH group, mean (SD)		Overall, mean (SD)		Main effect of time	Time-by-group interaction
	Pre	Post	Pre	Post	Pre	Post	*P* value	*P* value
Fruit intake (times per day in a typical week)	3.20 (1.21)	3.27 (0.94)	2.92 (0.95)	3.11 (0.52)	3.07 (1.10)	3.20 (0.77)	.60	.51
Vegetable intake (times per day in a typical week)	2.55 (0.94)	2.44 (0.78)	2.25 (0.62)	2.73 (0.52)[b]	2.41 (0.82)	2.58 (0.68)	.28	<.001
Child's sugary drink intake (times per day in a typical week)	1.72 (0.79)	1.60 (0.64)	1.70 (0.90)	1.41 (0.45)	1.71 (0.84)	1.51 (0.56)	.24	.22
60 min of MVPA[c] (days per week)	3.46 (1.81)	4.34 (1.29)	3.31 (1.60)	4.03 (1.03)	3.39 (1.71)	4.20 (1.18)[d]	<.001	.59
Sedentary time (hours per day)	3.35 (1.44)	3.24 (1.05)	3.97 (1.23)	3.53 (0.78)	3.64 (1.21)	3.38 (0.94)	.37	.72
Screen time (hours per day)	3.50 (1.38)	3.01 (1.01)	3.85 (1.32)	3.12 (0.72)	3.66 (1.36)	3.06 (0.88)[d]	.003	.43

[a]GH: Generation Health.

[b]Significantly higher in the blended group after the 10-week intervention.

[c]MVPA: moderate-to-vigorous physical activity.

[d]Overall effect of time is significantly higher after the 10-week intervention.

Parental Support Behaviors for Child Physical Activity and Dietary Behaviors

We detected a main effect of time for parental support for healthy eating ($F_{1,380}$=3.91; P<.001; ηp^2=0.01), self-regulation of support for healthy eating ($F_{1,380}$=91.13; P<.001; ηp^2=0.28), parental support for physical activity ($F_{1,380}$=5.55; P=.02; ηp^2=0.002), and self-regulation of support for physical activity ($F_{1,380}$=49.20; P<.001; ηp^2=0.16). After the intervention, parents reported higher scores on all these variables compared to the findings at baseline (Table 3). We also detected a significant group-by-time interaction for parental support for healthy eating ($F_{1,380}$=3.91; P=.04; ηp^2=0.01) and parental support for physical activity ($F_{1,380}$=6.66; P=.01; ηp^2=0.02). In both cases, parents in the blended GH group scored significantly higher than parents in the virtual GH group at follow-up.

Table 3. Preintervention and postintervention parental support for healthy eating and physical activity outcome variables.

Variable	Blended GH[a] group, mean (SD)		Virtual GH group, mean (SD)		Overall, mean (SD)		Main effect of time	Time-by-group interaction
	Pre	Post	Pre	Post	Pre	Post	*P* value	*P* value
Parental support for healthy eating	10.16 (1.17)	10.66 (0.79)[b]	10.09 (1.07)	10.21 (0.69)	10.13 (1.12)	10.46 (0.78)[c]	<.001	.04
Self-regulation of support for healthy eating	11.63 (3.58)	15.25 (2.25)	11.27 (3.30)	14.83 (1.86)	11.46 (3.45)	15.05 (2.08)[c]	<.001	.39
Parental support for physical activity	23.13 (3.62)	24.15 (2.67)[b]	22.81 (3.33)	22.20 (2.67)	22.98 (3.48)	23.24 (2.84)[c]	.02	.01
Self-regulation of support for physical activity	12.42 (3.38)	14.99 (2.43)	12.17 (3.24)	14.56 (2.00)	12.30 (3.29)	14.79 (2.24)[c]	<.001	.26

[a]GH: Generation Health.

[b]Significantly higher in the blended group after the 10-week intervention.

[c]Overall effect of time is significantly higher after the 10-week intervention.

Program Attendance

Blended GH attendance at the weekly in-person sessions was 77% for those who completed the program. Similarly, virtual GH attendance at the weekly group sessions was 76% for those who completed the program. There was no significant difference between blended and virtual GH completion rates (P=.65). Web portal usage was significantly greater for the virtual GH program than the blended GH program. Families who completed the blended GH program spent an average of 17 (SD 15.3) minutes

per week on the family portal, while families in the virtual GH program spent 50 (55.82) minutes (P<.001).

Program Satisfaction

Overall, parents were highly satisfied with both the blended and virtual programs. Nearly all parents who completed satisfaction surveys indicated that the weekly program sessions helped them learn and were useful for changing their lifestyle. There was no significant difference in the mean program satisfaction score between the blended (3.9/5) and virtual (3.8/5) GH programs. Postprogram interviews with parents identified areas of improvement for the virtual GH program. These included (1) a reminder from delivery staff about upcoming sessions on the day of the program; (2) support for implementing lifestyle changes for families who do not have a nuclear family structure; (3) a more in-depth explanation of how to navigate the family portal; (4) additional cooking class sessions; and (5) additional resources to support goal setting after the program ends.

Discussion

This study compared the effectiveness of a virtual GH program delivered during the COVID-19 pandemic with that of a blended GH program delivered prior to the pandemic. We observed that the virtual GH program was as effective as the blended GH program in improving child MVPA and reducing screen time. The virtual GH program appeared more effective than the blended GH program in improving vegetable intake among children. Additionally, parents in both the virtual and blended GH programs showed significant improvements in support behaviors for child physical activity and healthy eating, as well as self-regulation of support for child physical activity and healthy eating. Families in both the virtual and blended GH programs were satisfied with the program delivery. Overall, the findings from this study suggested that the virtual GH program was a feasible and effective option that has the added potential to improve the flexibility and scalability of delivering family-based childhood obesity management interventions.

Our results showed a large increase in child MVPA and a reduction in screen time following GH. Similar to the blended GH program, the virtual GH program added almost 1 day per week of at least 60 minutes of MVPA and reduced about 45 minutes of screen time per day. The multiple physical activity opportunities (eg, games and fundamental movement skills) during each session for children, the parent portal resources about limiting screen time and support for child physical activity, and the weekly family-based challenges may have contributed to intervention success. Our findings are consistent with the findings of previous studies. For example, a previous 12-week family-based childhood obesity management intervention (children aged 8-12 years) showed that MVPA increased by 53 minutes per week and screen time decreased by 34 minutes per day [31]. Similarly, in a previous 10-week family-based intervention (MEND) delivered in British Columbia, children showed an increase in weekly physical activity levels by 2.6 hours per week and a decrease in screen time by 3 hours per week following the intervention [10].

Furthermore, the findings about the levels of program engagement and satisfaction between the virtual and blended GH programs were noteworthy, as they suggested that families were willing to engage with the virtual delivery format. However, our results suggested that being a single parent may influence program completion, which has been previously reported [32,33]. Future studies must explore the potential reasons for not completing the program among single parents to help further improve intervention design. The increased portal engagement time may be a consequence of the additional interactive video and audio content. Conversely, it could be a consequence of more time at home during lockdown with less distractions and travel time for various activities. In our previous study evaluating the dose-response relationship of the blended GH program, we showed that the online GH portal complemented the in-person GH sessions. Specifically, additional engagements with the portal were associated with greater improvements in child physical activity and parental support behaviors, habits, and identity for physical activity [34]. Future research is warranted to explore the dose-response relationship for the virtual GH program. Overall, the results from this study are encouraging, especially since several studies have shown that child physical activity decreased while screen time increased during the pandemic [6,7].

Child vegetable intake following the intervention was significantly higher in the virtual GH group than in the blended GH group. This may have been due to the lockdown, as parents may have more opportunities to influence children's vegetable intake while they are at home every day [25]. However, previous childhood obesity interventions delivered in-person have reported significant improvements in dietary behaviors [10,11,35,36]. The lack of significant changes in the intake of fruits and sugary drinks may reflect a ceiling effect. Children at baseline were already consuming fruits about 5 times per day and were drinking sugary drinks 0 to 3 times per week. Furthermore, the unit (times per day in a typical week) of measure for changes in fruit and vegetable intake used in this study may not be as sensitive as other assessment tools (eg, servings of fruits and vegetables) to detect changes over the study period. Future studies may consider the use of other assessment tools that may be more sensitive to changes [37].

The findings of this study have several implications for family-based interventions aimed at promoting a healthy lifestyle for children who are overweight or obese. First, this is one of the first studies to demonstrate the effectiveness of adapting a blended family-based program to be delivered virtually during the COVID-19 pandemic for Canadians living in British Columbia. Second, this study showed that virtual family-based interventions could be as effective and engaging as a blended program to promote a healthy lifestyle among children. This suggests that a virtual approach is another GH program delivery option for families even after the pandemic. The virtual delivery format has the potential to improve the flexibility and scalability of family-based lifestyle programs designed for children who are overweight or obese. The results from this study add to the existing body of literature showing the effectiveness of virtual and online health interventions [31,34-36]. The family feedback received (eg, reminder sessions, portal tutorials, and

maintenance programs) can help inform future virtual intervention designs.

We recognize that this study is not without limitations. First, the program evaluation was only up to 10 weeks. Thus, the long-term effects of virtual and blended GH programs remain unclear, and future research is warranted. Second, this study lacked a control group, which may introduce potential bias. Third, we did not control for potential secular effects (eg, season and weather), which may influence lifestyle behaviors. Future studies are warranted to explore the effects of these potential variables on intervention effectiveness. Fourth, even though all the child and parental measures have been validated, the self-report measures may introduce potential bias. Furthermore, some questions used to assess parental support for physical activity were not pertinent during the COVID-19 pandemic. For example, parents were asked to respond to the statement, "I go out of my way to enroll my child in sports and other activities to get him/her to be physically active." During the initial months of the COVID-19 pandemic, schools were closed and extracurricular activities for children were cancelled. Therefore, we cannot be sure that parent responses to these survey items accurately reflected their opinions and attitudes or the contextual factors. Finally, the children's BMI was self-reported by caregivers during virtual GH delivery, and this may introduce bias. Future studies could consider collecting parental BMI, as it can influence a child's weight and lifestyle behaviors [38]. Finally, this study used a pre-post comparison design, where data were collected during different time periods. Thus, caution is required when generalizing the results.

Overall, a 10-week family-based intervention (the GH program) was effective in improving days of MVPA among children and reducing screen time, regardless of the delivery method (blended vs virtual). Similarly, satisfaction was high across delivery methods. Our findings suggest that virtually delivered early intervention programs are not inferior to in-person programs and offer an alternative delivery approach that enhances program flexibility and potential scalability.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Blended Generation Health and virtual Generation Health program outline.
[DOCX File , 36 KB - pediatrics_v5i4e40431_app1.docx]

Multimedia Appendix 2
Demographic information of Generation Health program completers and noncompleters.
[DOCX File , 19 KB - pediatrics_v5i4e40431_app2.docx]

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Abbreviations

BRFSS: Behavioral Risk Factor Surveillance System
GH: Generation Health
FLASHE: Family Life, Activity, Sun, Health, and Eating
M-PAC: multi-process action control
MVPA: moderate-to-vigorous physical activity
PAQ-C: Physical Activity Questionnaire for older children

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Original Paper

Assessing the Racial and Socioeconomic Disparities in Postpartum Depression Using Population-Level Hospital Discharge Data: Longitudinal Retrospective Study

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Abstract

Background: In the United States, >3.6 million deliveries occur annually. Among them, up to 20% (approximately 700,000) of women experience postpartum depression (PPD) according to the Centers for Disease Control and Prevention. Absence of accurate reporting and diagnosis has made phenotyping of patients with PPD difficult. Existing literature has shown that factors such as race, socioeconomic status, and history of substance abuse are associated with the differential risks of PPD. However, limited research has considered differential temporal associations with the outcome.

Objective: This study aimed to estimate the disparities in the risk of PPD and time to diagnosis for patients of different racial and socioeconomic backgrounds.

Methods: This is a longitudinal retrospective study using the statewide hospital discharge data from Maryland. We identified 160,066 individuals who had a hospital delivery from 2017 to 2019. We applied logistic regression and Cox regression to study the risk of PPD across racial and socioeconomic strata. Multinomial regression was used to estimate the risk of PPD at different postpartum stages.

Results: The cumulative incidence of PPD diagnosis was highest for White patients (8779/65,028, 13.5%) and lowest for Asian and Pacific Islander patients (248/10,760, 2.3%). Compared with White patients, PPD diagnosis was less likely to occur for Black patients (odds ratio [OR] 0.31, 95% CI 0.30-0.33), Asian or Pacific Islander patients (OR 0.17, 95% CI 0.15-0.19), and Hispanic patients (OR 0.21, 95% CI 0.19-0.22). Similar findings were observed from the Cox regression analysis. Multinomial regression showed that compared with White patients, Black patients (relative risk 2.12, 95% CI 1.73-2.60) and Asian and Pacific Islander patients (relative risk 2.48, 95% CI 1.46-4.21) were more likely to be diagnosed with PPD after 8 weeks of delivery.

Conclusions: Compared with White patients, PPD diagnosis is less likely to occur in individuals of other races. We found disparate timing in PPD diagnosis across different racial groups and socioeconomic backgrounds. Our findings serve to enhance intervention strategies and policies for phenotyping patients at the highest risk of PPD and to highlight needs in data quality to support future work on racial disparities in PPD.

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KEYWORDS

health disparity; hospital discharge summary; phenotyping; data quality; vulnerable population; postpartum depression; maternal health

Introduction

Background

In the United States, >3.6 million deliveries occur each year. Among them, up to 20% (approximately 700,000) of women experience postpartum depression (PPD) according to the Centers for Disease Control and Prevention [1,2]. However, this rate could be underestimated because of low screening rates, high proportions of unreported or undiagnosed cases, lack of help-seeking behavior, and cultural stigma [3-7]. Thus, it is challenging to phenotype patients with the highest risk for PPD. PPD can occur anytime in the following year after delivery. The earlier the diagnosis, the more favorable the outcomes of the treatment. PPD can negatively affect women's postpartum health and child development if left untreated [8]. Given its detrimental impacts, we must address how disparate PPD outcomes and complications could be attributed to demographic, socioeconomic, and behavioral factors [9,10].

Existing literature has shown that factors such as race, socioeconomic status, and history of substance abuse are associated with the differential risks of PPD. One such study found that the odds of hospital-based PPD (emergency room and inpatient visits, as defined in the study) were highest among the Black population and lowest among the Asian population [11]. Similarly, other researchers have found that African American and Latina mothers from small towns, cities, and rural areas are more vulnerable to PPD compared with White mothers [12]. Accrued evidence suggests that compared with White women, women of other races, women of lower socioeconomic status, those not living in urban areas, and those with a history of depression are more likely to be diagnosed with PPD [13]. However, limited research has considered how certain factors could have temporal associations with the outcome [14].

The disparity in PPD is also attributed to sociocultural factors. Previous research has documented that racial and ethnic groups perceive PPD differently [15-18]. Although consensus on which racial group exhibits greater help-seeking behavior is lacking, hesitancy to seek treatment is the common theme. Across White, Hispanic, Asian, and women of other races, many do not believe that they warranted treatment for PPD [3,4]. Social and cultural stigmas may have contributed to this perception to varying degrees. Those who seek help would be diagnosed and treated early on, and those who are more reluctant are more likely to develop adverse outcomes. The entirety of cultural perception of PPD is difficult to assess; however, its impact cannot be overlooked in understanding the racial disparity in PPD and its timing.

