Title

Feasibility of Using an Automated Device (iThermonitor) for Continuous Temperature Monitoring in Pediatric Patients

Authors

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ABSTRACT

Background: Fever is an important vital sign and often the first one to be assessed in a sick child. In acutely ill children, caregivers are expected to monitor a child’s body temperature at home after an initial medical consult. Fever literacy of many caregivers is known to be poor, and coupled with fever phobia, results in unnecessary healthcare utilization. In children with a serious illness, the responsibility of periodically monitoring temperature can add substantially to the already stressful experience of caring for a sick child.

Objective: We conducted a pilot study to assess the feasibility of using the iThermonitor, an automated temperature measurement device, for continuous temperature monitoring in post-operative and post-chemotherapy pediatric patients.

Methods: We recruited 25 patient-caregiver dyads from the Pediatric Surgery Department at the Massachusetts General Hospital (MGH), and the Pediatric Cancer Centers at the MGH & the Dana Farber Cancer Institute. Enrolled dyads were asked to use the iThermonitor device for continuous temperature monitoring over a 2-week period. Surveys were administered to caregivers at enrollment and at study closeout. Caregivers were also asked to complete a daily event monitoring log. The Generalized Anxiety Disorder-7 item (GAD-7) questionnaire was used to assess caregiver anxiety at enrollment and closeout.

Results: 19 participant dyads completed the study. All 19 caregivers reported to have viewed temperature data on the study provided iPad tablet at least once per day, and more than a third did so 6 or more times per day. 74% of participants reported experiencing an out-of-range temperature alert at least once during the study. Majority of caregivers reported that it was easy to learn how to use the device, and that they felt confident about monitoring their child’s temperature with it. Only 21% of caregivers reported concurrently using a device other than the iThermonitor to monitor their child’s temperature during the study. Continuous temperature monitoring was not associated with an increase in caregiver anxiety.

Conclusion: The iThermonitor is a highly feasible and easy to use device for continuous temperature monitoring in pediatric oncology and surgery patients.
Trial registration:

ClinicalTrials.gov Identifier: NCT02410252 (March 30, 2015)

KEY WORDS: Temperature, pediatric, continuous monitoring, connected health
INTRODUCTION

Critical pediatric illness can be a major source of stress for parents. Fever is a common symptom in post-operative pediatric patients as well as in those with neutropenia [1, 2]. Even though most fevers within 48 hours of a surgery are benign and self-limiting, fever can be a sign of underlying complication and parents are expected to be vigilant [1, 3].

Furthermore, pediatric cancer patients undergoing chemotherapy are also predisposed to infectious complications because of neutropenia induced by myelosuppressive therapy, and require caregivers to be watchful for even longer periods of time [3,4]. In both cases, fever is the first clinical sign of infection and early detection is essential to evaluate the risk for further complications and death [4, 5]. Continued monitoring of body temperature may be necessary to detect any sudden changes in body temperature that may be related to a significant cause [4].

Monitoring the child periodically for fever can add to the already stressful experience of taking care of a sick child. Fever phobia has been a well-documented phenomenon in parents [6]. Moreover, previous studies show that parental knowledge about normal body temperature and the temperature that indicates fever is often poor, and few parents can accurately take temperature measurements [7-10]. Even in parents who do not belong in any of these groups, the process of monitoring fever periodically can be significantly disruptive to daily routine and necessitate interruption of sleep. Automated fever monitoring for children can overcome several of the problems described above.

However, availability of a novel technology may not necessarily translate into its adoption. Parental concerns and receptivity towards new technology is an essential pre-requisite for adoption. The primary aim of this study was to evaluate the feasibility of using an automated device for continuous temperature monitoring in postoperative and post-chemotherapy pediatric patients. We also evaluated the usability, satisfaction, and engagement of caregivers with the device. Finally, we assessed if continuous temperature monitoring inadvertently increased caregiver anxiety.
METHODS

We conducted a pilot study to evaluate the feasibility of using the iThermonitor for continuous temperature monitoring in postoperative and post-chemotherapy pediatric patients.

