Original Article

Do mHealth interventions at the bedside work?—a pilot intervention for pediatric patients admitted with pain complaints

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Background: Pediatric admissions for pain have been increasing, and pediatric consultation-liaison (CL) psychologists are frequently consulted to address pain coping for hospitalized youth. Many apps have been developed to target pain coping strategies, but no specific intervention has been developed to target pain coping using mobile health (mHealth) at the bedside. We describe an innovative, pilot, proof of concept mHealth intervention program using clinical apps to target pain coping strategies in youth referred for a pediatric psychology consult during their hospitalization.

Methods: Parent-child dyads (n=18, youth ages 7–19) completed measures assessing the child's pain history, pain catastrophizing, and pain interference during their child's inpatient admission. Participants were loaned a tablet and prescribed specific clinical apps as part of their psychology consult to target pain coping. Youth tracked the frequency and duration of clinical app use. At about 2 weeks post-discharge families (n=10) completed a satisfaction survey about their experience with the intervention and again completed the pain outcome measures administered at baseline.

Results: The clinical apps were used frequently during the hospitalization, primarily for relaxation. Youth who tracked their app use in the hospital were more likely to participate at Time 2. There was significant attrition from enrollment to Time 2. There were no changes in pain level from Time 1 to Time 2. Pain catastrophizing scores for youth decreased significantly at the follow-up interval. Most participants felt that the clinical apps helped with inpatient pain management and 70% continued to use the clinical apps after discharge. Parents universally would recommend the mHealth intervention to other families.

Conclusions: The feasibility of this proof of concept intervention is mixed. The intervention was acceptable to our CL team, we had no implementation issues, and there were high levels of acceptability and accessibility for patients. However, attrition from across time points presents a challenge to interpretation of results and highlights the difficulty in implementing such an intervention with a high acuity population. Further research is needed to better describe the impact of clinical apps use on post-discharge outcomes, but this mHealth pilot showed promise as an adjunct to standard inpatient CL interventions for pediatric pain.

Keywords: Clinical apps; mobile health (mHealth); inpatient consultation-liaison psychology; pediatrics; pain

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Introduction

Mobile health (mHealth) is defined as "*the use of mobile computing and communication technologies in health care and public health*" (1). Youth have been targeted as ideal users for mHealth interventions given their fluency with technology as up to 88% of teens, and 75% of children own or have access to a smart device (2,3). Many mobile applications, or "clinical apps", have been developed to enhance pain coping skills, including deep breathing, biofeedback, mindfulness meditation, progressive muscle relaxation, distraction, and medication adherence. Smith and colleagues (4) completed an extensive review of the available clinical apps for pediatric pain management, highlighting the important role that technology can play in enhancing clinical care for this challenging population. Specifically, the authors noted that clinical apps for pain foster practice and allow for continued intervention in settings and times when the psychologist is not available (i.e., home).

From 2004 to 2010, pediatric hospitalizations for pain increased 831% with an average length of stay of 7.32 days (5). Consequently, consults for pain are one of the most common for pediatric consultation-liaison (CL) psychologists, who provide evaluation and cognitive behavioral interventions to assist with chronic and acute pain management for youth admitted to the hospital (6,7). As these interventions exclusively occur at the patient's bedside, use of portable technology may be particularly valuable. However, there are no studies to date exploring mHealth interventions using clinical apps in inpatient pediatric CL settings, particularly to supplement clinical intervention for youth with pain problems.

We describe an innovative, pilot mHealth intervention program using clinical apps to target pain coping strategies in youth referred for a pediatric psychology consult during their hospitalization. Our study is a proof of concept to determine if this type of intervention is appropriate for use in an inpatient pediatric setting, if it is feasible, and if the intervention translates into outpatient use.

Methods

Setting

Our institution is a 348 bed children's and women's hospital embedded within a large academic medical center in the Midwest. At the time of this study, our pediatric psychology CL team consisted of one attending licensed clinical psychologist and one pediatric psychology post-doctoral fellow (total of 1.25 FTE) covering around 330 new consult requests per year. On average, 14% percent of new consults were for pain complaints (second to adjustment concerns at 21%). The majority of our consults came from the oncology and general pediatric services (about 30% each).