Objective

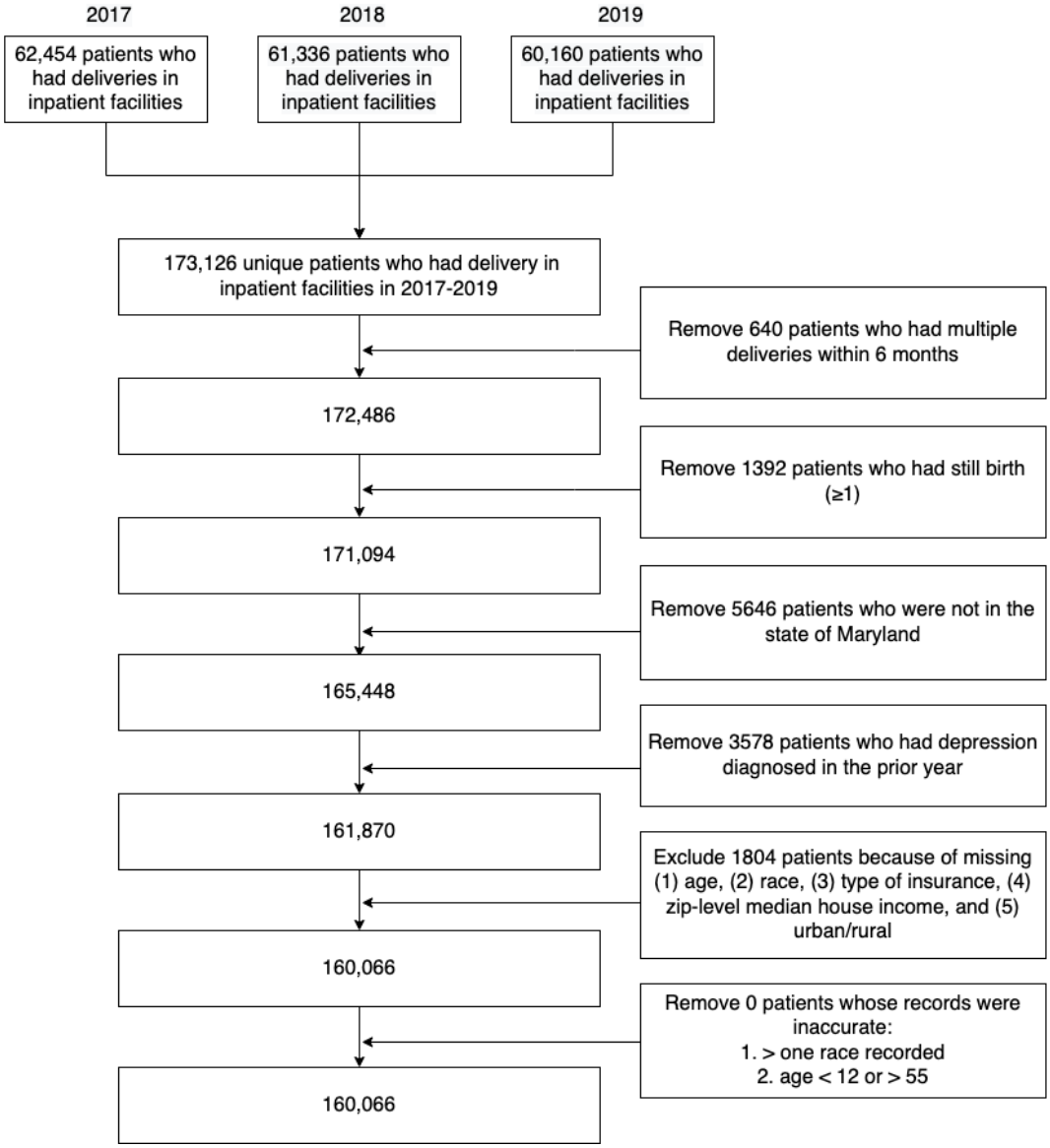
PPD screening and intervention strategies should not come as a one-size-fits-all approach, but rather be built upon the knowledge of disparate risks and timing of PPD. To address this gap, we investigated the racial and ethnic disparities in the risk and timing of PPD diagnosis using longitudinal statewide hospital discharge data.

Methods

Data Sources and Study Population

The Healthcare Cost and Utilization Project (HCUP) data contain the largest longitudinal collection of all-payer, encounter-level data in the United States [19]. In this study, we used the HCUP Maryland state data sets (ie, hospital-based care including hospital inpatient, emergency department, and ambulatory care services) from 2016 to 2019. We only included individuals whose sex was registered as female. A total of 173,126 females had a hospitalization for delivery and had at least one inpatient postpartum visit within the outcome time frame (2017 to 2019). According to the World Health Organization, extremely preterm births are births that occurred before 28 weeks (approximately 7 months) of pregnancy [20]. We excluded those who had multiple deliveries within 6 months because they were more likely to be attributed to data inaccuracies than preterm births. As we were only interested in PPD among females with live births, 1392 females with pregnancy terminations (including stillbirths) were excluded. We then excluded 5646 individuals who had hospital encounters outside of Maryland. As studies have shown that a history of depression increases the likelihood of PPD, we excluded those who had a depression diagnosis a year before their delivery encounter. For example, females who delivered in 2017 were filtered for a depression diagnosis in 2016. Finally, 1804 patients were excluded owing to missingness of data on age, race, insurance type, zip-level median household income, or urbanicity. The final study population included 160,066 patients (Figure 1).

Figure 1. CONSORT (Consolidated Standards of Reporting Trials) diagram depicting the study population selection process.



Dependent Variables

The outcomes of interest were PPD diagnosis (hereon referred to as PPD) and the time to diagnosis from childbirth. PPD was defined and identified based on the presence of selected International Classification of Diseases (ICD-10) diagnosis codes (Multimedia Appendix 1) for depression in the first 12 months after delivery [14]. The timing of PPD diagnosis was measured by the number of days after delivery.

Independent Variables

The independent variables included age, race and ethnicity, marital status, zip-level median household income, primary insurance type (referred to as insurance), and residential area type (ie, urban vs rural). Race and ethnicity were categorized into 6 major groups: non-Hispanic White, non-Hispanic Black, non-Hispanic Asian or Pacific Islander, non-Hispanic Native American, Hispanic, and other (races). In this study, we refer to non-Hispanic White as White, non-Hispanic Black as Black, non-Hispanic Asian or Pacific Islander as Asian or Pacific Islander, and non-Hispanic Native American as Native American.

Statistical Analysis

We fitted a multivariate logistic regression model to explore the association between PPD diagnosis and the covariates, which included age, race and ethnicity, marital status, zip-level median household income, primary insurance type, and the residential area type. We also included the Charlson Comorbidity Index score because existing literature points to the positive association between chronic conditions and postpartum mental illness [21]. We calculated the cumulative incidence of PPD over the 12-month postpartum period stratified by race and ethnicity. We then applied the Cox regression model, treating the outcome as a time-to-event variable, to examine the association between PPD and race and ethnicity over the postpartum period adjusted by the other covariates. We treated patients with no depression records by the end of the year as censored observations, and the time to censoring was calculated based on the date of the patient's last encounter. We further performed a log-rank test

to examine differences in the timing of PPD diagnosis for each race and ethnicity.

Guided by previous studies, we adopted the cutoffs for the timing of PPD diagnosis as within 4 weeks, 4 to 8 weeks, and beyond 8 weeks after delivery [22]. Using these temporal cutoffs, we conducted multinomial logistic regression to further explore the risk differences for patients of different ages, race and ethnicity, marital status, primary insurance type, and residential area type.

For all regression models, associated CIs and *P* values were calculated. *P* values of <.001 were deemed statistically significant.

Sensitivity Analysis

We performed a sensitivity analysis to assess whether our findings were robust against the exclusion of having a history of depression (Multimedia Appendix 2). Additional logistic regression, Cox regression, and multinomial regression were performed by including patients who had prior depression (encounter records of any diagnosis of ICD-10 Clinical Modification codes of depression).

In the primary analysis, we defined the diagnosis of PPD based on the existence of any depression-related ICD-10 codes within 1 year after giving birth. However, HCUP data are at the hospital discharge summary level; thus, each observation contains all the information on one entire hospital stay, excluding the more granular data. Furthermore, there is no specific ICD-10 code for “baby blues” (referred to as short-lasting moodiness and sadness in mothers), which occurs in 80% of the women 2-3 days after childbirth. Therefore, based on the current data source, we did not distinguish women who had PPD from those who had “baby blues.” We performed additional logistic regression by excluding patients who were diagnosed with depression during the same hospital stay as the delivery.

All visualization and statistical analyses were conducted using R (version 4.1.2; R Foundation for Statistical Computing) and the package survival [23,24].

Ethics Approval

The Johns Hopkins institutional review board determined this study as a nonhuman subject research. Under section 8 of the Health Insurance Portability and Accountability Act of the HCUP Data Use Agreement, it states that HCUP, which conforms to the definition of a limited data set, does not require institutional review board review.

Results

Diagnosis of PPD

Our study included 160,066 women who underwent a delivery hospitalization in Maryland from January 1, 2017, to December 31, 2019. Table 1 presents the demographic information of the study population grouped by the presence of PPD diagnosis. Of the study population, 40.63% (66,939/160,066) were White, 30.58% (48,953/160,066) were Black, 17.78% (28,465/160,066) were Hispanic, 6.72% (10,760/160,066) were Asian or Pacific Islander, 0.37% (590/160,066) were Native American, and 3.92% (6270/160,066) were of other races and ethnicities. We also stratified the population characteristics by race groups (Table S1 in Multimedia Appendix 2). Compared with White women, Black and Hispanic women had higher proportions of public insurance (54.5% and 64.8%, respectively) enrollees. Among all racial groups, the Black population had the highest proportion of individuals living in areas with <US $59,000 median household income (26,360/160,066, 16.47%).

The cumulative incidence of PPD in hospital-based care for women with no prior depression in the first year after delivery was 8.31% (13,297/160,066). Figure 2 compares the cumulative incidence of PPD among patients of different race and ethnicity. The cumulative incidence was the highest for White women (8779/65,028, 13.5%) and lowest for Asian and Pacific Islander women (248/10,760, 2.3%). Figure 3 shows the distribution of the timing of PPD diagnosis. Among those diagnosed, 91.1% (12,113/13,297) were diagnosed during the same hospital stay as childbirth (0 days to PPD diagnosis). The longest time to diagnosis after delivery was 349 days. Excluding patients who were diagnosed during the same hospital stay as childbirth, the median time to diagnosis was 68 days. The median time to diagnosis was 65 days for White women, 76 days for Black women, 51 days for Hispanic women, 66 days for Asian or Pacific Islander women, 20 days for Native American women, and 60 days for women of other races and ethnicities.

Table 1. Population demographics stratified by the presence of postpartum depression (PPD) diagnosis.

Variable	No PPD (n=146,769)	PPD (n=13,297)
Age (years)		
Mean (SD)	30.0 (5.74)	29.9 (5.67)
Median (Range)	30.0 (12.0-55.0)	30.0 (13.0-51.0)
Race, n (%)		
White	56,249 (38.32)	8779 (66.02)
Black	46,059 (31.38)	2894 (21.76)
Hispanic	27,491 (18.73)	974 (7.32)
Asian or Pacific Islander	10,512 (7.16)	248 (1.86)
Native American	560 (0.38)	30 (0.22)
Other	5898 (4.02)	372 (2.8)
Marital status, n (%)		
Single	58,807 (40.07)	5635 (42.38)
Married	82,996 (56.55)	7100 (53.39)
Legally separated	755 (0.51)	114 (0.86)
Divorced	1156 (0.79)	235 (1.77)
Widowed	97 (0.07)	25 (0.19)
Other	2958 (2.01)	188 (1.41)
Zip-level median household income (US $), n (%)		
1-45,999	10,690 (7.28)	1176 (8.84)
46,000-58,999	12,906 (8.79)	1588 (11.94)
59,000-78,999	50,205 (34.2)	4028 (30.29)
>79,000	72,968 (49.72)	6505 (48.92)
Insurance type, n (%)		
Medicaid	59,279 (40.39)	4992 (37.54)
Medicare	311 (0.21)	113 (0.85)
Private insurance	77,556 (52.84)	7603 (57.18)
Self-pay	3136 (2.14)	125 (0.94)
No charge	2152 (1.47)	50 (0.38)
Other	4335 (2.95)	414 (3.11)
Urban or rural, n (%)		
Metropolitan areas of ≥1 million population	132,081 (89.99)	11,376 (85.55)
Metropolitan areas of 250,000 to 1 million population	7031 (4.79)	1172 (8.81)
Metropolitan areas of <250,000 population	4479 (3.05)	407 (3.06)
Urban population of 2500 to 19,999, adjacent to a metropolitan area	3176 (2.16)	342 (2.57)
Urban population of 2500 to 19,999, not adjacent to a metropolitan area	1 (0)	0 (0)
Completely rural or <2500 urban population, adjacent to a metropolitan area	1 (0)	0 (0)
Charlson Comorbidity Index score		
Mean (SD)	0.134 (0.430)	0.257 (0.586)
Median (Range)	0 (0-12.0)	0 (0-9.00)

Figure 2. Cumulative incidence by race. Solid lines represent the cumulative incidence. Dashed lines represent the lower and upper bounds of the 95% CI.

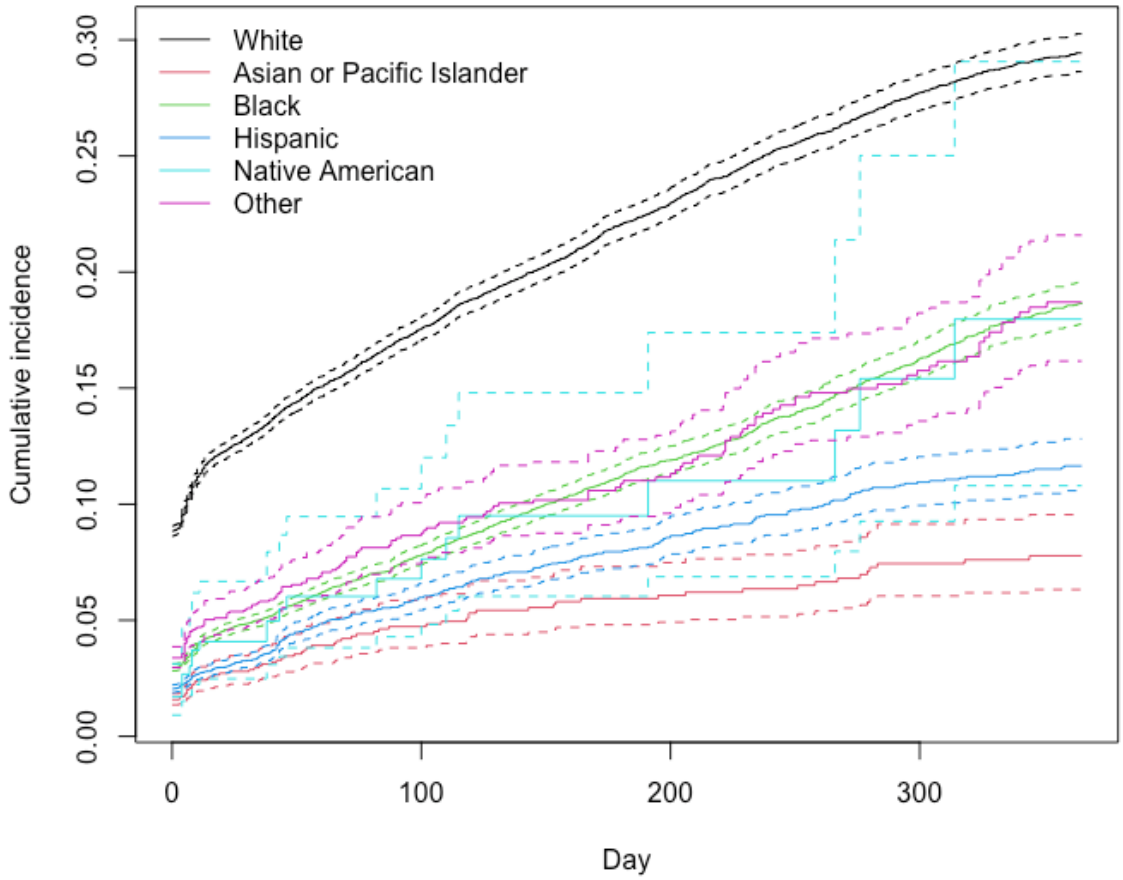


Figure 3. Time to postpartum depression (PPD) diagnosis (Left: including PPDs that occurred on the day of delivery; Right: excluding PPDs that occurred on the day of delivery).