Recruitment
We recruited 25 patient-caregiver dyads from Massachusetts General Hospital (MGH), Dana Farber Cancer Institute's (DFCI) Pediatric Cancer Center and MGH Pediatric Surgery Department for voluntary participation in a research study that would involve use of the iThermonitor device for 14 days after enrollment with up to two study visits. Post-operative pediatric patients from the MGH Pediatric Surgery department were enrolled on the day of discharge or within 72 hours after outpatient surgery. Pediatric cancer patients were enrolled on the day of discharge after a routine visit or chemotherapy admission.

Potential candidates were patients who were deemed to be appropriate for the study by specialty care physicians involved in their care. Additionally, participants were sought through the MGH Broadcast listserv and fliers placed in clinicians’ offices. Study staff screened patient lists received from collaborating physicians to determine patient eligibility. Inclusion criteria outline the enrollment of pediatric patients aged 2-17 years of age with undergoing myelosuppressive therapies for acute leukemia's and other childhood cancer or any thoracic, abdominal surgeries that were discharged same day or within 72 hours of treatment or surgical procedure. Additionally, all participants had to speak English, be willing to shave axillary hair and have a caregiver 18 years of age or above.

Patients were excluded if they had a history of allergy to hydrogel dressing or ongoing skin diseases, ongoing febrile illness or documented infectious disease, undergoing chemotherapy for a terminal illness. Eligible candidates were contacted via phone to determine their interest in participation and those who met the eligibility criteria and were recruited.

Study Procedures

Formal enrollment in the study occurred during an in-person enrollment visit scheduled with the patient and the caregiver. At the enrollment visit, after explaining study details and procedures, pediatric participants and their caregivers were given sufficient time to review the consent form and encouraged to ask questions. Caregivers consented to the study on behalf of the pediatric participant and were asked to complete the enrollment questionnaire. Pediatric participants aged 10 -17 years were also required to confirm their willingness to participate in the study by signing an assent form. An informed consent form was signed and collected prior to the study. The enrollment questionnaire was administered after obtaining informed consent which contained questions on demographic information, caregiver technology use and General Anxiety Disorder-7 questionnaire (Supplementary Material 1, 2). Each day, pediatric participants were asked to wear the device while caregivers were asked to complete an “event monitoring log” every day over the study period.
of 14 days (Supplementary Material 3). Participants were given instructions to attach the iThermonitor to the skin by a hydrogel dressing that can be changed as needed. Temperature data collected by the iThermonitor was automatically uploaded to a paired receiver (an iPad Mini tablet computer) within a range of five meters for cloud storage. The provided iPad mini was pre-loaded with the iThermonitor app that was used to pair the receiver with the iThermonitor device.

Temperature data were then downloaded and stored in the Partners Healthcare network files. Data files were available to only the Partners Institutional Review Board (Partners IRB) approved study staff at Partners Connected Health (PCH). If a participant required hospital admission, they were asked to stop using the device during their hospital stay. If such a stay resulted in less than 50% of data being collected, participants were administratively dropped from the study. All participants were asked to continue to receive medical treatment and adhere to other management protocols as recommended by their physicians.

After 14 days of use, participants were either scheduled for a closeout visit to return the devices and complete the closeout questionnaire (Supplementary Material 2, 4) or were sent an electronic questionnaire via REDCap (an electronic study data capture system) along with shipping material to return their study devices.

**Intervention**

The iThermonitor (Figure 1), is a FDA class II device that continuously captures body temperature and automatically delivers the data wirelessly (via Bluetooth or Wi-Fi) to mobile devices or for cloud storage. It also generates and delivers out-of-range temperature alerts on a mobile application for caregivers or providers, allowing them to remotely monitor their child’s temperature (Supplementary Material 5).

**Figure 1: iThermonitor Device**
Data Collection

Feasibility of using the iThermonitor was the primary outcome of interest. Success as a feasible continuous temperature monitoring tool was defined *a priori* as “80% of the participants viewing the temperature data on the device by for at least 80% of study period”. This was assessed in two ways:

- Participant responses from the ‘event monitoring log’.
- Participant responses to the checklist administered as part of the closeout questionnaire (See below).

“Please indicate **Yes** or **No** for each column every day during the study” with the following response two questions:

1. The iThermonitor stayed on the body for most of the day?
2. I was able to view the temperature data on the iPad mini?

Secondary outcomes were assessed by a close-out survey designed by study investigators to obtain caregiver feedback about the following: a) Frequency of receiving out-of-range temperature alerts; b) Usability of the device; c) Acceptability of the device; and d) Caregiver satisfaction in using the iThermonitor. These surveys were administered as part of the closeout questionnaire.