Participants

Youth between the ages of 7–19 years who were referred to our pediatric psychology CL service for the treatment of acute or chronic pain were recruited for this study. Participants were excluded if their medical status was too severe to allow them to participate (i.e., encephalopathy). Of the 28 eligible participants approached, 6 declined participation due to illness-based impairment or not being interested in the study. Of the 22 enrolled participants, 4 were unable to complete Time 1 (baseline) measures due to worsening clinical status (18% attrition rate at baseline). Therefore, participants consisted of 18 parent-child dyads (*Table 1*). Time 2 (follow-up) data was collected approximately 2 weeks after discharge and was completed by 10 of the 18 participants (45% attrition rate at follow-up). The 8 who did not participate in data collection at Time 2 were lost to follow-up as they did not respond to e-mail requests to complete the follow-up surveys.

Procedure

The study was approved by the institutional review board of the University of Michigan (No. 00090298) and parental consent and child assent were obtained from each participant dyad. The specifics of our iPad lending program are published elsewhere (8).

Time 1

In the context of care as usual, youth with a consult for pain concerns were invited to participate in the study during the initial consult with the CL psychologist. Declining to participate did not affect care or alter the course of treatment while hospitalized. Once enrolled, youth and a parent or guardian completed baseline assessment measures independently either online via a secure online survey program (9), or on a paper copy provided. Two participants younger than 8 years old were included in the sample and either read the survey independently or had it read to them. Participants were loaned study-specific iPads pre-loaded

Table 1 Participant characteristics Time 1 (n=18)

Variable	n	%
Gender		
Female	9	50
Ethnicity		
Caucasian	12	66.7
African American	5	27.8
Middle Eastern	1	5.6
Primary medical condition		
Inflammatory bowel disease	6	33.3
Neurofibromatosis	2	11.1
Complex regional pain syndrome	2	11.1
Constipation	1	5.6
Cyclic vomiting and abdominal pain	1	5.6
Cancer	2	11.1
Stroke	1	5.6
Genetic connective tissue disorder	1	5.6
Pelvic fracture	1	5.6
Migraine	1	5.6

with pain management clinical apps. The CL psychologist instructed the family in the use of the clinical apps and a subset of clinical apps were recommended at the discretion of the psychologist based on the clinical assessment and treatment goals. Participants were given a paper tracking form to record the name of the clinical app(s) along with the frequency and duration of use. The menu of clinical apps (*Table 2*) was screened by members of the study team to ensure their content was consistent with evidenced-based interventions for pain, relevant to pediatric populations, and vetted by other authors (4).

Time 2

Follow-up data collection occurred approximately 2 weeks after the child's discharge from the hospital via an email from study staff with a secure link. A $10 iTunes gift card was mailed to each participant after completing the entire study as an incentive to complete Time 2 measures. This particular incentive was chosen with the hope that participants would purchase clinical apps to use for pain coping.

Measures

At Time 1, demographic and consult specific information was collected via medical record chart review. Demographic information included patient age, gender, ethnicity, and primary medical condition. Consult specific information included the primary medical diagnosis, length of stay, and number of psychology contacts during the admission. Contact information for follow-up was provided by the child's parent/guardian.

The following measures were completed at both Time 1 and Time 2:

Pain and symptom survey

This self-report measure was completed by youth participants and consists of the following scales:

(I) Numeric Rating Scales (NRS), on which the respondent rated their pain intensity from 0 (no pain) to 10 (worst possible pain) at present, their average pain level over the past 6 months, their worst pain level over the past 6 months, worst pain level in the past week, and number of days of pain. NRS scales have demonstrated good validity and reliability for use with children 8 years and older (10).

(II) Body Map, which is derived from the 2011 American College of Rheumatology (ACR) survey and asks children to indicate where on the body map they are feeling pain. Number of pain locations (from 0–19) can be computed for descriptive purposes. This type of map has been used on children as young as 4 years old, with assistance (11).