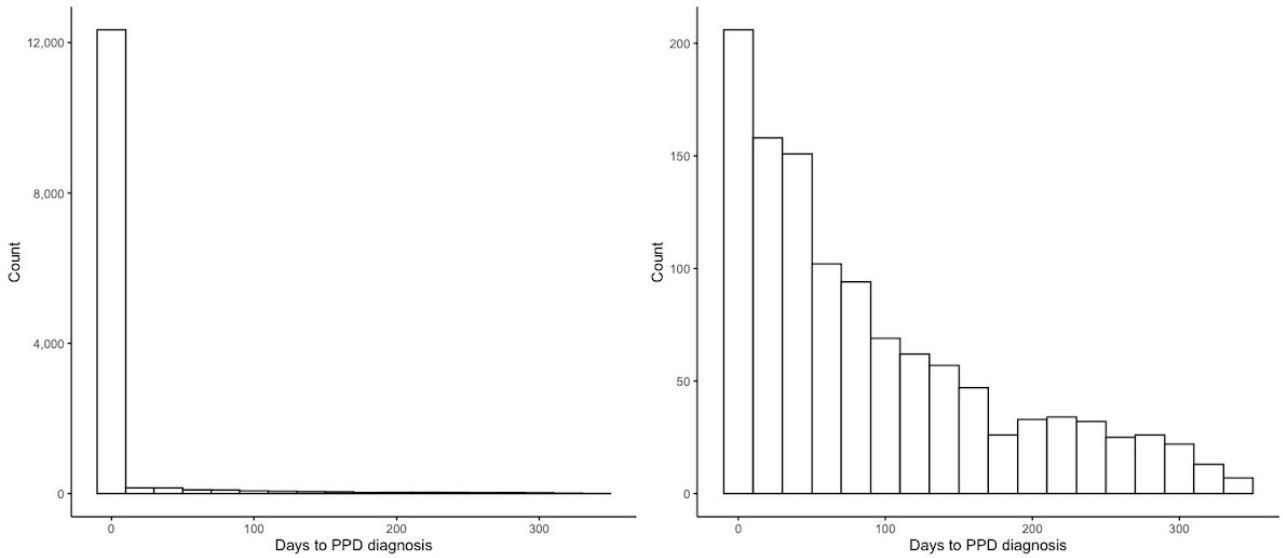


Table 2 shows the results of a multivariate logistic regression to assess the association between racial and socioeconomic factors and the risk of PPD. Compared with White women, the adjusted odds ratio (OR) of PPD was significantly lower for Black women (OR 0.31, 95% CI 0.30-0.33), Asian or Pacific Islander women (OR 0.17, 95% CI 0.15-0.19), Hispanic women (OR 0.21, 95% CI 0.19-0.22), Native American women (OR 0.35, 95% CI 0.24-0.50), and women of other races and ethnicities (OR 0.38, 95% CI 0.34-0.42). Married women have significantly higher odds of PPD than women who were divorced (OR 1.99, 95% CI 1.71-2.31), legally separated (OR 1.97, 95% CI 1.60-2.41), single (OR 1.45, 95% CI 1.38-1.51), or widowed (OR 2.96, 95% CI 1.82-4.64). Women living in areas with a median household income <US $46,000 have lower odds of PPD than women living in areas with median household income >US $59,000 (OR 0.79, 95% CI 0.73-0.85). Compared

with women who enrolled in private insurance, the odds of PPD were higher for women with Medicare (OR 3.40, 95% CI 2.69-4.26) and lower for women who self-paid (OR 0.70, 95% CI 0.58-0.84) or had no charge such as charities (OR 0.60, 95% CI 0.45-0.80). Compared with women living in metropolitan areas with population sizes >1 million, the odds of PPD were lower for those living in metropolitan areas with population sizes <250,000 (OR 0.60, 95% CI 0.54-0.67), lower for those living in urban areas with population sizes of 2500 to 19,999 (adjacent to a metropolitan area; OR 0.75, 95% CI 0.66-0.84), and higher for those living in metropolitan areas with population sizes of 250,000 to 1 million (OR 1.21, 95% CI 1.13-1.30). Women with higher Charlson Comorbidity Index scores had higher odds of PPD than those with lower Charlson Comorbidity Index scores (OR 1.47, 95% CI 1.43-1.52).

Table 3 presents the results of the multivariate Cox regression analysis. Compared with White women, the adjusted hazards of PPD were significantly lower for Black women (hazard ratio [HR] 0.34, 95% CI 0.33-0.36), Asian and Pacific Islander women (HR 0.21, 95% CI 0.19-0.24), Hispanic women (HR 0.27, 95% CI 0.25-0.29), Native American women (HR 0.36, 95% CI 0.25-0.52), and women of other races and ethnicities (HR 0.43, 95% CI 0.38-0.48). Women >35 years (HR 1.10, 95% CI 1.05-1.15) had higher hazards of PPD compared with those aged 20 to 35 years. Compared with married women, the hazards of PPD were significantly higher for women who were divorced (HR 1.78, 95% CI 1.55-2.05), legally separated (HR 1.75, 95% CI 1.44-2.12), single (HR 1.42, 95% CI 1.35-1.48), widowed (HR 2.84, 95% CI 1.87-4.32), or those with missing marital status records (HR 1.29, 95% CI 1.12-1.50). Compared with women who lived in areas with median household incomes of <US $46,000, the hazards were lower for women who lived in areas with median household incomes of US $59,000-78,999 (HR 0.85, 95% CI 0.80-0.92) and areas of income >US $79,000 (HR 0.86, 95% CI 0.81-0.93). Compared with women enrolled in private insurance, the hazards of PPD were higher for women enrolled in Medicare (HR 2.13, 95% CI 1.76-2.59) but lower for women who had no charges such as charities (HR 0.44, 95% CI 0.33-0.59) or self-paid (HR 0.56, 95% CI 0.47-0.67). Compared with women living in metropolitan areas with population sizes of >1 million, women living in metropolitan areas with population sizes of 250,000 to 1 million had higher hazards of PPD (HR 1.14, 95% CI 1.07-1.23). In contrast, the hazards of PPD were lower for those living in metropolitan areas with population size <250,000 (HR 0.57, 95% CI 0.51-0.64) and those living in urban areas with a population size of 2500 to 19,999 (adjacent to a metropolitan area; HR 0.73, 95% CI 0.65-0.82). Women with higher Charlson Comorbidity Index scores had higher hazards of PPD compared with those with lower Charlson Comorbidity Index scores (HR 1.19, 95% CI 1.17-1.23). The log-rank test suggested a significant difference in the timing of diagnosis among patients of different races and ethnicities at the 0.1% level (Table 4).

The results of the multinomial logistic regression are presented in Table 5. Compared with White women, the risk of diagnosis after 8 weeks relative to within 4 weeks was significantly higher for Black women (relative risk [RR] 2.12, 95% CI 1.73-2.60) and Asian and Pacific Islander women (RR 2.48, 95% CI 1.46-4.21). Compared with women enrolled in private insurance, women who had Medicaid (RR 1.69, 95% CI 1.37-2.10) or self-paid (RR 3.65, 95% CI 2.05-6.50) had higher risks of diagnosis after 8 weeks relative to before 4 weeks. Women who had no charge (such as charities or donations) had a higher risk of diagnosis after 4 to 8 weeks relative to before 4 weeks (RR 9.76, 95% CI 3.79-25.08). Compared with women living in metropolitan areas with population sizes >1 million, the risks of PPD in 4 to 8 weeks relative to before 4 weeks were lower for those living in metropolitan areas with population sizes of 250,000 to 1 million (RR 0.20, 95% CI 0.08-0.51). Compared with women living in metropolitan areas with population sizes of >1 million, the risks of PPD after 8 weeks relative to before 4 weeks were higher for those living adjacent to metropolitan areas with population sizes of 2500 to 19,999 (RR 2.15, 95% CI 1.42-3.25). Women who had higher Charlson Comorbidity Index scores exhibited higher risks of diagnosis in both 4 to 8 weeks (RR 1.34, 95% CI 1.14-1.56) and after 8 weeks (RR 1.28, 95% CI 1.16-1.41) relative to before 4 weeks (RR 1.34, 95% CI 1.14-1.56; RR 1.28, 95% CI 1.16-1.41).

Table 2. Multivariate logistic regression depicting the association between racial and socioeconomic factors and risk of postpartum depression.

Variable	Odds ratio (95% CI)	*P* value
Age group (years)		
20-35	Ref[a]	N/A[b]
<20	1.05 (0.95-1.16)	.31
≥35	1.05 (1.01-1.10)	.02
Race		
White	Ref	N/A[b]
Black	0.31 (0.30-0.33)	<.001[c]
Hispanic	0.21 (0.19-0.22)	<.001[c]
Asian or Pacific Islander	0.17 (0.15-0.19)	<.001[c]
Native American	0.35 (0.24-0.50)	<.001[c]
Other	0.38 (0.34-0.42)	<.001[c]
Marital status		
Married	Ref	N/A[b]
Single	1.45 (1.38-1.51)	<.001[c]
Legally separated	1.97 (1.60-2.41)	<.001[c]
Divorced	1.99 (1.71-2.31)	<.001[c]
Widowed	2.96 (1.82-4.64)	<.001[c]
Other	1.26 (1.08-1.46)	.003
Zip-level median household income (US $)		
1-45,999	Ref	N/A[b]
46,000-58,999	0.98 (0.90-1.06)	.56
59,000-78,999	0.79 (0.73-0.85)	<.001[c]
>79,000	0.79 (0.74-0.85)	<.001[c]
Insurance type		
Private insurance	Ref	N/A[b]
Medicaid	1.08 (1.03-1.13)	.002
Medicare	3.40 (2.69-4.26)	<.001[c]
Self-pay	0.70 (0.58-0.84)	<.001[c]
No charge	0.60 (0.45-0.80)	<.001[c]
Other	1.16 (1.04-1.28)	.007
Urban or rural		
Metropolitan areas of ≥1 million population	Ref	N/A[b]
Metropolitan areas of 250,000 to 1 million population	1.21 (1.13-1.30)	<.001[c]
Metropolitan areas of <250,000 population	0.60 (0.54-0.67)	<.001[c]
Urban population of 2500 to 19,999, adjacent to a metropolitan area	0.75 (0.66-0.84)	<.001[c]
Urban population of 2500 to 19,999, not adjacent to a metropolitan area[d]	N/A	N/A
Completely rural or <2500 urban population, adjacent to a metropolitan area[d]	N/A	N/A

Variable	Odds ratio (95% CI)	*P* value
Charlson Comorbidity Index score	1.47 (1.43-1.52)	<.001[c]

[a]Ref: reference group.

[b]N/A: not applicable.

[c]*P*<.001 indicates statistical significance.

[d]Estimates could not be calculated owing to small sample size.

Table 3. Multivariate Cox regression depicting the association between the racial and socioeconomic factors and hazards of postpartum depression.

Variable	Hazard ratio (95% CI)	*P* value
Age group (years)		
20-35	Ref[a]	N/A[b]
<20	1.11 (1.01-1.23)	.03
≥35	1.10 (1.05-1.15)	<.001[c]
Race		
White	Ref	N/A[b]
Black	0.34 (0.33-0.36)	<.001[c]
Hispanic	0.27 (0.25-0.29)	<.001[c]
Asian or Pacific Islander	0.21 (0.19-0.24)	<.001[c]
Native American	0.36 (0.25-0.52)	<.001[c]
Other	0.43 (0.38-0.48)	<.001[c]
Marital status		
Married	Ref	N/A[b]
Single	1.42 (1.35-1.48)	<.001[c]
Legally separated	1.75 (1.44-2.12)	<.001[c]
Divorced	1.78 (1.55-2.05)	<.001[c]
Widowed	2.84 (1.87-4.32)	<.001[c]
Other	1.29 (1.12-1.50)	<.001[c]
Zip-level median household income (US $)		
1-45,999	Ref	N/A[b]
46,000-58,999	1.02 (0.94-1.11)	.58
59,000-78,999	0.85 (0.80-0.92)	<.001[c]
>79,000	0.86 (0.81-0.93)	<.001[c]
Insurance type		
Private insurance	Ref	N/A[b]
Medicaid	0.96 (0.92-1.01)	.11
Medicare	2.13 (1.76-2.59)	<.001[c]
Self-pay	0.56 (0.47-0.67)	<.001[c]
No charge	0.44 (0.33-0.59)	<.001[c]
Other	1.11 (1.00-1.23)	.06
Urban or rural		
Metropolitan areas of ≥1 million population	Ref	N/A[b]
Metropolitan areas of 250,000 to 1 million population	1.14 (1.07-1.23)	<.001[c]
Metropolitan areas of <250,000 population	0.57 (0.51-0.64)	<.001[c]
Urban population of 2500 to 19,999, adjacent to a metropolitan area	0.73 (0.65-0.82)	<.001[c]
Urban population of 2500 to 19,999, not adjacent to a metropolitan area[d]	N/A	N/A
Completely rural or <2500 urban population, adjacent to a metropolitan area[d]	N/A	N/A

Variable	Hazard ratio (95% CI)	*P* value
Charlson Comorbidity Index score	1.19 (1.17-1.23)	<.001[c]

[a]Ref: reference group.

[b]N/A: not applicable.

[c]*P*<.001 indicates statistical significance.

[d]Estimates could not be calculated owing to small sample size.

Table 4. Log-rank test depicting the survival by race groups.

Log-rank test	Chi-square *(df)*	*P* value
White versus Black	1676 (1)	<.001[a]
White versus Asian or Pacific Islander	785 (1)	<.001[a]
White versus Hispanic	1676 (1)	<.001[a]
White versus Native American	36.2 (1)	<.001[a]
White versus other	241 (1)	<.001[a]

[a]*P*<.001 indicates statistical significance.