Lastly, the Generalized Anxiety Disorder–7 item questionnaire (GAD-7) was also administered as part of the enrollment and closeout surveys to assess change in caregiver anxiety levels [12].

**STATISTICAL ANALYSIS**

Descriptive statistics were used to characterize the study sample, and survey responses. GAD-7 scores were coded as a categorical variable as follows: mild anxiety (total score 0 to 5) and moderate/severe anxiety (total score 6-15) [12]. Proportion of participants with mild and moderate/severe anxiety at enrollment and closeout was compared using Cochran's Q test. All analysis was
conducted using STATA version 14.2 with an alpha of 0.05 set *a priori*. Since this was an exploratory study with descriptive statistics, a complete case analysis approach was adopted for this study.

**Sample Size**

Since this was a pilot study, we did not conduct formal power calculations for sample size estimations. Previous usability studies recommend a sample size of 20 users which will identify at least 95% of usability problems [13]. We assumed a 20% loss to follow-up rate and arrived at a sample size of 25 patient-caregiver dyads.

**RESULTS**

**Participant recruitment**

We recruited a total 25 patient-caregiver dyads. The first study participant was enrolled on April 24th, 2015 from the MGH Department of Pediatric Oncology, and subsequently a total of 17 participants were enrolled from this department over a period of more than 18 months. The first participant from MGH Department of Pediatric Surgery site was recruited on December 23rd, 2016 and a total of 8 participants were enrolled with enrollment completion on February 2nd, 2017. Details of participant selection are provided in Figure 2.

**Figure 2. Participant Enrollment flowchart**

![Participant Enrollment flowchart](image)

**Participant characteristics**

The mean age of participants was 8 years (SD 5 years) (Table 1). Of the 25 enrolled participants, 4 withdrew consent during the study and 2 were administratively dropped out. 19 participants...
completed the study and were included in this analysis. 94% of participants identified themselves as White, and three out of four participants were male (Table 1). Mean age of caregivers was 41, ranging from 28 to 54 years. One in two caregivers were employed, one in three were homemakers and the rest were unemployed. 71% of the study participants were pediatric oncology patients, with hematologic malignancy as the most common diagnosis (Table 1). Surgical procedures varied widely among the eight participants, with hernia repair being the only reoccurring procedure.

Table 1. Participant characteristics

<table>
<thead>
<tr>
<th>Demographic Details</th>
<th>Study Group (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male, n (%)</td>
<td>14 (74)</td>
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<tr>
<td>Age of Participants, Mean (SD)</td>
<td>9 (6)</td>
</tr>
<tr>
<td>Age of Caregivers, Mean (SD)</td>
<td>41 (8)</td>
</tr>
<tr>
<td>Race, n (%)</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>17 (94)</td>
</tr>
<tr>
<td>Asian</td>
<td>1 (6)</td>
</tr>
<tr>
<td>Employment Status of Caregivers, n (%)</td>
<td></td>
</tr>
<tr>
<td>Employed full-time</td>
<td>5 (26)</td>
</tr>
<tr>
<td>Employed part-time</td>
<td>3 (16)</td>
</tr>
<tr>
<td>Homemaker</td>
<td>6 (32)</td>
</tr>
<tr>
<td>Unemployed</td>
<td>5 (26)</td>
</tr>
<tr>
<td>Baseline Conditions, n (%)</td>
<td></td>
</tr>
<tr>
<td>(i) Malignancies</td>
<td>12 (63)</td>
</tr>
<tr>
<td>Hematologic</td>
<td>9 (47)</td>
</tr>
<tr>
<td>Intracranial tumor</td>
<td>1 (5)</td>
</tr>
<tr>
<td>Rhabdomyosarcoma</td>
<td>1 (5)</td>
</tr>
<tr>
<td>Osteosarcoma</td>
<td></td>
</tr>
<tr>
<td>(ii) Surgical Procedures</td>
<td>1 (5)</td>
</tr>
<tr>
<td>Hernia Repair</td>
<td>7 (37)</td>
</tr>
<tr>
<td>Circumcision</td>
<td>2 (11)</td>
</tr>
<tr>
<td>Laparoscopy</td>
<td>1 (5)</td>
</tr>
</tbody>
</table>
Orchipexy  1 (5)
Foreign body removal  1 (5)
Unknown  1 (5)

202Attitudes towards technology

Most caregivers reported favorable attitudes towards technology. All caregivers reported owning smartphones, and using them to access the internet, send/receive emails, text messages, and to share pictures. However, only two-third of caregivers reported using smartphones or other technology to track weight, diet or exercise, and only one-third reported using any technology to track health.