(III) Pain Catastrophizing Scale for Children (PCS-C) (12). The PSC-C is 13-item instrument for ages 9–15 years that measures an exaggerated negative mental response to pain. It includes an overall score of 0–52 based on responses to items on a 5-point Likert scale ranging from not at all [0] to extremely [4], with higher scores indicating more catastrophizing. Scoring the measure results in percentile scores derived from raw scores on the total catastrophizing scale and three subscales: rumination, magnification, and helplessness. For the purposes of this study, a percentile score of 75 or above was considered clinically significant. Evidence of construct and predictive validity is adequate.

Table 2 Clinical app descriptions

Category	Application	Description
Relaxation	Breathe2Relax	Hands on diaphragmatic breathing exercises
	Tactical Breather	Stunning HD scenes with a natural soundscape
	Pranayama	Sleep zen sounds and white noise
	Gaze HD App	Breathing will biofeedback component (put phone on belly)
	Relax Melodies	Biofeedback app for breathing, sensor for heart rate (sold separately)
	Belly Bio Interactive Breathing	Meditation for young people
	Inner Balance	Bio behavioral exercises (e.g., relaxation, imagery, acupressure and aromatherapy) and parental education
	Smiling Mind	
	Healing Buddies Comfort kit	
Distraction	Me Moves	Interactive fine motor skills activities
	Bubble Wrap	Bubbly wrap popping simulator
	Dr. Panda's Hospital	Help take care of sick animals at the hospital
	Calm Counter	Visual and audio tool to help people calm down when they are angry or anxious
Adherence and behavior	My Med Schedule	Medication reminders and schedules
	Camp Pain Retreat	For parents and children with recurring headaches and stomachaches
	Take A Chill-Stressed Teens	Tools to help manage stress and bring mindful practice to daily routine
	eCBT Mood	Uses principles of CBT to assist with depression
	Super Better	Game that helps achieve personal health-related goals
	Epic Win	Goal-setting game that focuses on health behaviors
	iReward Chart	Reward tracker behavior chart

(IV) Pain Catastrophizing Scale for Children, parent version (PCS-P) (13). The PCS-P is a 13-item instrument for parents measuring their own exaggerated negative mental response to pain in their children. Scoring and subscales are the same as described for the child version above. Good internal consistency and validity have been reported.

(V) PROMIS Pediatric Pain Interference Scale and PROMIS Parent Proxy Report Scales (14). Both versions of this measure were developed by the NIH Patient Reported Outcomes Measurement Information System (PROMIS) item bank to measure pain interference in children across chronic medical conditions. The short forms consist of 8 items each and were validated to measure the impact of pain on daily activities over the past week for children ages 8–17 years according to self- and parent proxy-report (15,16). The parent proxy form has demonstrated moderate to low agreement (correlations ranging from 0.37–0.69) with the child/adolescent form across domains (15,16). Total raw scores for both forms are converted to standardized T-scores with a mean of 50 and standard deviation of 10. For the purposes of this study, a T-score of 60 or greater (at least one standard deviation above the mean) was considered clinically significant.

Confidence

Participants were asked to rate their confidence in their ability to manage their pain after discharge on a 0–10 scale (0= lowest confidence; 10= highest confidence). This was included as a proxy measure of child's perceived self-efficacy

and locus of control over their pain management.

Time 2 satisfaction survey

Participants were asked to provide the following information: frequency of clinical app use since discharge, follow-through with recommendations provided by the CL provider at discharge (e.g., outpatient therapy), if the mHealth technology encouraged outpatient follow-up, how much the use of the clinical apps affected their confidence in their ability to manage their pain in the future (on a scale from 0–10), and which clinical apps they liked the best. Parents were asked if they would recommend these clinical apps to other patients and families in the hospital and if the clinical apps were helpful for coping with their children's medical condition.

Data analysis

Descriptive statistics were used to calculate demographic characteristics of the sample and scores on the study measures. Pearson correlations were used to describe relationships between measures. One-way ANOVA was used to determine differences in those who participated in the Time 2 evaluation. Exploratory analyses using *t*-tests were conducted to examine changes in scores obtained from on measures at Time 1 and Time 2.