Table 5. Multivariate multinomial regression depicting the association between the racial and socioeconomic factors and the timing of postpartum depression diagnosis (between 4 and 8 weeks and after 8 weeks compared with before 4 weeks).

Variable	After 8 weeks, RR[a] (95% CI)	*P* value	Between 4 and 8 weeks, RR (95% CI)	*P* value
Age group (years)				
20-35	Ref[b]	N/A[c]	N/A[c]	N/A[c]
<20	0.91 (0.63-1.32)	.62	0.84 (0.42-1.67)	.61
≥35	0.98 (0.78-1.22)	.82	1.22 (0.85-1.74)	.28
Race				
White	Ref	N/A[c]	N/A[c]	N/A[c]
Black	2.12 (1.73-2.60)	<.001[d]	1.55 (1.07-2.23)	.02
Hispanic	1.32 (0.9-1.83)	.10	1.31 (0.75-2.28)	.34
Asian or Pacific Islander	2.48 (1.46-4.21)	<.001[d]	3.19 (1.44-7.04)	.004
Native American	1.06 (0.14-7.87)	.96	3.05 (0.40-23.07)	.28
Other	1.19 (0.71-2.00)	.51	1.96 (0.97-3.96)	.06
Marital status				
Married	Ref	N/A[c]	N/A[c]	N/A[c]
Single	1.34 (1.08-1.66)	.008	1.47 (1.02-2.12)	.04
Legally separated	1.76 (0.89-3.50)	.11	0.64 (0.09-4.73)	.66
Divorced	1.24 (0.66-2.34)	.51	0.70 (0.17-2.93)	.63
Widowed[e]	0.99 (0.13-7.41)	.99	N/A[e]	N/A[e]
Other	0.71 (0.31-1.64)	.42	2.78 (1.32-5.90)	.007
Zip-level median household income (US $)				
1-45,999	Ref	N/A[c]	N/A[c]	N/A[c]
46,000-58,999	1.00 (0.73-1.37)	.98	2.15 (1.20-3.86)	.01
59,000-78,999	1.02 (0.77-1.34)	.91	1.55 (0.91-2.65)	.11
>79,000	1.00 (0.75-1.33)	.99	0.97 (0.56-1.68)	.9
Insurance type				
Private insurance	Ref	N/A[c]	N/A[c]	N/A[c]
Medicaid	1.69 (1.37-2.10)	<.001[d]	1.32 (0.92-1.90)	.13
Medicare	1.87 (0.94-3.70)	.07	N/A[e]	N/A[e]
Self-pay	3.65 (2.05-6.50)	<.001[d]	2.29 (0.80-6.57)	.12
No charge	1.51 (0.35-6.57)	.58	9.76 (3.79-25.08)	<.001[d]
Other	2.00 (1.29-3.10)	.002	0.62 (0.19-1.97)	.41
Urban or rural				
Metropolitan areas of ≥1 million population	Ref	N/A[c]	N/A[c]	N/A[c]
Metropolitan areas of 250,000 to 1 million population	1.20 (0.89-1.62)	.22	0.20 (0.08-0.51)	<.001[d]
Metropolitan areas of <250,000 population	1.32 (0.83-2.10)	.24	2.23 (1.17-4.24)	.01
Urban population of 2500 to 19,999, adjacent to a metropolitan area	2.15 (1.42-3.25)	<.001[d]	0.45 (0.14-1.44)	.18
Urban population of 2500 to 19,999, not adjacent to a metropolitan area[e]	N/A	N/A	N/A	N/A

Variable	After 8 weeks, RR[a] (95% CI)	*P* value	Between 4 and 8 weeks, RR (95% CI)	*P* value
Completely rural or <2500 urban population, adjacent to a metropolitan area[e]	N/A	N/A	N/A	N/A
Charlson Comorbidity Index score	1.28 (1.16-1.41)	<.001[d]	1.34 (1.14-1.56)	<.001[d]

[a]RR: relative risk.

[b]Ref: reference group.

[c]N/A: not applicable.

[d]*P*<.001 indicates statistical significance.

[e]Estimates could not be calculated owing to small sample size.

Sensitivity Analyses

The results of the post hoc sensitivity analyses are presented in Multimedia Appendix 2. Additional regression models that included patients with prior depression and those that excluded patients who had depression diagnosed during the same stay as childbirth produced estimates close to our main analysis. Hence, the direction of our findings remains consistent.

Discussion

Principal Findings

This study investigated the disparate timing of PPD among individuals who had an inpatient delivery in Maryland from 2017 to 2019. We performed logistic regression to evaluate the adjusted odds of PPD among the races and ethnicities. In addition, we performed multinomial and Cox regression analyses to examine the timing of PPD, adjusted for demographics, socioeconomic characteristics, and comorbidities. Disparate timing of PPD diagnosis could inform strategies to identify the most vulnerable patients and initiate treatment promptly.

The odds of PPD are significantly higher among individuals who are White, with more comorbid conditions, without a partner, with Medicare, with residential addresses in areas of lower median household income, and from metropolitan areas of population sizes 250,000 to 1 million. We found lower odds of PPD for individuals who were Black or Hispanic, contradicting previous literature that found higher odds [11,25]. Differences in findings could be attributed to four factors: (1) demographic composition, (2) data sources and quality, (3) varying health care access, and (4) culture. Maryland has the fifth largest Black or African American population (nearly 30%) [26]; thus, the population could be meaningfully different to start with compared with previous studies, which used data from other states such as California [9]. In addition to inherent differences between data sources, the disparity in health care access among racial groups may also affect data quality and completeness. In other words, sources of disparity include both the underlying racial and socioeconomic population as well as data quality. Individuals without proper access to hospital and PPD care would not be recorded in the HCUP databases in the first place. Therefore, the HCUP database only captures individuals who can access a hospital facility, thus possibly skewing the results across socioeconomic strata. Finally, sociocultural barriers such as stigma, lack of social support, and adversities to mothering could also explain the lower odds among Black and Hispanic individuals [27,28]. Fears of negative perception and stigma could impede individuals from reporting symptoms to their care provider, and a lack of social support and adversities to mothering (poverty, marital status, and income) create additional burdens for receiving appropriate care.

Cox regression also found significantly higher hazards for individuals who were White, with more comorbid conditions, without a partner, with Medicare, with residential addresses in areas with lower median household income, and from metropolitan areas of population sizes 250,000 to 1 million. Similarly, results from the multinomial regression suggest that, among individuals with PPD, the odds of delayed diagnoses are significantly higher for those who are not White, with residential addresses in areas with higher median household income, and those enrolled in public insurance.

The findings from both analyses indicate significant associations between being single and having higher risk of PPD. Having a partner typically means additional mental and financial support during and after childbirth. In contrast, giving birth to a child without additional support could be a huge burden. As shown in Table S1 in Multimedia Appendix 2, races exhibited different patterns of marital status. This could be interpreted as the manifestation of cultural differences regarding pregnancy and marriage. Going through pregnancy and delivery without additional support increases the burden of childbirth and the risk of PPD [28,29].

From multinomial regression, we found disparate timing of PPD diagnosis, which could be explained by cultural perceptions of PPD. Previous studies have shown hesitancy to seek PPD treatment as a common theme [3,4]. Furthermore, multiple studies have shown hesitancy to seek treatment could have manifested through social, behavioral, and financial barriers (ie, fear of judgment, social support, financial cost, and transportation) [15,28]. These same burdens could also explain why racialized individuals present later in the postpartum period. Racialized individuals were likely to cope with said social, behavioral, and financial challenges before receiving care, if any. As a result, there could be a gap between when individuals conceive of help-seeking thoughts or behaviors and when they receive the care, hence delaying effective treatment. A higher median household income at the zip-level might reflect better access to care rather than delayed diagnoses. Similarly, urban or rural areas themselves are not direct risk factors for delayed diagnoses, but they reflect the extent of patient capture or

coverage. On the one hand, patients may present later to the health care system, but they are captured at the least. On the other hand, patients with greater health care access barriers may not be captured at all. Finally, in contrast to the previous literature, we found inconclusive evidence that individuals with Medicaid were diagnosed earlier than those with Medicare [14]. However, this could be attributed to the small sample size, as we only had 410 patients with Medicare (ie, patients with disability, end-stage renal disease, or amyotrophic lateral sclerosis) who delivered in the study time frame. Taken together, the log-rank test, Cox regression, and multinomial regression concur that the risks of PPD and timing of diagnosis vary by race group, and non-White race groups experience higher risks of delayed diagnosis. In turn, delayed treatment increases the chances of poor health outcomes.

Disparate timing in diagnosing PPD calls for alternative phenotyping strategies to provide higher and earlier screening rates for individuals with certain racial, sociodemographic, and economic backgrounds. Previous studies did not find the best screening tool or the best time duration for screening [30]. A recent study suggested that early screening for PPD should be coupled with multiple follow-ups in the year after delivery [31]. Our findings suggest that racial groups such as Black, Asian, and Hispanic should be screened earlier as they are more likely to have delayed PPD diagnoses. Instead of screening all individuals at the same rate, a targeted approach would conserve resources for the vulnerable populations with the highest risks.

This study has several policy implications. Various state-level policies support PPD screening and interventions. According to a 2015 study, 13 states have enacted mandates to address education, screening, awareness, and state-level reporting in patients with PPD [32]. One of the most promising intervention strategies is offering home visits [32]. What could enhance this approach is accounting for the racial disparity in PPD diagnosis as well as timing. If state policies could mandate insurance coverage for PPD home visits, this could overcome some of the hesitancy to seek treatment and provide timely care.

Limitations

Our study had a few limitations. First, our data source is based in Maryland, which has a higher Black population than the national average. Consequently, our findings may not be generalizable to states with different demographic characteristics. Second, our study is limited by the quality of data captured in the HCUP data sets. HCUP reports races and ethnicities together; thus, no ethnic distinctions are made for the race groups in our study. As previously mentioned, a high proportion of PPD cases is unreported or undiagnosed. Even in the absence of a hospital PPD diagnosis, individuals could have developed PPD without a subsequent hospital visit. Moreover, our study did not include the PPD records in outpatient settings such as mental health facilities or obstetrics and gynecology clinics. Therefore, the overall PPD rates across the population or different racial groups could have been underreported in this study. Third, we applied the Cox regression model to measure the risk differences between racial groups during the postpartum period, but other methods, such as the Cure model, might be more flexible for the assumptions made in this study [33]. Fourth, hierarchical models are typically used to model group-level effects such as median household income (ie, zip-level); however, our multilevel analysis resulted in findings that resemble those from the multivariate logistic regression. Finally, this study did not distinguish between PPD after a cesarean section and a vaginal delivery, although studies have shown that cesarean sections significantly increased the risk of PPD [34]. Future studies analyzing the disparate risks of PPD should differentiate between the types of delivery.

Future Work

There are 3 considerations for future studies to build upon the findings of this study. First, to the best of our knowledge, few existing studies have acknowledged the impact of data quality on the results. As discussed, not only could there be racial and socioeconomic disparities, but disparities could also arise from data quality. To guide clinical practice and intervention policies, the impact of data quality must be further evaluated. Second, additional work is needed on sociobehavioral factors related to PPD as this is not well understood at present. This could support targeted strategies for diagnosis and treatment initiations. Finally, future research should consider a combination of data sources when studying PPD. The Pregnancy Risk Assessment Monitoring System is the only database that tracks the occurrence of screening across states (81% of all deliveries) [8]. As there is a lack of a central database for all delivery-related data, future studies should consider using multiple data sources to analyze racial disparities in PPD diagnoses.

Conclusions

This study aimed to address the underlying racial disparities in PPD phenotyping and to provide targeted and timely care. We found significant racial disparities in the risk and timing of PPD diagnosis. Compared with White individuals, Black, Hispanic, and Asian individuals have lower odds of PPD, and Black and Asian individuals are more likely to have a PPD diagnosis later in the postpartum period. Diagnosis of patients with potential PPD should account for the disparate risks and timing among races and ethnicities. Our findings serve to enhance intervention strategies and health care policies as well as highlight data and informatics needs to support future work on racial disparities in PPD.

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Authors' Contributions

All the authors contributed to the conception and design of the study. Material preparation, data collection, and data analyses were performed by SL and XD. The first draft of the manuscript was written by SL and XD, and all authors critically reviewed and commented on the manuscript. All authors have read and approved the final manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Postpartum Depression ICD-10 Codes.
[DOCX File , 14 KB - pediatrics_v5i4e38879_app1.docx]

Multimedia Appendix 2
Sensitivity Analysis Results.
[DOCX File , 3662 KB - pediatrics_v5i4e38879_app2.docx]

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Abbreviations

HCUP: Healthcare Cost and Utilization Project
HR: hazard ratio
ICD-10: International Classification of Diseases
OR: odds ratio
PPD: postpartum depression
RR: relative risk

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Original Paper

The Relationship Between Social Integration and Physical Activity, Diet, and Sleep Among Youths: Cross-sectional Survey Study

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Abstract

Background: Social integration has been shown to predict physical activity (PA), diet, and sleep in adults. However, these associations have not been well-studied in youth samples. Using a life course perspective, it is imperative to study this in youths as social and health behaviors are established early in life.

Objective: The purpose of this study was to understand the relationship between social integration and PA, diet, and sleep for urban, middle-school youth.

Methods: Cross-sectional baseline data from middle-school youths (N=73) who participated in an afterschool health behavior intervention were included in this study.

Results: Time with friends significantly predicted moderate to vigorous intensity PA (β=.33, *P*=.02). Time spent with family was significantly related to fruit consumption (t_{66}=1.38, *P*=.005) and vegetable consumption (t_{72}=1.96, *P*=.01).

Conclusions: Social integration appears to be related to both PA and nutrition behaviors in youths. Future research should expand on our findings to explain how different domains of social integration may impact youths' health behaviors.

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KEYWORDS

social integration; youth; nutrition; sleep; physical activity; adults; exercise; health; wellness; health behavior; school students; diet; children; health behavior intervention

Introduction

The Centers for Disease Control and Prevention recommends healthy eating, physical activity (PA), and optimal sleep for youths to achieve and maintain a healthy weight [1]. Youths who meet recommendations for PA, diet, and sleep are more likely to display healthy growth, body composition, physical fitness, cognitive development, academic achievement, and overall quality of life [2], in addition to a decreased mortality risk later in life [3]. Unfortunately, the majority of youths do not meet these recommendations for PA [4], diet-related behaviors [5], or sleep [6]. Youths of color, especially females of color, are more likely to experience physical inactivity, a poor diet, and poor sleep patterns [7].

Nearly 6 in 10 youths lack any PA outside of school settings, and PA typically declines as youths age [8]. Similarly, youths develop food preferences from their childhood and are often maintained throughout life [9]. These preferences can promote or hinder, youths' healthy eating habits into adulthood [9]. Sleep duration for youths tends to be less than optimal and continues to decrease with age, resulting in a negative impact on school

performance, emotional health, and physical health [10]. Improving health behaviors early in life is essential to improving population health, as youths establish patterns early in life that extend into adulthood [11]. One factor influencing youths' health-promoting behaviors is their social environment. The social environment is an accumulation of many aspects of social life, including social networks, the social support of those in the network, and social integration. More specifically, evidence suggests that social integration may have a unique influence on behaviors that are important to healthy development and disease prevention. Social integration is the interaction between an individual and their social environment, including both formal (eg, participation in sports clubs and church) and informal aspects (eg, spending time with family and friends) [12].