208Feasibility

In response to the single-item question, all caregivers indicated viewing temperature data on the iPad at least once every day (Figure 3). Majority (84%) of caregivers of pediatric surgery patients reported viewing temperature data one time per day. In comparison, most caregivers of pediatric oncology patients reported viewing temperature data for 6 or more times per day. However, only 7 (37%) participants completed the daily event monitoring log for 12 out of the 14 days, i.e. for more than 80% of the study duration. 100% of these participants reported that they viewed temperature data for each of the 12 days.

216Out of range temperature alerts

75 % of the caregivers reported receiving an out of range temperature alert at least once during the study period. Of these, 63% caregivers reported receiving an alert three or more times.

219Figure 3. Frequency of viewing temperature on iPad

220
Usability, Acceptability and Satisfaction

All caregivers reported that it was easy to learn to use the iThermonitor. 84% caregivers reported feeling comfortable using the device to monitor their child's temperature, and 79% reported that they could easily monitor their child's temperature with it.

74% caregivers reported finding the mobile application very useful in monitoring temperature. However, only 52% found the out-of-range feature useful. 74% caregivers reported feeling more confident about monitoring their child's temperature by using the device, and 79% reported that they would recommend it to a friend or a family member. Only 21% of caregivers reported that they used another device to monitor the child's temperature during the study.

Caregiver Anxiety

16% participants had mild anxiety, and 21% had moderate or severe anxiety at enrollment. At closeout, 11% had mild anxiety, and 5% had moderate or severe anxiety. However, this difference in proportions was not statistically significant (p=0.29).
DISCUSSION

We conducted a pilot study to evaluate the feasibility of using the iThermonitor as a home-based continuous temperature monitoring tool in post-operative and post-chemotherapy pediatric patients. The iThermonitor may be a feasible tool to replace conventional temperature monitoring in pediatric patients. Caregivers reported that it was easy to use and increased their confidence in monitoring the child's temperature. Our findings demonstrated that caregivers are willing to engage with continuous temperature monitoring devices, without experiencing an increase in anxiety. This finding is important considering the well documented phenomenon of fever phobia [5].

We used two methods for measurement of feasibility- self-reported response in the closeout questionnaire and daily event monitoring log. The feasibility of using the device as assessed by the self-reported response (84%) was substantially higher than that obtained through the daily event monitoring log (37%). The feasibility assessed from the event monitoring log was lower likely due to the added burden on the study participant to complete one log for each day of participation in the study. In contrast, the burden of participation in the one-time self-reported response in the closeout questionnaire was much lower. Therefore, despite the possibility of response bias involved with the self-reported questionnaire, it is likely to be a better measure of feasibility in our study [14].

Fever is one of the first and most common complication in pediatric surgical patients [15]. Discharge instructions for caregivers often require them to monitor body temperature and take definitive action if it crosses a threshold [10]. However, fever literacy in caregivers has been reported to be low in previous studies [16]. A systematic review of literature concluded that parental knowledge about body temperature monitoring is poor [7]. Parents have been reported to base their fever management practices on inaccurate temperature readings [7]. Pediatric illnesses are associated with significant stress experienced by the caregiver and some studies have also reported that parents worry about failing to recognize a serious problem in their acutely sick child [17]. Ability of the caregiver to stay at home with the child and monitor vital signs such as temperature can vary by socioeconomic factors such as education, literacy, income and marital status [18]. The stress resulting from these factors is only compounded in caregivers of pediatric patients who have a serious illness that requires surgery or prolonged medical treatment [19, 20].
Digital health technologies are particularly well-suited to eliminate human error from relatively simple tasks in home-based caregiving such as body temperature measurement [21]. These technologies also offer an easy, safe and comfortable method to monitor body temperature in pediatric patients [5]. Additionally, digital health technologies such as the iThermonitor provide a unique opportunity to caregivers to access important data (temperature readings) through the convenience of a phone or tablet computer thereby eliminating the burden of constant temperature monitoring by the caregiver. Furthermore, the out-of-range temperature alerts feature may help reduce the caregiver’s stress by bringing the caregiver’s attention to any unwanted changes in the body temperature.