Results

Time 1

Sample characteristics

Descriptive statistics are summarized in *Table 1*. The age of participants ranged from 7–19 years (M =13.5, SD =3.3), 50% were female, and 66.7% identified as Caucasian. All but one of the parent respondents were mothers. Eleven of the 18 participants (61%) were admitted for chronic pain problems, whereas the remaining 7 were admitted for acute pain (e.g., surgery, injury). Participants were admitted to the hospital for an average of 2 weeks (M =14.7 days), but with significant variability in length of stay (SD =13.1, range, 1–40 days). Participants received an average of 2.7 contacts from psychology during their stay (SD =1.7, range, 1–6). All participants reported access to a smart device at home.

Pain and symptom survey

Youth reported a mean of 5.0 out of 10 (10= highest) pain rating on the day of the psychology consult. They rated their mean highest pain in the past 6 months as an 8.8 out of 10 and average pain in the past 6 months as a 5.5 out of 10. On average, youth had a variable duration of pain (M =105.6, SD =260.4, range, 4–1,095 days). Abdominal pain was the most common pain location, reported by 36.8% of participants, and 10.5% reported multiple pain locations.

Pain catastrophizing

As a group, youth did not indicate clinically significant levels of pain catastrophizing. However, the proportion of youth with scores in the clinical range was: 33.3% for total catastrophizing, 33.3% for rumination, 44.4% for magnification, and 27.8% for helplessness. Only the mean parent score on the rumination subscale (M =77.9) was clinically significant, possibly highlighting their own maladaptive ruminative response to their child's pain. The proportion of parent scores that fell in the clinical range was 44.4% for total catastrophizing, 72.2% for rumination, 50% for magnification, and 44.4% for helplessness.

Pain interference

Youth and parent mean T-scores were 60.8 and 65.5, respectively (*Table 3*). Specifically, 50% of youth and 89% of parent T-scores were within the clinical range.

Confidence

Participants reported high levels of confidence in their ability to manage their pain (mean confidence level of 7.3 out of 10; SD =2.1; range, 3–10) after discharge.

Clinical app use

Thirteen (72.2%) participants tracked their clinical app usage during the hospitalization. We do not have usage data for those who did not track. The majority of these participants used the clinical apps frequently during their hospitalization (M =88.4, SD =140.8, range, 0–540 minutes). This corresponds to an average use of 8.5 minutes per inpatient day (SD =6.9). One participant did not use the intervention in the hospital as they were unexpectedly discharged several hours after enrollment.

The most commonly used clinical apps were from the relaxation category (72% of participants) followed by the distraction apps (61% of participants). The adherence and behavior clinical apps were used the least (11% of participants). However, review of the individual consultation reports indicated that the CL psychologists emphasized the relaxation clinical apps for most participants given the

Table 3 Time 1 measures

Variable	Mean	SD	Range
Current pain	5.0	3.6	0–10
Average pain past 6 months	5.5	2.5	1–10
Worst pain past 6 months	8.8	1.6	4–10
Worst pain past week	7.8	2.5	2–10
Number of days of pain	105.6	260.4	4–1,095
Pain catastrophizing scale—youth			
Total	55.3	26.9	11–93
Rumination	55.7	23.5	6–91
Magnification	60.3	29.2	14–100
Helplessness	54.5	28.0	6–100
Pain catastrophizing scale—parent			
Total	64.8	22.4	24–94
Rumination	77.9	19.1	38–100
Magnification	63.6	23.8	14–90
Helplessness	58.6	22.8	22–92
Pain interference scale-youth	60.8	5.6	47–69
Pain interference scale-parent	65.5	5.4	56–78

nature of the referral question.

Time 2

Sample

Youth who tracked their iPad use in the hospital were significantly more likely to participate at Time 2 ($F = 5.25$, $P<0.05$). No other variables were statistically significant.

Pain

In terms of pain after discharge, 40% were experiencing no pain the day of survey completion ($M = 2.4/10$; $SD = 3$; range, 0–8) and reported their mean pain in the past 2 weeks 3.5/10 ($SD = 2.3$; range, 1–7). There was no statistically significant change in their pain rating from the day of Time 1 and Time 2 surveys.