Informal social integration has been shown to be related to health. For example, social integration influences PA, both cross-sectionally and longitudinally, where informal social integration with friends appears to be more predictive of PA than informal social integration with family [13]. Informal integration also predicts higher fruit and vegetable consumption [14]. Those who are more socially integrated have higher-quality sleep than those who are less socially integrated [15]. Overall, social integration has been linked with a reduced mortality risk [16,17].

While evidence is well-developed in adult populations, the relationship between social integration and PA has not been well-studied in youths, especially among racially and ethnically marginalized adolescents traditionally underrepresented in research. From a life course perspective, it is imperative to study this in youths, as social and health behaviors are established early in life. Therefore, the purpose of this study is to examine and describe the relationship between social integration and PA, nutrition, and sleep behaviors among urban, middle-school youths.

Methods

Overview

This study used baseline data from an after-school program to improve health behaviors in middle-school youths (ages 10-14). Parents and youths provided written informed consent and assent, respectively, before participating in this study. The after-school program provided web-based opportunities for exercise sessions such as yoga, dance, and general cardio endurance exercise owing to COVID-19. Fresh produce was available for pick-up once per week or delivered to families if they lacked transportation.

Middle-school youths in the Kansas City Public School District, Kansas City, Missouri, participated in this study. Of the 14,128 students in the district, 54% are Black, 27% are Hispanic or Latinx, 11% are White, and 8% are of other races and ethnicities [18]. All students in Kansas City Public Schools qualify for free school breakfast and lunch.

The data were collected between August 2020 and May 2021. As part of baseline data collection, youths completed a survey that assessed obesogenic behaviors, including PA, social integration, dietary behaviors, and sleep. Youths (n=76) who completed a baseline survey represented sixth, seventh, and eighth graders. Those who did not provide any valid answers to the nutrition, sleep, PA, or social integration questions were excluded (n=3), resulting in a sample of 73 youths.

Ethics Approval

All study procedures were approved by the institutional review board of the University of Missouri-Kansas City under protocol number #2017528.

Measures

PA

Self-report measures of PA were collected using the International Physical Activity Questionnaire (IPAQ) Short Form [19]. The IPAQ Short Form is a 7-day recall questionnaire to estimate recent PA behavior and was used to calculate vigorous- and moderate-intensity PA [19]. Youths reported time spent doing moderate-intensity activities in the past 7 days if the activity required moderate physical effort and breathing, such as carrying light loads, bicycling at a regular pace, or doubles tennis. Youths reported time spent doing vigorous-intensity activities in the past 7 days if the activity required hard physical effort and breathing, such as heavy lifting, aerobics, or fast bicycling. The IPAQ Short Form also measures walking and sedentary behavior. However, time spent walking and sitting is not presented in this study. Three responses were 3 SDs away from the mean and excluded from data analysis for being outliers.

Social Integration

Youths' social integration was measured through an adapted version of Cundiff and Matthew's 1-item measure [20]. The question was adapted into a 2-item measure for youths to report separately on time spent with friends and family. Response options were reported on a 5-point scale that ranged from <1 hour per week to >20 hours per week for time with family and time with friends, respectively.

Dietary Behaviors

Dietary questions were adapted from the 2019 Youth Risk Behavior Survey High School instrument to measure dietary behaviors [21]. Questions were asked about fruit, vegetable, soda, and sports drink consumption in the past 7 days. The original Youth Risk Behavior Survey response options ranged on a 7-point scale from no consumption to >4 times a day; for this study, these response options were collapsed into 3 response categories (*yes*, *no*, and *not sure*). *Not sure* responses were excluded from data analysis.

Sleep

Sleep was measured by a single question from the 11-item Kutcher Adolescent Depression Scale [22]. Youths reported sleep difficulties from the past 7 days, with response options ranging from *hardly ever*, *much of the time*, *most of the time*, to *all of the time*. *Hardly ever* responses were classified as no persistent sleep issues. *Much of the time*, *most of the time*, and *all of the time* responses were combined and classified as having sleep issues. Sleep was collapsed into a dichotomous variable (0=no sleep issues, 1=persistent sleep issues) for data analysis.

Analysis Plan

Univariate statistical analyses were conducted for all study variables. Independent samples *t* tests were conducted to examine differences between dichotomous variables (diet and sleep) and social integration variables. Linear regression analyses were used to estimate the effect of social integration on moderate to vigorous intensity PA (MVPA). All statistical analyses were conducted using SPSS software (version 26; IBM Corp) [23].

Results

Youths' demographics are presented in Table 1. Among the participating youths (N=73), 34 (47%) identified as female and 38 (52%) identified as male. The sample diversely represented race/ethnicity groups, with 44% (32/73) reported being African American or Black, 26% (19/73) reported being White, 6% (4/73) reported being Hispanic` or Latinx, 7% (5/73) reported being Asian, and 18% (13/73) reported being multiracial or multiethnic. All youths were in the sixth, seventh, or eighth grades (mean age 12.04, SD 0.93 years). Regarding youths' diet and sleep behaviors in the last 7 days, 61% (40/66) reported eating fresh fruit, 61% (43/70) reported eating vegetables, 26% (19/72) reported drinking soda, 16% (11/69) reported drinking a sports drink, and 51% (36/71) reported abnormal sleep issues. Youths reported engaging in 286.40 (SD 307.19) minutes of MVPA per week. Youths reported social integration on a 5-point scale. Youths reported time with family at 4.26 (SD 1.21) or between 11 to 20 hours per week and time with friends at 2.02 (SD 1.12) or between 1 to 5 hours per week.

Tables 2 and 3 present the results of the *t* tests that examined differences in social integration for fruit, vegetable, soda, and sports drink consumption and sleep difficulties. Fruit consumption was significantly related to time spent with family (t_{66}=1.38, *P*=.005) but not significantly related to time spent with friends (t_{66}=2.61, *P*=.08). Vegetable consumption was significantly related to time spent with family (t_{72}=1.96, *P*=.012) but not significantly related to time spent with friends (t_{72}=0.067, *P*=.68). Youths who spent more time with family were more likely to consume fruit and vegetables on the last day. There were no substantial differences in time spent with family or friends based on soda, sports drinks, and sleep variables.

Table 4 presents the results of the linear regression analyses examining associations between social integration and PA. MVPA was related to time spent with friends (β=.33, *P*=.02) but not to time spent with family (β=.01, *P*=.94). For every 1 SD increase in time spent with friends, MVPA increased 0.33 SDs.

Table 1. Univariate statistics.

Variables	Values
Sex, n (%)	
Female	34 (47)
Male	38 (52)
No response	1 (1)
Age (years), mean (SD)	12.04 (0.9)
Race and ethnicity, n (%)	
African American or Black	32 (44%)
White	19 (26%)
Asian	5 (7%)
Hispanic or Latinx	4 (6%)
Multiracial or multiethnic	13 (18%)
Fresh fruit consumption, n (%)	
Yes	40 (61%)
No	26 (39%)
Vegetable consumption, n (%)	
Yes	43 (61%)
No	27 (39%)
Soda consumption, n (%)	
Yes	19 (26%)
No	53 (74%)
Sports drink consumption, n (%)	
Yes	11 (16%)
No	58 (84%)
Sleep issues, n (%)	
Yes	36 (51%)
No	35 (49%)
MVPA[a] (minutes per week), mean (SD)	286.4 (307.2)
Time with family	4.3 (1.2)
Time with friends	2.0 (1.1)

[a]MVPA: moderate to vigorous intensity physical activity.

Table 2. Associations between social integration and dietary behaviors.

Variable	Consumed, mean (SD)	Did not consume, mean (SD)	*t* test (*df*)	*P* value
Fruit				
Time with family	4.44 (1.03)	4.00 (1.41)	1.38 (66)	.005
Time with friend	2.34 (1.25)	1.57 (0.84)	2.61 (66)	.08
Vegetable				
Time with family	4.49 (1.07)	3.87 (1.39)	1.96 (70)	.012
Time with friend	2.12 (1.17)	1.91 (1.08)	0.67 (70)	.68
Soda				
Time with family	4.07 (1.39)	4.33 (1.18)	–0.71 (72)	.12
Time with friend	2.00 (1.04)	2.05 (1.16)	–0.13 (72)	.81
Sports drink				
Time with family	4.30 (1.25)	4.27 (1.22)	0.06 (69)	.95
Time with friend	2.20 (1.03)	2.07 (1.16)	0.34 (69)	.93

Table 3. Association between social integration and sleep behaviors.

Variables	No persistent sleep issues, mean (SD)	Persistent sleep issues, mean (SD)	*t* test (*df*)	*P* value
Time with family	4.21 (1.27)	4.31 (1.18)	0.33 (71)	.54
Time with friend	2.13 (1.17)	1.90 (1.08)	–0.81 (71)	.76

Table 4. Associations between social integration and moderate to vigorous intensity physical activity.

Variable	β	SE	95% CI	*P* value
Time with family	.01	32.90	–67.84 to 72.44	.94
Time with friends	.33	35.62	13.96 to 157.12	.02

Discussion

The purpose of this study was to understand associations between social integration and PA, diet, and sleep behaviors for a sample of urban, middle-school youths. Overall, this study found that social integration is a substantial predictor of PA and fruit and vegetable consumption for middle schoolers in Kansas City, Missouri. However, social integration did not appear to be associated with other diet-related behaviors or sleep.

Our findings suggest that time spent with friends could be an essential component of youths' PA, as time spent with friends was associated with MVPA. These results are consistent with previous findings in adult samples; time spent with friends significantly predicted PA both cross-sectionally and longitudinally [13,24]. Our results also align with those of previous research that found peer influence and socialization to be the most commonly cited motivators for PA among middle schoolers [25]. Spending time with family appears to have less impact on youths' PA, similar to adult samples where time spent with family did not predict or had weaker associations with PA [13,24]. Despite these findings, previous research does indicate that parental involvement can increase youths' PA [26]. The results of this study support the growing body of evidence that different domains of social integration, specifically time with friends, can be a powerful predictor of PA in youths.

In this sample, time spent with family was related to fruit and vegetable consumption, but time spent with friends was not. Our findings align with those of similar studies in adults, where social integration was found to be a substantial predictor of fruit and vegetable consumption [14]. Our results suggest that social integration, specifically time with family, appears to be a large predictor of diet behaviors in youths. Future studies should be conducted with larger samples, different populations, and other ages to understand if the results of this study are consistent across varying groups.

Social integration was not shown to be a predictor of improved sleep among youths in this study. These findings contradict those of similar studies performed with adult samples, which found that adults with higher social integration had higher sleep quality [15]. Our findings may be impacted by a notable increase in sleep disturbances during the COVID-19 pandemic in school-aged youths [27].

To our knowledge, this is the first study to assess the role of social integration with PA, diet, and sleep behaviors in youths. This study is strengthened by the participation of racially and ethnically marginalized youths. Current research consistently underrepresents populations of color [28,29]. Participation by underrepresented groups provides valuable insight into the specific associations between social integration and PA, diet,

and sleep for youths in these groups. This study is also strengthened by the use of validated self-report measures.

This study is limited by its small sample size, potential self-report issues, and lack of generalizability to other populations. Self-reported data has several limitations, including social desirability bias, overestimation of behavior, and poor recall. Future studies should attempt to use measures that provide more variability and rigor (ie, a tool to measure multiple elements of sleep hygiene) and collect data using a monitoring device, such as accelerometry. This study also took place during the COVID-19 pandemic, which disrupted communication and contact with youths as school instruction transitioned to remote web-based learning. The pandemic may have impacted time spent with friends and family as well as PA, sleep, and diet behaviors. Further, we did no assess important physical environmental-level factors such as availability of parks or grocery stores, walkability of neighborhoods, community assets that may impact PA, diet, sleep, and social integration in these populations. Future research should consider attempting to understand how the social and physical environments interact to influence PA, diet, and sleep.

Our findings support the notion that different domains of social integration may promote positive health behaviors in youths. Increased time with friends may promote MVPA in youths. School sports, before- or after-school programs, or other group-based programs may offer a valuable opportunity to work with friend groups to increase PA. However, these types of programs may not be available to middle schoolers, have a fee to participate, or be competitive. These barriers may make sports and other programs unavailable to those who need it most [30]. Additional opportunities to increase youths' social integration with friends to promote PA may include parental influence by fostering increased peer-to-peer engagement during nonschool hours. Increased time with family may promote increased fruit and vegetable consumption in youths, although families with low incomes and lower educational attainment are less likely to have accurate nutrition knowledge [31]. Therefore, increasing parent knowledge around nutrition is essential to transfer accurate nutrition knowledge and behavior to youths. Future research should investigate how these different aspects of social life may increase social integration and thereby influence PA and diet behavior.

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Conflicts of Interest

None declared.

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Abbreviations

IPAQ: International Physical Activity Questionnaire
MVPA: moderate-to-vigorous physical activity
PA: physical activity

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Review

mHealth Technology Design and Evaluation for Early Childhood Health Promotion: Systematic Literature Review

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Abstract

Background: Recent increases in smartphone ownership among underserved populations have inspired researchers in medicine, computing, and health informatics to design and evaluate mobile health (mHealth) interventions, specifically for those supporting child development and growth. Although these interventions demonstrate possible effectiveness at larger scales, few of these interventions are evaluated to address racial disparities and health equity, which are known factors that affect relevance, uptake, and adherence in target populations.

Objective: In this study, we aimed to identify and document the current design and evaluation practices of mHealth technologies that promote early childhood health, with a specific focus on opportunities for those processes to address health disparities and health equity.

Methods: We completed a systematic literature review of studies that design and evaluate mHealth interventions for early childhood health promotion. We then analyzed these studies to identify opportunities to address racial disparities in early- and late-stage processes and to understand the potential efficacy of these interventions.

Results: Across the literature from medical, computing, and health informatics fields, we identified 15 articles that presented a design or evaluation of a parent-facing health intervention. We found that using mobile-based systems to deliver health interventions was generally well accepted by parents of children aged <5 years. We also found that, when measured, parenting knowledge of early childhood health topics and confidence to engage in health-promoting behaviors improved. Design and evaluation methods held internal consistency within disciplines (eg, experimental study designs were the most prevalent in medical literature, while computing researchers used user-centered design methods in computing fields). However, there is little consistency in design or evaluation methods across fields.

Conclusions: To support more interventions with a comprehensive design and evaluation process, we recommend attention to design at the intervention (eg, reporting content sources) and system level; interdisciplinary collaboration in early childhood health intervention development can lead to large-scale deployment and success among populations.

Trial Registration: PROSPERO CRD42022359797; https://tinyurl.com/586nx9a2

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KEYWORDS

mobile health technologies; early childhood health promotion; child development; parent support technologies; mobile phone

Introduction

Background

Early childhood health outcomes, such as social, motor, and cognitive development, largely depend on parental knowledge and behaviors. Both the American Academy of Pediatrics and the Centers for Disease Control provide guidelines for parents that educate them on health promotion strategies for their children [1,2]. These guidelines are often presented in local health centers, schools, or community sites [3]. However, finding and acting on information about early childhood health can be challenging [4,5]. For families affected by racial and economic disparities, having access to information, care providers, and resources to support health-promoting behaviors is a substantial barrier to parental action [6]. Mobile phone–based interventions have been developed to provide parents education on child health topics [7]. These interventions have been evaluated in highly diverse populations and are shown to be feasible for deployment at a larger scale, especially in lower-resource areas [8,9].