Limitations

One major limitation of our study is the lack of a control group that used another temperature measurement device such as a digital thermometer without a companion app or automated temperature measurement features. Therefore, we are unable to ascertain the benefit of these features relative to a simple digital thermometer. Secondly, we evaluated caregiver engagement through self-reported data and this may be subject to recall bias. Finally, our study sample represents a relatively narrow selection of pediatric illnesses. Our findings may not hold true in other pediatric illnesses. A larger sample size is required to evaluate the long-term impact of such continuous monitoring devices.

Conclusion

Overall, the iThermonitor is an easy-to-use device that is highly feasible for continuous monitoring of temperature in pediatric oncology and surgery patients. Most parents quickly developed enough confidence in the device to not use any other temperature monitoring device during the study. Though findings from this pilot study have limited generalizability, a device such as the iThermonitor may have the potential to reduce caregiver stress resulting from taking care of a sick child around the clock. Finally, it may also improve caregiver knowledge on temperature fluctuations and help them better monitor their child.

ACKNOWLEDGMENTS

We thank the MGH Department of Pediatric Surgery as well as the Pediatric Cancer Centers at DFCI and MGH for their help with recruitment of participants. We also thank Mursal Atif for her meticulous engagement in data collection; as well as Jamie Ruccio and Sue Rossov for helping with study setup. Lastly, we sincerely thank all participants without who this study would not have been possible.
CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

LIST OF ABBREVIATIONS

MGH: Massachusetts General Hospital
DFCI: Dana Farber Cancer Institute
GAD-7: Generalized Anxiety Disorder Questionnaire
PCH: Partners Connected Health

REFERENCES


Supplementary Material 1

**iThermonitor Enrollment Questionnaire**

<table>
<thead>
<tr>
<th>Study ID:</th>
<th>____________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
<td>____________________</td>
</tr>
</tbody>
</table>

There are three sections in this form – A, B and C. Section A contains questions about your child. Sections B and C contains questions for the caregiver.

**Section A: Child-specific information**

*Please answer the following questions about your child.*

1. What is your child’s age? _____(Years) or _____(Months)

2. What is your child’s gender?
   (Circle the number of your answer.)
   1. Male
   2. Female

3. Is your child Hispanic or Latino?
   (Circle the number of your answer.)
   1. Yes
   2. No
Which one or more of the following would you say is your child's race?
(Circle the number of your answers, more than one may apply.)

1. American Indian or Alaska Native
2. Asian
3. Black or African American
4. Native Hawaiian or other Pacific Islander
5. White
6. Other, please specify: ______________________________

Section B: Caregiver-specific information

Please answer the following questions about yourself.

1. What is your age? ________ (Write in number of years.)

2. What is your gender?
(Circle the number of your answer.)

1. Male
2. Female

3. What is your marital status?
(Circle the number of your answer.)

1. Married
2. Living with partner
3. Divorced or separated
4. Widowed
5. Single, never been married

4. What is the highest grade at school or years in college that you have completed?
(Circle the number of your answer.)

1. 1st – 8th grade
2. 9th – 11th grade
3. 12th grade, completed high school, or GED
4. 1 to 3 years of college
5. 4 or more years of college

6. Are you Hispanic or Latino?  
   (Circle the number of your answer.)
7. Which one or more of the following would you say is your race?  
   (Circle the number of your answers, more than one may apply.)
8. What is your current employment status?  
   (Circle the number of your answer.)

Section C: Technology Ownership and Use
1. Do you ever go online to access the Internet or World Wide Web, or to send and receive email? (Circle the number of your answer.)

   1. Yes
   2. No [skip to question 4]

2. When you use the Internet, do you access it through...
   (For each item, please circle the number for your answer. You may answer “YES” to more than one question.)