Pain catastrophizing

There were statistically significant reductions in mean youth pain catastrophizing total score {$t[9] = 4.47$, $P<0.05$}, rumination {$t[9] = 3.37$, $P<0.05$}, magnification {$t[9] = 2.33$, $P<0.05$}, and helplessness {$t[9] = 4.07$, $P<0.05$} subscales. There were no statistically significant changes over time for parent reports of pain catastrophizing.

Pain Interference

As a group, youth and parents did not report statistically significant changes in perceived pain interference from Time 1 to Time 2.

Confidence

Participants rated their confidence level in their ability to continue to manage their pain as a result of the intervention a mean 6.67 out of 10 (highest) ($SD = 3.0$; range, 1–10), which is consistent with their confidence during the hospitalization and not statistically significant.

Clinical app use

Parents reported that their children used the apps for an average of 2.2 days after discharge ($SD = 1.39$; range, 0–4 days) for an average of 2.8 minutes per session ($SD = 2.05$; range, 1–7 minutes). Seventy percent of youth reported using the apps in the prior 2 weeks. Eight out of 10 participants reported that Breathe2Relax was their

favorite clinical app, with 1 each reporting their favorite was Dr. Panda's Hospital and Bubble Wrap.

Satisfaction

The majority of parents (89%) surveyed strongly agreed or agreed that using the apps helped their child to relax, that their child liked the intervention, and would recommend them to other patients and families in the hospital. Most parents also agreed or strongly agreed (89%) that their child would continue to use the strategies they learned to help them relax in the future, and that their child would use the apps again. Parents commented: "*I like the concept and think it's helpful*", "*the apps were a great idea and has helped her to relax more*", and "*this works on mild to moderate pain but not well when more severe pain kicks in*".

Discussion

The use of apps to supplement clinical interventions is considered an emerging mHealth approach in pediatric psychology and may address current obstacles that impact pediatric outcomes (17,18). There has been a strong call for the adaptation of evidence-based outpatient interventions to inpatient pediatric psychology CL practice, particularly in the areas of mHealth and eHealth (19). We developed a novel mHealth intervention using commercially available apps to target youth with pain referred for psychology consultation. This pilot proof of concept study represents the first to describe the use of clinical apps to complement evidence-based CL interventions in a sample of hospitalized youth with pain.

The feasibility of this intervention depends on which aspect of feasibility is examined (20). In terms of acceptability, the project was acceptable to our small clinical team as we anecdotally found that it enhanced our clinical care and was easy to use with the system put in place (8). Participants and parents had high levels of satisfaction with the intervention and parents would recommend the intervention to other families. This is consistent with satisfaction with pediatric pain management apps used in an outpatient setting (21). We did not encounter any implementation issues such as technological difficulties, loss of devices, or disruption of care due to the addition of the mHealth technology. The majority of youth continued to use the apps after discharge, although for only a few days. It is unclear if that dosing of the intervention would be enough to lead to measurable change and may account for the limited changes on the pain outcome measures. A particular strength of this intervention was the use of commonly available clinical apps (many free of charge) as this likely allowed for greater accessibility after discharge (4).

However, we experienced significant attrition rates at each time point of the study from recruitment to follow-up, with total attrition of over 50%. This significantly impacts our ability to fully determine the efficacy of this intervention. While the largest loss occurred at follow-up, the fact that some patients were unable to participate upon enrollment due to their medical status suggests that this type of intervention may not be feasible in the sickest of hospitalized pediatric patients who are experiencing pain. In addition, those willing to use the device and track their use were more likely to participate at Time 2. As a result, those who were more motivated to track may have received a higher dose of the intervention (17). While the goal was to provide an evidence-based therapy at a location and time that was convenient for our patients (17), we learned that during an inpatient hospitalization may not be the ideal intervention point for all patients, particularly those who are more ill.