The Bright Futures guidelines from the American Academy of Pediatrics for early childhood health promotion outline three areas of focus for comprehensive child development practice: (1) anticipatory guidance, (2) development and behavior screening, and (3) social determinants of health screening. Anticipatory guidance topics refer to proactive advice on activities that promote healthy growth, including nutrition, dental care, and physical activity [1,10]. Development and behavior screening includes tracking and monitoring milestones such as motor and cognitive development, growth, and communication skills [11]. Screening for social determinants of health includes monitoring the environment in which the child grows, including topics such as parent smoking behavior, housing, food security, and parent social support networks [12]. Pediatric experts have referenced the importance of addressing all 3 topics in regular visits with pediatric patients to identify upstream factors that may affect development [13] and to understand the challenges of parents when adhering to recommendations. There is an opportunity to address the effects of health inequity on experiences with mobile health (mHealth) technologies [14,15].

Objectives

This systematic literature review aimed to document current research on mobile-based health promotion interventions and understand the methods used to design and evaluate these systems. As we focused on parent-facing interventions for early childhood health (ages 0-5 years), we also examined the opportunities for design and evaluation in this area to critically engage with the potential for racial disparities in intervention effectiveness. In this study, we aim to answer these research questions:

1. What are the design, evaluation, and reporting practices in computing, medical, and health informatics fields for early childhood health interventions?
2. What opportunities exist to address the risk of technology-generated disparities in early childhood health interventions' design, evaluation, and reporting practices?

Prior Work

mHealth Interventions

mHealth interventions use mobile systems (including SMS text messaging, mobile apps, mobile-optimized websites, and wearable technologies) to deliver health interventions [16]. mHealth interventions are commonly developed and tested in low-income or middle-income communities [17]. They are described as providing fast access to care, being low cost to build and implement, and being accessible because most people own a cell phone. Researchers have explored opportunities for mHealth interventions to support both adults and children with self-management of their health [8,18]. Researchers have also developed interventions that support caregivers with monitoring the health of others [19].

mHealth interventions have the potential to extend health intervention content to hard-to-reach populations, they are often criticized for their lack of regulatory oversight, potential data privacy risks, and lack of implementation in clinical settings [20].

Intervention-Generated Disparities

Health disparities between groups occur when one group in a population experiences higher levels of poor health outcomes compared with the general population [5]. Both socioeconomic factors and health systems can influence access to resources that influence health outcomes [21]. Researchers have developed health equity models that address *upstream factors* [22], such as socioeconomic status, to identify the causes of disparity and adapt care to address those causes [22]. Although health interventions are designed to reduce poor health outcomes in specific groups, researchers have identified that considering health equity in designing and evaluating interventions is crucial to prevent intervention-generated inequalities [23]. Intervention-generated inequality occurs when interventions are more effective for already advantaged groups, widening the disparity between groups that are doing well and those that are not. Veinot et al [22] identified the characteristics of health interventions that worsen inequalities between disadvantaged and advantaged groups. In this work, they present a model to prevent intervention-generated inequalities by addressing inequality in access, uptake, adherence, and effectiveness and recommend prevention opportunities in the evaluation and reporting phases.

mHealth Literature Reviews

mHealth intervention research exists at the intersection of computing, health informatics, and medical disciplines, which are highly segmented and specialized. To identify trends across these fields, researchers have used the literature review method in many forms to survey existing research on mobile-based technologies and to examine opportunities for growth in the field. Berrouiguet et al [24] summarized the use of SMS text messaging as a health care tool for psychiatric disorders and reported evaluation methods and positive perceptions of SMS text messaging by participants. Lau et al [25] coupled a systematic search of mobile app stores with a literature review of psychosocial wellness. Bradway et al [26] used a scoping literature review to identify the qualitative and quantitative

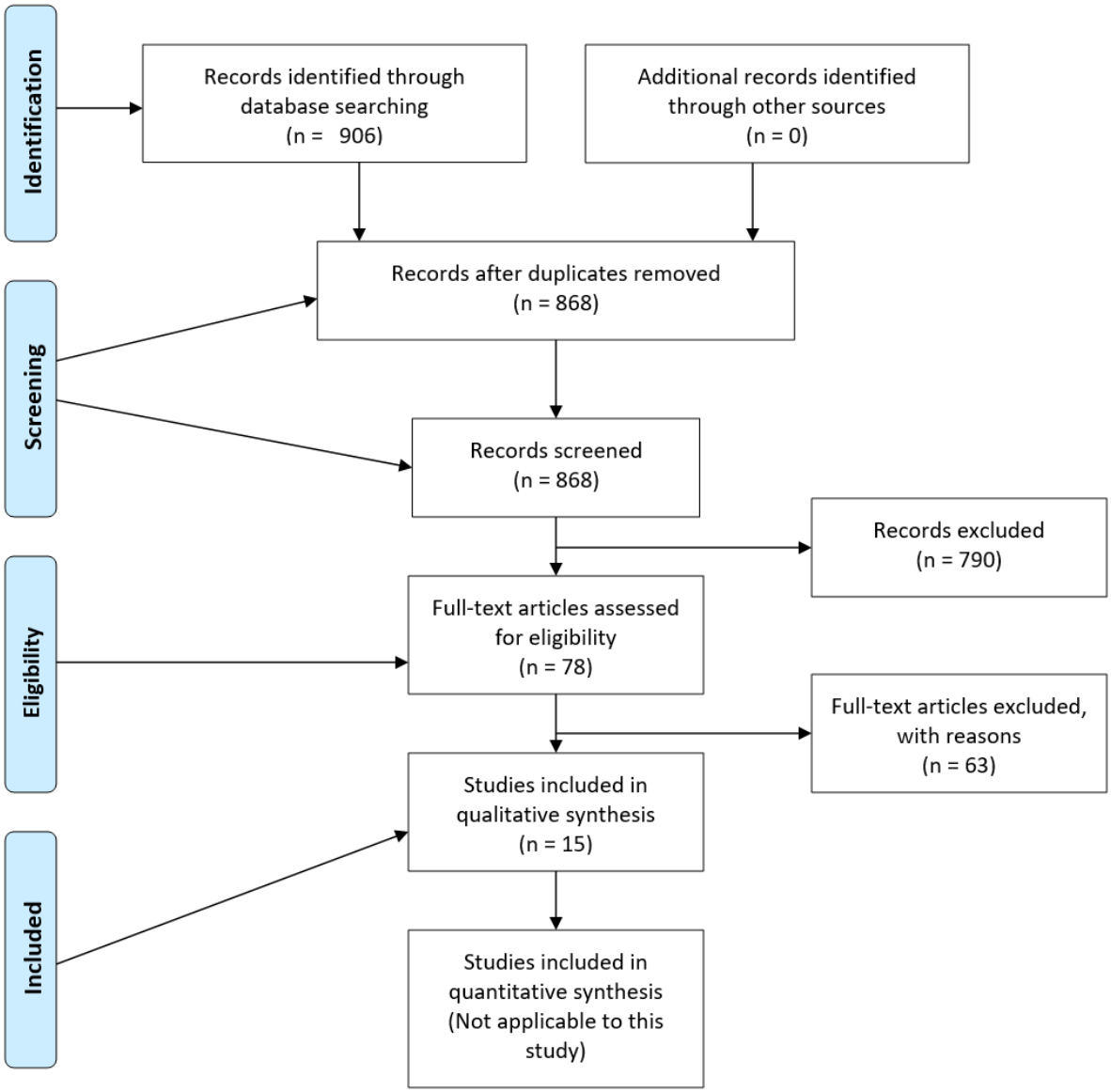
methods used to evaluate mHealth systems for chronic disease self-management and identified the best practices for comprehensive evaluations of complex mHealth tools. Wang et al [27] conducted a *systematic review of systematic reviews* to evaluate the potential of mHealth interventions to support diabetes and obesity treatment and management. Although mHealth interventions are promising, they identified that further research is needed to establish long-term effectiveness. Anderson-Lewis et al [28] also evaluated mHealth interventions deployed in historically underserved and minority populations in the United States and recommended that research should expand to include mobile phone and tablet apps. To our knowledge, there have been no systematic evaluations of mHealth interventions designed to support early childhood health or evaluations that focus on how racial disparities potentially influence the effectiveness of these interventions. Our review intends to survey the work happening in computing, medical, and health informatics fields to identify opportunities to address racial disparities in the evaluation and design of health interventions. We also intend to bridge findings across disciplines to promote the effectiveness of delivery systems, design methods, evaluation methods, and reporting standards that future interventions might adopt.

Methods

Reporting Standards

We completed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) checklist and confirm that the study is compliant. The full protocol for this study is available in Figure 1.

Figure 1. Flow diagram of the study selection process.



Search Strategy

We completed a database search for full-text scholarly articles in medical, computing, and health informatics fields in February 2022 using the electronic databases PubMed, Embase, CINAHL Complete, ERIC, Compendex, Inspec, and ACM Digital Library. We coordinated with our university's health sciences library to identify these databases, as they are relevant to medicine, technology, and research at the intersections of health and technology, where we would expect to find the literature on mobile-based health interventions.

Our search strings included terms describing early childhood health, mobile technologies, and the parents and primary caregivers of young children. We refined and adapted the keyword strings to be compatible with the unique search mechanics of each database (eg, using different typographic marks as search operators). The complete search strings by database are presented in Multimedia Appendix 1. We limited our search to studies within the past 10 years (2011 to 2022) to reflect the rapid rate at which technology development and adoption evolves [29].

Selection Criteria

We included studies if they (1) presented and tested a mobile app, SMS text messaging system, or mobile website to be used by participants; (2) included a health scope related to anticipatory guidance, development and behavior screenings, or social determinants of health topic areas outlined in Bright Futures Guidelines for Health Supervision of Infants, Children, and Adolescents, fourth edition; (3) targeted parents or guardians of children aged 0 to 5 years directly as users; (4) included a study related to the practicality of the app for target users (eg, usability, feasibility, pilot study, or randomized controlled trial); (5) were published within the past 10 years; and (6) are a completed, peer-reviewed journal paper or conference paper.

Studies were excluded if they (1) involved a study of a mobile app created to support pregnancy or postpartum health alone, (2) exclusively targeted other caregivers as end users for the system (eg, day care providers, paid caregivers, nurses, and community health workers), or (3) consisted solely of randomized controlled trial protocol documentation. In addition, we excluded studies not written in English, government reports, articles, and opinion pieces.

Selection Process

The database search results were downloaded and organized in a spreadsheet and duplicates were removed. One researcher screened the search results by using the inclusion and exclusion criteria in 3 distinct groupings. First, we used the inclusion and exclusion criteria to screen the titles of the results. Next, we accessed the abstracts for the remaining results and applied the inclusion and exclusion criteria. Finally, we performed a full-text review of the remaining studies. The PRISMA flow diagram detailing the number of studies present in and after each phase is presented in Figure 1.

Data Extraction

One researcher reviewed each full text of the included studies and documented the relevant information in a spreadsheet. This information included (1) titles, authors, country, and year of publication; (2) type of field the study was published in (eg, computing, medical, and health informatics); (3) type of mobile technology the study evaluated (eg, texting or SMS text messaging system or mobile app); (4) study design used to evaluate the technology; (5) target population; (6) number of participants recruited for the study and their reported demographics; (7) features and functionalities of the mobile technology; (8) sources for content in the mobile technology; (9) outcomes measured for the child; (10) reported parent perceptions of the technology and outcomes related to changes in parent knowledge and decision-making processes; and (11) reported outcomes for usability, feasibility, or acceptability.

Results

Selection and Inclusion of Studies

We screened 906 results from database searches and excluded 891 (98.3%) studies during the screening process. We removed 38 duplicates before beginning the screening process. During title screening, we excluded 83.3% (755/906) of studies. Of the remaining 151 studies, we excluded 73 (48.3%) studies during the abstract screening phase, leaving 78 (51.7%) papers for full-text screening. We excluded 6.9% (63/906) of studies during the full-text screening process, leaving 1.7% (15/906) studies that met the inclusion criteria. Figure 1 visually represents the number of studies excluded during each phase of the screening process.

Characteristics of the Included Studies

The full overview and characteristics of the studies are presented in Table 1. The publication dates ranged from 2014 to 2021, and most studies (9/15, 60%) were published in 2017, 2019, or 2020. Among the 15 studies, 11 (73%) were published in journals and 4 (27%) were peer-reviewed full conference papers.

All (15/15, 100%) the studies developed and contributed to a novel intervention. Overall, 7% (1/15) of studies evaluated an existing mobile app and iterated its design with feedback from parents [30]. Of 15 studies, 3 (20%) studies evaluated only the feasibility of the intervention [32,34,35], whereas 8 (53%) studies evaluated the intervention's potential to achieve specific health outcomes [36-39,41-44]. The technologies evaluated in these studies included 8 mobile apps [30,33,35,38,40-43], 4 SMS text message systems [32,36,37,44], 1 voice message system [34], 1 website optimized for mobile devices [39], and 1 social media platform [31]. A total of 40% (6/15) of articles reported technical specifications for how they built and deployed the intervention [31,32,36,37,41,43], 40% (6/15) of studies were conducted in the United States [31-33,38-40], and 6% (1/15) of studies was dually conducted in the United States and Mexico [30]. Overall, 20% (3/15) of studies were conducted in Iran [37,42,43], and the remaining (5/15, 33%) studies were conducted in Cambodia [34], China [36], Guatemala [44], Sweden [41], and Switzerland [35]. Tables 2 and 3 provide detailed information about the study findings and technologies evaluated.

Table 1. Article characteristics.

Study	Field	Country	Number of Participants (parents)	ORBIT[a] model classification
Armenta et al [30], 2019	Computing	United States and Mexico	11	Nonexperimental evaluation of feasibility; no measurement or documentation of child health outcomes
Suh et al [31], 2014	Computing	United States	14	Nonexperimental evaluation of feasibility; no measurement or documentation of child health outcomes
Olson et al [32], 2016	Medical	United States	31	Nonexperimental evaluation of feasibility; no measurement or documentation of child health outcomes
Hayes et al [33], 2014	Computing	United States	14	Nonexperimental evaluation of feasibility; no measurement or documentation of child health outcomes
Huang and Li [34], 2017	Medical	Cambodia	126	Nonexperimental evaluation of feasibility; no measurement or documentation of child health outcomes
Jacques et al [35], 2020	Health informatics	Switzerland	12	Nonexperimental evaluation of feasibility; no measurement or documentation of child health outcomes
Jiang et al [36], 2019	Health informatics	China	558	Nonexperimental evaluation of feasibility; no measurement or documentation of child health outcomes
Khademian et al [37], 2020	Medical	Iran	211	Pilot and early experimental evaluation of child health outcomes
Lozoya et al [38], 2019	Medical	United States	33	Pilot and early experimental evaluation of child health outcomes
Nezami et al [39], 2018	Pediatrics	United States	51	Pilot and early experimental evaluation of child health outcomes
Nolen et al [40], 2018	Health informatics	United States	8	Pilot and early experimental evaluation of child health outcomes
Nystrom et al [41], 2017	Medical	Sweden	315	Pilot and early experimental evaluation of child health outcomes
Seyyedi et al [42], 2020	Medical	Iran	110	Pilot and early experimental evaluation of child health outcomes
Zolfaghari et al [43], 2021	Medical	Iran	58	Pilot and early experimental evaluation of child health outcomes
Domek et al [44], 2016	Medical	Guatemala	321	Pilot and early experimental evaluation of child health outcomes

[a]ORBIT: Obesity-Related Behavioral Intervention Trials. The ORBIT model establishes a pathway of phases that supports the translation of information in behavioral and social science research into health interventions [45].