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. A regular dial-up telephone line.</td>
<td>1</td>
</tr>
<tr>
<td>b. Broadband such as DSL, cable or FiOS.</td>
<td>1</td>
</tr>
<tr>
<td>c. A cellular network (e.g., smartphone, 3G/4G)</td>
<td>1</td>
</tr>
<tr>
<td>d. A wireless network (Wi-Fi)</td>
<td>1</td>
</tr>
</tbody>
</table>

3. Have you ever used the Internet to do any of the following things?
   (For each item, please circle the number for your answer.)

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Send or receive email.</td>
<td>1</td>
</tr>
<tr>
<td>b. Send or receive instant messages or chat online.</td>
<td>1</td>
</tr>
<tr>
<td>c. Upload pictures to share with others.</td>
<td>1</td>
</tr>
<tr>
<td>e. Look for health or medical information online.</td>
<td>1</td>
</tr>
<tr>
<td>f. Track weight, diet or exercise routine.</td>
<td>1</td>
</tr>
<tr>
<td>g. Track any other health indicators like blood pressure, sleep patterns, headaches, etc.</td>
<td>1</td>
</tr>
<tr>
<td>h. Check your bank account balance or do</td>
<td>1</td>
</tr>
</tbody>
</table>
any online banking.

<table>
<thead>
<tr>
<th>i. Use a social networking service like Facebook or MySpace.</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

4634. **Do you have any of the following devices?**

(For each item, please circle the number for your answer.)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. A landline telephone.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b. A desktop computer.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c. A laptop computer or netbook.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>d. A tablet computer like an iPad.</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

4665. **Have you ever used your cell phone or smartphone to do any of the following things?**

(For each item, please circle the number for your answer.)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Send or receive email.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b. Send or receive text messages.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c. Take a picture to share with others.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>d. Access the Internet.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>e. Look for health or medical information online.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>f. Track weight, diet or exercise routine.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>g. Track any other health indicators like blood pressure, sleep patterns, headaches, etc.</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>
469

4706. How much do you agree or disagree with each of the following statements?

(For each item, please circle the number for your answer.)

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Somewhat agree</th>
<th>Somewhat disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I am willing to try new technology.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>b. I plan to make greater use of technology in the future to manage my health.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>c. I generally feel confident using new technology.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>d. I generally feel confident that I can use new technology to manage my medical condition.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>e. I worry about security issues of sending health information by the Internet.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>f. It is easy for me to follow instructions and set up new technology.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>g. I have no difficulty setting up computers or Internet modems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>h. Learning how to use new technology is easy for me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>i. New technology can be useful in keeping me healthy.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>I find using new technology to be a waste of time.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
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<td>-----------------------------------------------</td>
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<td><strong>Supplementary Material 2</strong></td>
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<td>489</td>
<td>Subject ID:</td>
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<td>491</td>
<td>Date:</td>
<td>____________</td>
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### GAD-7

Over the **last 2 weeks**, how often have you been bothered by the following problems?

(Use "✓" to indicate your answer)

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>Several days</th>
<th>More than half the days</th>
<th>Nearly every day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Feeling nervous, anxious or on edge</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2. Not being able to stop or control worrying</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3. Worrying too much about different things</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. Trouble relaxing</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5. Being so restless that it is hard to sit still</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6. Becoming easily annoyed or irritable</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>7. Feeling afraid as if something awful might happen</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

*(For office coding: Total Score T =  +  +  )*
Please indicate Yes or No for each column everyday during the study.

<table>
<thead>
<tr>
<th>Day</th>
<th>The iThermonitor stayed on the body for most of the day</th>
<th>I was able to view the temperature data on the iPad mini</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

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Supplementary Material 4

iThermonitor Closeout Questionnaire

Study ID: ________________

Date: ________________
Thank you participating in the iThermonitor study. Please answer the following questions about your experience using the device to monitor your child's temperature.