Clinically, our outcomes were mixed. Due to the pilot and exploratory nature of this project along with attrition at Time 2, we did not have the ability to fully examine the relationship between clinical app use and outcomes following discharge. However, our exploratory analysis of those who remained in the study following the hospital-based intervention found clinically significant improvements pain catastrophizing for youth. Although the mean pain report did not change from Time 1 to Time 2, it is notable that 40% of the sample was without pain on the day of the Time 2 assessment. Given the exploratory nature of the pilot, and the likelihood that other factors impacted outcomes (i.e., pain medications or other medical interventions) we cannot confidently state that improvements are directly related to clinical app use.

Particularly relevant to CL psychologists is the fact that many youth engaged with the clinical app intervention outside of the face to face consult both in the hospital and at home. Engagement in "homework" is crucial for clinical progress in cognitive behavioral interventions and use of apps can help foster practice of pain interventions delivered by psychologists (4). Interestingly, when looking across studies of psychologist *vs.* patient administered interventions for pediatric pain there were no significant differences in outcomes, highlighting the importance of

empowering youth with the skills to promote their own recovery (22).

This pilot study had some inherent limitations that impact the generalizability of the outcome results. This was a small, heterogeneous sample with no control group or multiple baseline design which is a threat to generalizability. Further, this was not a stand-alone intervention and occurred within the context of medical treatment for pain and a pediatric psychology consult intervention. Thus, there were other confounding factors within the care participants received that limit our ability to determine the comparative effectiveness of the mHealth intervention (e.g., passage of time, medications, physical therapy, psychologist factors). Moreover, the attrition rate from Time 1 to Time 2 was high, which limits the interpretation of the results. For instance, selective attrition may have occurred, with those participants who perceived less benefit from the clinical apps being more likely to drop out of the study. Conversely, those who had significant improvements in their symptoms may have been less likely to participate in the Time 2 evaluation. Another possible limitation is the reliability of the self-reported frequency and duration of clinical app use, particularly since 1/3 of participants did not track their use. The researchers were unaware of a program that could electronically track this data, which would have been ideal.

This pilot study is the first of its kind to explore the specific role of mHealth interventions for pain intervention on an inpatient pediatric psychology CL service, and results of this pilot suggest this mHealth model is promising for use with this population. Future randomized controlled trials exploring the efficacy of a mHealth intervention are needed to determine the impact of this intervention on pain outcomes relative to other interventions. Studies are warranted to better target which pediatric patients would benefit from this type of intervention. Clinician researchers may want to involve parents in the mHealth intervention as previous studies have found that this can strengthen the intervention effect, particularly for younger patients (23). Finally, similar interventions geared toward other common presenting problems on a psychology CL service (e.g., illness adjustment) should be explored.

When using mHealth interventions, CL psychologists need to stay abreast of the research evidence, particularly given how quickly technology changes. This may pose a challenge to CL psychologists who already feel stretched thin (19). It is particularly important that interventions using clinical apps are integrated with other evidence-based cognitive behavioral interventions, rather than used alone (24). CL psychologists should review the quality of the applications they recommend to patients to ensure they use evidenced-based, developmentally appropriate content (4,8). Finally, when recommending mHealth interventions for children, pediatric psychologists should be aware of pediatric media guidelines set by the American Academy of Pediatrics regarding screen time (<2 hours/day), keeping internet connected devices out of bedroom, and the importance of monitoring what media are youth are using (25).

Conclusions

While mHealth interventions appear to be a viable behavioral health change modality for youth (23), our results suggest that mHealth interventions may not be optimal for all hospitalized youth. Interventions should be individually targeted toward youth who have enthusiasm for mHealth, are motivated to use clinical apps on their own time, motivated to improve their health, have access to the technology at home, and are clinically well enough to participate (i.e., not in severe pain, alert, ability to focus on the intervention). These findings are consistent with the literature which suggests that youth respond well to mHealth interventions and that behaviorally based clinical applications have the potential to impact health outcomes (1,24).

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jhmhp.2018.04.03). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki

(as revised in 2013). The study was approved by the institutional review board of the University of Michigan (No. 00090298) and parental consent and child assent were obtained from each participant dyad.

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