Table 2. Summary of findings.

Study	Technology description	Study design	Usability and feasibility evaluations of the technology.	Child outcomes	Parent knowledge and decision-making
Armenta et al [30], 2019	Mobile app for child milestone tracking	Qualitative usability study—evaluated 3 versions of a mobile app: original, translation, and redesign	Evaluated the user interface and workflows for basic functions for the first app to identify objectives for a redesign. Found that the first app had several issues with basic functions (eg, data entry and creating new profiles). Evaluated the redesigned app and successfully resolved usability issues previously identified.	Not measured	Not measured
Suh et al [31], 2014	Social media network (Twitter), website, and text messaging system for tracking child health milestones	Deployment study and qualitative, exploratory study	Parents reported difficulty with responding to tweets using the program's syntax and did not like that the program used a social networking site. Parents liked the accessibility of the content related to child milestones and opportunities to interact with other parents through the platform.	Not measured	Not measured
Olson et al [32], 2016	SMS texting with personalized messages about child development and local child health resources	Feasibility study	Parents reported high satisfaction with the frequency of text messages. Parents also shared preference for text messages over website-based programs, owing to ease of access.	Not measured	Parents reported increased awareness of language-promoting activities and local child development resources
Hayes et al [33], 2014	Mobile app for tracking infant weight, diapers, infant emotions, reminders, and parent moods	Qualitative technology probe, interviews, surveys, and log analysis	Did not track any usability issues. Parent feedback revealed that the app does not require much training to use it as a beginner.	Not measured	Parents expressed that the app supported parent-focused outcomes (tracking mental health) and that using the app did not contribute to additional stress levels
Huang and Li [34], 2017	Interactive voice response system by using prerecorded voice phone calls	Feasibility study	Intervention was well accepted by parents, as parents expressed interest in paying for the service and referenced the tool's cultural relevance.	Not measured	Not measured
Jacques et al [35], 2020	Mobile app for recording food quality and intake and tracking nutrition information of foods	Feasibility study	Parents rated the app as high on the ease-of-use scale [46].	Not measured	Not measured
Jiang et al [36], 2019	SMS texting with information about feeding and breastfeeding	Quasi-experimental design	Not measured	Measured child's BMI before and after intervention. Intervention did not demonstrate a significant effect on the children's BMI	Not measured
Khademian et al [37], 2020	SMS texting with information about child oral health	Randomized control trial	Not measured	Not measured	Maternal knowledge about oral health and related practices improved after intervention

Study	Technology description	Study design	Usability and feasibility evaluations of the technology.	Child outcomes	Parent knowledge and decision-making
Lozoya et al [38], 2019	Mobile app with guided videos, reminders, and social feed for child's oral hygiene	Experimental pretest-posttest and qualitative interviews	Not measured.	Documented dietary habits, oral health practices, and dental appointment attendance for all children before intervention. Did not find any changes to those practices after intervention	Did not find a significant quantitative change in parent knowledge. Found that parents reported a positive experience with the mobile app's reminders and guided brushing features
Nezami et al [39], 2018	Mobile-optimized website, SMS text messages, and physical list of foods with nutrition information	Randomized controlled trial	Adherence to the intervention was higher than in previous studies with mothers of young children. Dropout was more likely among people of color; however, dropout did not differ by treatment group.	Children consumed less beverages in the intervention group	Not measured
Nolen et al [40], 2018	Mobile app with videos, reminders, and facts about a child's oral health	Usability study	On average, parents believed that the app could keep them informed about their child's oral health. Parents rated navigation of the interface and design elements as poor. Parents shared that several of the features in the app did not work.	Not measured	Not measured
Nystrom et al [41], 2017	Mobile app for tracking child's food intake and exercise	Randomized controlled trial	Not measured	Measured child BMI or FMI[a] levels and did not find a change after intervention. Found that child activity levels increased	Not measured
Seyyedi et al [42], 2020	Mobile app with guidance on feeding and direct chat with clinicians	Randomized controlled trial	Not measured.	Intervention group improved nourishment status	Mother's nutritional literacy improved for both groups; however the intervention group had greater improvement
Zolfaghari et al [43], 2021	Gamified mobile app with tracking and reminders for oral hygiene practices	Pretest-posttest controlled clinical trial	Not measured.	Reported significant improvement in child tooth brushing frequency. Both groups had reduced child plaque measurements, but reduction was higher in the gamified intervention group	Measured improvements in parent knowledge about oral health in both groups, but higher improvement was found in the gamified group
Domek et al [44], 2016	Vaccine reminder texting program	Pilot randomized controlled trial	Identified that the vaccine SMS texting reminder system is feasible for the LMIC[b] context, and reported high user satisfaction with the technology.	No significant impact on vaccine rates in the intervention group compared with the control group	Parents expressed that the reminders were helpful in following up with their child's vaccine series

[a]FMI: fat mass index.

[b]LMIC: lower middle–income country.

Table 3. Technology systems and features.

Studies	Technology system	Functions and features	Early childhood areas (as outlined by Hagan et al [1])	Content sources
Armenta et al [30], 2019	Smartphone app	Translated version of existing smartphone app (from English to Spanish). Includes developmental milestone tracking through checklists, exporting, and sharing completed checklists, and recording notes about milestones. Supports profiles for >1 child.	Developmental milestone surveillance	First iteration of mobile app developed using the CDC's[a] Learn the Signs. Act Early campaign. The second iteration of the mobile app was derived from the Spanish version of the CDC's milestone list
Suh et al [31], 2014	Social media network (Twitter), website, and SMS text messaging	Parents follow an account that shares age-based milestone questions (sometimes coupled with images) at regular intervals. Then, the parent can respond by posting a tweet or direct messaging the account.	Developmental milestone surveillance	Not reported
Olson et al [32], 2016	SMS text messaging	Sends 3 SMS text messages per week for 12 weeks with information on child development and local child health resources. Sends messages with survey questions about parent's strategies to support their child's health.	Developmental milestone surveillance	Not reported
Hayes et al [33], 2014	Smartphone app	Tracking infant weight, diapers, and emotions. Includes mood tracking for parents. Generates data files for health care professionals and reminders for tracking in the app.	Feeding, growth development, and parent mental health	Not reported
Huang and Li [34], 2017	Interactive voice response system	Sends prerecorded messages through phone call to parents, starting 3 days after birth. Messages are sent every 4 days until the child is 28 days old. Messages are 60-90-seconds long and have a variety of voices offered.	Developmental milestone surveillance	Consulted with local midwives for more information about message content
Jacques et al [35], 2020	Smartphone app	Digitizes food recording features, including intake and quantity. Provides information on added fats or sugars in foods after parents use the app to take pictures of food labels.	Food and nutrition	Consulted with expert pediatric dietetics at Geneva Children's Hospital
Jiang et al [36], 2019	SMS text messaging	Weekly text messages provide anticipatory guidance about feeding, and requests more information from parents about breastfeeding statuses for themselves and their child.	Feeding and breastfeeding	Developed using WHO[b] breastfeeding and infant or young child feeding recommendations. Consulted with local child health care experts
Khademian et al [37], 2020	SMS text messaging	Daily SMS text messages provide guidance about oral health. SMS text messages were designed using gain- and loss-frame formatting.	Care of teeth and gums	Consulted with local pediatric dentistry professors and educational management specialists
Lozoya et al [38], 2019	Smartphone app	Provides documents and videos with oral hygiene instructions. Tracks tooth brushing times and sends brushing reminders. Includes a social feed to share brushing and flossing experiences with a social network.	Care of teeth and gums	Not reported in this paper; documented in preceding paper
Nezami et al [39], 2018	Mobile-optimized website, SMS text messaging, paper-based list, stickers, and charts	Text message prompt at the end of every week to collect the mother's personal data, which is then used to create a tailored email about nutrition and quality of foods consumed.	Food and nutrition	Not reported in this paper; documented in a preceding protocol paper

Studies	Technology system	Functions and features	Early childhood areas (as outlined by Hagan et al [1])	Content sources
Nolen et al [40], 2018	Smartphone app	Sends tooth brushing reminders for morning and night, tracks frequency of brushing and flossing events, includes videos for guided brushing, and has facts about oral health in articles.	Care of teeth and gums	American Dental Association website
Nystrom et al [41], 2017	Smartphone app	Mobile app sends push notifications with general information about nutrition and exercise. Provides advice and strategies to change behaviors, supports weekly tracking of child's intake and exercise. App provides weekly feedback (graphical and automated comments) based on personal data. The mobile app also supports direct contact with a dietician or psychologist.	Food and nutrition, physical activity	Not reported
Seyyedi et al [42], 2020	Smartphone app	Provides articles with age-based guidance education based on feeding children. Provides a chat feature where clinicians can directly answer parent questions in the app.	Feeding and breastfeeding	Maternity Guidelines for Maternal and Child Health Services issued by the Iranian Ministry of Health. Cross-referenced content with guidance from a local nutritionist
Zolfaghari et al [43], 2021	Smartphone app	Provides written information about oral hygiene, nutrition, fluoride intake, and content of dental visits. Mobile app sends reminders to brush teeth at night.	Care of teeth and gums	American Association for Pediatric Dentistry Guidelines. Mobile app was evaluated by oral medicine specialists, pediatric dentists, and electronic learning and programing technicians
Domek et al [44], 2016	SMS text messaging	SMS text message reminders sent to parents at 6, 4, and 2 days before the next scheduled child vaccination date (as part of a 3-dose vaccination series).	Vaccines	Guatemala Ministry of Public Health and Social Assistance, Pan American Health Organization, and project optimize

[a]CDC: Centers for Disease Control and Prevention.

[b]WHO: World Health Organization.

Features of the Technology Interventions

Among the studies that evaluated mobile apps, features included a tracking component for parent and child behaviors, articles about child health topics, reminder systems using push notifications [33,38,40,43], milestone questionnaires [30], and data file generation for a physician to review [33]. SMS text messaging interventions provide anticipatory guidance for parents to save and review their child's health and development [32,36], send reminders for in-person appointments [44], and request information about parent or child behavior status [36]. One intervention used the social media network Twitter, where parents would send tweets as responses to daily milestone questions [31]. Another intervention sent parents prerecorded phone calls with information about milestones multiple days per week for a month [34]. One intervention also provided personalized summaries of the tracked content to parents by email [39].

Methods Used for Design and Evaluation

Studies from medical fields have generally used experimental methods to evaluate the feasibility or effectiveness of interventions. Of the 15 studies, 5 (33%) used randomized controlled trials [37,39,41,42,44], 2 (13%) used a pretest-posttest design [38,43], and 1 (6%) engaged parents in qualitative interviews to hear their experiences [38]. Moreover, 13% (2/15) of studies published in medical fields used a feasibility study to evaluate their intervention [32,34]. Studies published in computing fields have used methods from design disciplines to evaluate interventions. Furthermore, 13% (2/15) of studies asked participants to adopt the intervention in their everyday lives to understand its feasibility and acceptability. Of the 15 studies, 1 (6%) evaluation used a deployment study coupled with qualitative interviews [31], and the other used a technology probe and interviews, surveys, and a log analysis in their comprehensive evaluation [33]. The other computing study conducted a usability evaluation of their designs [30]. Studies published in health informatics fields have used interdisciplinary methods based on traditional computing and medical research. Of the 15 studies, 1 (6%) study experimentally measured changes in child weight and activity levels after the onset of the intervention [36], 1 (6%) study conducted a feasibility evaluation [35], and 1 (6%) acquired parent feedback through a usability study [40].

Content Sources

A total of 20% (3/15) of studies from computing fields evaluated an intervention that supported parents in developmental milestone tracking [30,31,33]. Of these 3 studies, only 1 (33%) [30] mentioned its content sources for developmental milestone topics and related Spanish translations; however, another study referenced developing the intervention "based on a series of formative studies" [33]. Overall, 33% (1/3) of studies provided generic guidance for infants up to 28 days old and reported that

they consulted local midwives for guidance [34]. The remaining studies addressed single-topic areas of early childhood health promotion.

Moreover, 26% (4/15) of studies focused on feeding- and nutrition-related content, 50% (2/4) of these studies were published in health informatics fields, and the remaining (2/4, 50%) studies were published in medical fields. Of these feeding and nutrition studies, 75% (3/4) reported how they developed the content for their intervention [35,36,42] and 50% (2/4) studies [36,42] consulted both national guidelines for feeding and nutrition and relevant experts (pediatric dietitians or nutritionists). Of these 4 studies, 1 (25%) study consulted pediatric dieticians at a local hospital where they were recruited for their study [35] and 1 (6%) study redirected attention to their related protocol paper for details on how they developed the intervention [39].

Overall, 26% (4/15) of studies presented an intervention targeting pediatric oral health and related parenting behaviors, and of these, 4 studies, 3 (75%) were published in medical fields [37,38,43]. Of these 3 studies, 1 (33%) reported that they reviewed national guidelines for pediatric dentistry and had their system evaluated by oral medicine specialists, pediatric dentists, and electronic learning and programing technicians [43]. The other (1/3, 33%) study reported that they consulted pediatric dentistry professors and an education management specialist to develop content for their intervention [37]. Furthermore, 33% (1/3) of studies did not report how they developed the content for the intervention [38]. The remaining pediatric oral health study was published in a health informatics field, and the intervention was developed using the American Dental Association's website [40].

Of the 15 studies, 1 (6%) study targeted vaccine adherence and consulted the country's Ministry of Public Health and Social Assistance, a health organization, and a special government project group focusing on vaccine adherence [44] and 1 (6%) study, which evaluated a speech- and language-focused intervention, did not report how they developed content for their intervention [32]. None of the studies in this review evaluated an intervention that comprehensively addressed anticipatory guidance, development and behavior screening, and social determinants of health topics, as recommended in the Bright Futures Guidelines for Pediatricians [1].

Demographics Reporting

Across all studies in this review, the number of adult participants enrolled in the study ranged from 8 to 58. The demographics-reporting formats varied across all studies; however, all studies included similar demographic characteristics. Studies published in medical and computing fields reported at least three of the following characteristics: child age and gender, parent age and gender, income level, parent education level, mobile phone ownership or familiarity, and race or ethnicity characteristics. None of the studies published in health informatics fields reported race or ethnicity data of their participant samples. A total of 26% (4/15) of studies opted for nontraditional approaches to describe socioeconomic status: 1 (25%) study reported parental eligibility for a low-income support program [32], 1 (25%) reported parental use of rental accommodations [36], 1 (25%) reported parental work status [44], and 1 (25%) reported parents' home or car ownership [42]. Moreover, 20% (3/15) studies that examined feeding or nutritional outcomes also tracked child weight or BMI [36,39,41].