The following are statements about your experience using the iThermonitor. Please rate how much the following statements concerning the iThermonitor are true for you. (Please circle the number of your answer):

<table>
<thead>
<tr>
<th></th>
<th>Definitely NOT true</th>
<th>A little bit true</th>
<th>Mostly true</th>
<th>Definitely true</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overall, I am satisfied with how easy it was to use the device</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>It was easy learning to use the device</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>I felt comfortable using the device</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>I was able to easily monitor my child's temperature by using this device</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>I feel more confident monitoring my child's temperature by using the device</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>The device was helpful in starting discussions about my child's health with my doctor</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Using the device makes me feel more connected to my care team</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>I found the mobile application very useful in monitoring my child's temperature</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>I found the out-of-range temperature alert function very useful when my child's temperature was out of range</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>I would recommend iThermonitor to a friend or family member</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>The iThermonitor stayed on my child's body for most days during the study.</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>
12) I was able to view my child's temperature data on the provided iPad mini for most days during the study.

Yes  No

2. Did you view your child's temperature on the iThermonitor app?
(Please circle one of these options)
a. Yes  

b. No  

c. Prefer not to answer

3. Did you use another device other than the provided iPad mini to monitor your child's temperature? (Please circle one of these options)
a. Yes  

b. No  

c. Prefer not to answer

4. How often did you view the measurements? (Please circle one of these options)
a. Hourly  

b. 2-hourly  

c. 4-hourly  

d. Daily  

e. 2-3 times per week  

f. Once a week  

g. never  

h. other: _________________

5. Was viewing measurements on the app useful in being able to better manage your child's health? (Please circle one of these options)
a. Yes  

b. No  

c. Prefer not to answer  

6. Did viewing measurements on the app help you become more interested in your child's health? (Please circle one of these options)
563 a. Yes
564 b. No
565 c. Prefer not to answer
566
5677. Did you discuss the iThermonitor device with others?
568 (Please circle one of these options)
569 a. Yes
570 b. No
571 c. Prefer not to answer
572
5738. Did you discuss the iThermonitor device with your doctor?
574 (Please circle one of these options)
575 a. Yes
576 b. No
577 c. Prefer not to answer
578
5799. If you were given the choice would you like to continue using the iThermonitor device
to monitor your child’s health?
580 (Please circle one of these options)
581 a. Yes
582 b. No
583 c. Prefer not to answer
584
58510. If the iThermonitor were for sale in a store, would you buy it?
586 (Please circle all that apply)
587a. Yes, for my child.
588b. No
589c. Prefer not to answer
590d. Yes, for someone else (please tell us who): ________________________________
591
59211. How much do you like the components of the iThermonitor system below? (Please
circle the number of your answer)
Did you experience problems using the iThermonitor?  
(Please circle one of these options)

- a. Yes  
- b. No* 
- c. Prefer not to answer *

*If No or “Prefer not to answer”, skip to question 14

What problems did you experience? 
(Please circle all that apply)

- a. Problems keeping the device on my child’s body  
- b. Problems linking the device with my smartphones  
- c. Problems with the iThermonitor battery  
- d. Problems setting out-of-range temperature alerts  
- e. Other problems: __________________________

Please explain in detail the nature of the problem(s) you experienced as marked above:

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>A little bit</th>
<th>I like it</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td></td>
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<td>b)</td>
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<tr>
<td>d)</td>
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</tbody>
</table>

59512. Did you experience problems using the iThermonitor?
596   (Please circle one of these options)
597   a. Yes  
598   b. No*  
599   c. Prefer not to answer *
600   *If No or “Prefer not to answer”, skip to question 14

60213. What problems did you experience? 
603   (Please circle all that apply)
604   a. Problems keeping the device on my child’s body  
605   b. Problems linking the device with my smartphones  
606   c. Problems with the iThermonitor battery  
607   d. Problems setting out-of-range temperature alerts  
608   e. Other problems: __________________________
609

61014. Please explain in detail the nature of the problem(s) you experienced as marked above:
611 ____________________________________________
15. What else would you want added to the iThermonitor system to help you better monitor your child's health?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

16. Did the iThermonitor alert you when your child's temperature was out-of-range during the study period?

a) Yes
b) No
c) Prefer not to answer

[If No or "Prefer not to answer", skip to question 17]

17. How many times did the iThermonitor detect out-of-range temperatures? (If multiple times, please indicate number)

a) Once
b) Twice
c) 3 times
d) Other: ____times

18. We understand that this questionnaire may not fully capture your experiences participating in this study. Would you be interested in speaking with a research staff about your experiences in this research study?

a) Yes
b) No

Your answers are important to us. Please take a moment to check that you have answered all of the questions. Thank you for taking the time to complete this questionnaire!