Feasibility of Mobile-Based Interventions for Parents and Children by Publishing Fields

Computing Fields

Evaluation objectives varied across the studies. More than half (8/15, 53%) of the studies in this review did not report changes in parents' knowledge or decision-making processes [30,31,34-36,39-41]. Among the studies published in computing fields, 33% (1/3) of studies experimentally measured stress levels before and after the intervention and found that the intervention did not contribute to increased stress levels [33]. The same study found that their intervention scored high in their usability evaluations; parents reported ease of use during the onboarding process, and they appreciated seeing visualizations and parent-focused content (eg, information about parents' mental health). Of the 3 studies, the other 2 (66%) published in computing fields did not report on outcomes related to parent or child behavior changes, as they focused on usability evaluations [30,31] and 1 (33%) study reported that parents had difficulty with the delivery system of the intervention through Twitter, mentioning that syntax made the response process difficult, and parents did not like sharing their child's health information on a social network [31]. However, the same study also reported that parents generally appreciated the accessibility of content in the intervention. The other study reported that parents struggled during interface testing, as discovery of new features (eg, tracking milestones or creating a new profile) and related workflows were self-led, leading to parents perceiving the app as confusing and undirected [30]. The same study reported that parents preferred the ability to customize milestones that they share, increasing font size, and reviewing translations to Spanish, as they were not culturally relevant.

Health Informatics Fields

One interface-focused evaluation published in a health informatics field measured the intervention's impact on child BMI, which demonstrated that it did not significantly impact the BMIs of children in the study [36]. Another study examining the usability of their gamified mobile app found that parents believed the app could keep them informed about their child's oral health and support progress toward positive oral health behaviors [43]. The same study found that parents thought the app was user-friendly, although the interface design and process for parents to recognize and correct errors in tracking were rated low. This study also found that the gamified intervention was more effective in reducing child plaque than the nongamified approach. The remaining mobile apps published in a health informatics field reported a high ease of use of the interface and camera although parents had problems navigating the mobile app and expressed dissatisfaction with features that did not work [35]. However, the content, information, and reminders provided were rated as positive features in this app.

Medical Fields

Overall, 25% (2/8) of studies published in medical fields did not measure child-centered health outcomes [32,37]. These studies focused on changes in parenting behaviors or knowledge after the onset of the intervention or the feasibility of the intervention for evaluations in larger populations. In all, 12% (1/8) of studies found that maternal knowledge about pediatric oral health and related practices improved after the onset of the intervention and that high participation rates in the intervention indicated positive parent experiences with the technology [37]. In this intervention, parents specifically referenced that they liked the reminders and guided brushing videos the app provided. The other study reported that parents had increased awareness of language-promoting activities and local resources for child development support [32]. This same study reported that parenting behaviors that promote language development increased, and parents reported that the number of texts and content of the messages were accessible and easier to navigate than when searching the internet. Of 8 studies, 1 (12%) study did not evaluate interventions related to child outcomes or parent knowledge [34].

The remaining (4/8, 50%) studies published in medical fields measured child health outcomes after the onset of the intervention. Several studies have indicated that mobile-based interventions lead to significant child outcomes. Of the 8 studies, 1 (12%) study found that although BMI measurements of the intervention group did not differ significantly from those of the control group, physical activity levels did improve [41] and 2 (25%) interventions targeting nutrition-related outcomes, including reduced sugary beverage consumption [39] and improved child weight [42], found that children met the goals set during the intervention evaluation. Another study found a significant improvement in child toothbrushing frequency, and the gamified version of the intervention was more successful in controlling plaque than the control group [43]. However, 12% (1/8) of studies reported that the intervention had no significant impact on quantified child outcomes [38], despite positive experiences reported by parents.

Discussion

Principal Findings

We completed a systematic literature review of mobile-based health interventions for early childhood health promotion published within the past 10 years. Of the 15 articles we reviewed, we found that using mobile-based systems to deliver health interventions was generally well accepted by parents of children <5 years of age. We also found that, when measured, parenting knowledge of early childhood health topics and confidence to engage in health-promoting behaviors improved. For child health outcomes, several studies reported that the intervention did lead to targeted outcomes in child health, which indicates the potential for population-level improvements. In this section, we describe the opportunities for intervention designers and evaluators to critically engage with concepts in design practice, risk of technology-generated disparities, and reporting standardization.

Progression of Research Studies

The Obesity-Related Behavioral Intervention Trials model establishes a pathway of phases that supports the translation of information in behavioral and social science research into health interventions [45]. Using the Obesity-Related Behavioral Intervention Trials model, we documented the preparedness of the systems evaluated in the studies for large-scale phase 3 efficacy testing. In phase 3 efficacy testing or clinical research, researchers examine the efficacy of interventions and monitor outcomes in larger, more diverse populations, and over longer periods. We identified that 53% (8/15) of the studies evaluated their systems using nonexperimental methods and established the feasibility of the systems for target populations without documenting child health outcomes [30-35,37,40]. The remaining (7/15, 46%) studies conducted early experimental evaluations of the systems in larger populations and evaluated related child outcomes [36,38,39,41-44]. However, it is important to note that of the 6 studies that completed large-scale evaluations, 83% (5/6) of studies were published in medical fields [37,39,41,42,44], and the other was published in a health informatics field [36]. This indicates a lack of large-scale efficacy evaluations of early childhood health technologies in computing and health informatics fields.

Computing researchers have identified that novel technology designs often do not reach larger-scale testing and deployment in larger populations owing to funding constraints, lack of organizational support to maintain systems, retention of designers at original organizations, and incompatibility between early-stage designs and large-scale clinical evaluation processes [47]. Multidisciplinary collaboration across computing, medicine, and health informatics can lead to larger-scale evaluations, as medical trials are more likely to be funded in the long-term [7]. Partnerships between these disciplines can also support higher-quality designs and evaluations as researchers can be dedicated to 1 area of a project. For example, the Text4Baby program included a multiyear collaboration between computing and medical researchers. This project led to evaluations specifically for low-income parents and was evaluated at multiple stages, including a pilot evaluation [48] and a randomized controlled trial [49]. The Text4Baby program was also evaluated across diverse contexts, including Spanish-speaking parents [48], pregnant people who smoke, and pregnant and postpartum people from underserved areas [50]. Chandler et al [51] documented the cultural tailoring practices for mHealth tools aimed at addressing sexual and reproductive health outcomes for black and Latina women and identified opportunities to improve long-term outcomes and address health disparities. In domains other than child development support, researchers have called for more impactful collaborations between computing and medical researchers. Calvo et al [52] documented an initiative to bridge researchers in computing, medicine, and health informatics around the global mental health epidemic and identified challenges and solutions related to interdisciplinary collaboration. As the applications of technology-based interventions for child development are often novel, there is an opportunity to recognize the success of interdisciplinary collaboration in other domains and set standards for future work in this area. With support

across these disciplines, the early stages of the design and evaluation process can include larger and more diverse populations and introduce multiple dimensions of evaluation that address interface design, population relevance, and clinical objectives.

Reporting Guidelines

We identified that there is inconsistency in the reporting of race or ethnicity data and socioeconomic backgrounds in the samples. Several studies in this review did not report the racial or ethnic backgrounds of the participants in their samples. In all, 33% (5/15) of studies did not report socioeconomic data for their participant samples [31,34,35,38,41]. Researchers have found that reporting the demographic makeup of research samples helps illuminate potential disparities in the effectiveness of novel systems [14]. To address the potential of interventions to contribute to intervention-generated inequality, Veinot et al [22] recommended setting recruiting objectives that lead to testing in more diverse samples by targeting members of both disadvantaged and advantaged groups in early evaluations. We also identified that there is consistency in demographic reporting formats within fields but not across them. To improve the generalizability of results across fields, researchers might rely on national guidelines for reporting demographics [53]. In addition, Siek et al [54] documented that certain racial disparities within technology use can sometimes be flattened when differences between groups are not reported or analyzed. Therefore, consistency in the reporting formats for racial demographics is necessary. Reporting demographics can also support broader research objectives to identify trends in technology use among specific populations [22]. As such, there is a need for researchers to both report their participant demographics with more granularity consistency and document the effectiveness of systems with attention to the unique experiences of different racial groups. Improvements in reporting have the potential to support more accurate and granular identification of those affected most by health disparities. For example, researchers have identified standards for demographic reporting that support the accurate identification of health disparities within public policy [55].

Research Across Fields

The research objectives, methods, and paper formats tended to be consistent within fields. Among studies from medical fields, papers tended to be shorter in page length, focused on evaluating child health outcomes, and used quantitative methods to experimentally evaluate the effectiveness of the systems. Computing fields focused on using qualitative research methods to identify whether the design of systems was feasible for target populations and documented the opinions of participants on interface and interaction experiences. As expected, studies published in health informatics fields use a hybrid of methods from both computing and medical traditions, experimentally documenting child health outcomes and the feasibility of systems for deployment in larger populations. Researchers in computing, health informatics, and medical fields have all focused on the impact of usability and feasibility on the long-term effectiveness of interventions [23,56]. Researchers at the individual level might adopt a mix of qualitative and quantitative methods to complete more comprehensive evaluations of systems; however, interdisciplinary collaboration is needed to develop comprehensive and large-scale evaluations [54]. Partnerships between computing, medical, and health informatics researchers could lead to funding for large and long-term evaluations, a more comprehensive design process, and resources designated to developing content that addresses >1 need in the target population.

Content Development Process Reporting

Reporting content sources support the decision-making process in uptake for both parents and pediatricians [4]. For pediatricians to recommend mHealth systems such that their guidance is aligned with the guidance from the systems, interventions should report their content sources and refer to national guidelines for content [12]. As mentioned in the studies from this review, an expert review of the content can be helpful in the design process. Although each study contributed a technology on a different topic area in child health (eg, some addressed nutrition, others addressed physical activity), none of the studies in this review developed a technology that comprehensively addressed anticipatory guidance, development and behavior screening, or social determinants of health topics.

The social determinants of health topics are of particular importance, as they have the potential to support communities affected by racial disparities. The impact of social determinants on health content is 2-fold. First, screening for social determinants of health can illuminate the health risk factors that are directly influenced by social contexts. Garg, Boynton-Jarrett, and Dworkin maintain that social determinants of health screening are imperative for identifying how race influences health outcomes [12]. Within child health promotion, social determinants of health screening can lead to tailored recommendations [13]. Second, the social determinants of health frameworks can be useful for informing the content of health technologies through features that are adjacent to core health guidance. For example, researchers have evaluated consumer health apps and have identified that the technology literacy, price, and system demands of mobile apps influence the user experience [57], which are all related to the social contexts in which people interact with systems. Thus, social determinants of health content can be relevant to both the content and implementation formats of technology systems.

Design and Implementation Recommendations

There are several design, evaluation, and implementation recommendations that arise from the findings of this review and align with guidance in avoiding potential intervention-generated inequalities. Researchers might engage more diverse populations in the early design phases of systems to identify potential barriers to adherence in later testing phases and access them in later implementation phases. Computing researchers have identified that using human-centered methodologies in the early design and evaluation phases of system development leads to more effective and sustainable outcomes [58,59]. Including and reporting both the experiences of diverse populations and demographic sample makeup can illuminate potential disparities in health interventions. In this review, most studies focused on the evaluation of developed

prototypes and sought to understand how to improve these designs for later iterations in the target populations. Although usability and feasibility evaluations are beneficial for determining goals for future designs, understanding the broader contexts in which people use systems requires further specificity [23]. Evaluating systems, including specific objectives to address the effectiveness of racially diverse communities, can promote the recognition of racial disparities. For example, Brewer et al [60] presented several case studies documenting the impact of context-specific considerations in health informatics interventions related to race and community. The case studies included in this work highlight strategies for implementation and design that directly respond to the experiences marginalized communities have with their health and related technologies. Unless there are specific objectives for late-stage evaluations to capture the experiences of underserved populations, these evaluations cannot respond to technology-generated disparities.

Involving underserved populations in early-stage design processes can illuminate the influence of racial disparities and the potential for technology-generated disparities. There is an opportunity to document the earlier stages of design and use methods in early-stage processes that promote meaningful engagement with the target populations. For example, researchers have relied on design methods that enable target populations to become cocreators of systems, including co-design [59] and participatory design [61]. There is a broad spectrum of participation in target populations, extending from the community level to individualized participation [62]. Early-stage involvement in design processes is crucial to meaningfully address the risk of technology-generated disparities, as design specifications born out of conversations with target populations can respond directly to their unique needs [14].

Meaningful engagement with communities also extends to contexts in which they are likely to interact with health interventions and environmental factors that contribute to the effectiveness of these systems. Developing interventions within the community context can foster awareness of the reality of how communities experience and interact with technology. For example, Muñoz and Arriaga [63] documented the preferences of low-income parents when tracking child development by using technology. In this work, the researchers met parents at centers for women, infants, and children and identified context-driven guidelines for technologies, including sharing information between multiple caregivers and across generations. Modifying studies to be culturally aware can foster greater participation from communities. From the same work by Muñoz and Arriaga [63], 1 member of this research team spoke Spanish, the dominant language in this community, and the researchers included Spanish materials. This led to a substantial increase in the recruitment of Spanish-speaking parents (nearly doubled). Researchers have also demonstrated that deploying interventions in diverse contexts requires attention to the unique community contexts. Escobedo and Arriaga [64] engaged with parents in a neighborhood childcare center, where they evaluated a milestone-tracking application. In this study, the researchers collaborated with Spanish-speaking parents and identified that official translations of developmental milestones from the Centers for Disease Control did not reflect the Spanish variant (Mexican Spanish), which is primarily spoken in the United States. Through careful engagement with communities, both design and evaluation processes can be responsive to the unique experiences of diverse communities.

Researchers might also engage families as designers of technologies to identify well-suited delivery methods and feature specifications. Studies have engaged families in design practice and have found that systems are better aligned with family experience [65]. The user interface and experience can also be honed through this type of research engagement [66]. Although this systematic review did not specifically focus on the design and evaluation of features in these technologies, researchers have demonstrated the influence of features on outcomes [67]. Although none of the articles included in this review included feature-level analyses, including the evaluation of features may lead to an understanding of what features affect proximal outcomes.

Limitations

There are limitations to our findings. We did not include articles that described the components of an mHealth technology or a study to evaluate it but did not have participant groups using the technology (eg, study protocols). We also did not include studies where mHealth technology was a part of a larger intervention or studies of technologies developed for parents of children with specific health conditions, such as autism. This may exclude technologies that address areas of early childhood health promotion, specifically those covering developmental delays. Finally, our analysis of this work was heavily informed by Bright Futures Guidelines for Health Supervision of Infants, Children, and Adolescents, which was developed in the United States and thus could include content that is culturally different from developmental screening content in other countries. The Bright Futures guidelines are unique to the developmental screening processes in the United States, which may frame child health needs differently than other countries. As such, our analysis may not reflect each unique context in which these child health technologies have been developed.

Conclusions

We conducted a systematic review of mobile-based technologies for the promotion of early childhood health. We categorized studies by field to identify trends in design and evaluation practices and opportunities for those processes to address health disparity reduction. More mHealth interventions are needed that comprehensively address all areas of early childhood health, including anticipatory guidance, development and behavior screening, and the social determinants of health screening. None of the studies evaluated in this review contributed to a system that addressed all 3 of these topics. To fully understand the accuracy of health recommendations and identify reasons for a lack of adherence, it is necessary for early childhood health promotion tools to comprehensively address all the areas affecting child health. Without considerations of upstream factors, intervention risk is less effective, particularly in underserved populations.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Full search strings by database.
[DOCX File , 14 KB - pediatrics_v5i4e37718_app1.docx]

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Abbreviations

mHealth: mobile health
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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