ASPIRA: Employing a Serious Game in an mHealth App to Improve Asthma Outcomes

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Abstract—This paper presents the design, implementation and evaluation of a home based intervention targeting economically disadvantaged children to improve asthma clinical outcomes. The monitoring and intervention activities were delivered within an embedded astronaut-themed game to promote user acceptance and compliance to the clinical protocol. An iterative, user-centered design process was used to prototype the asthma home monitoring system (Aspira) involving a tablet application, digital spirometer and a particulate monitor linked to a data management server. Children of low socio-economic demographic populations were the main target group for this study as they have significantly high asthma rates and lack of condition awareness. Aspira is the first intervention of its kind that provides the target audience an easy to use and low-cost in-home monitoring application. Aspira’s design is grounded in the principles of social cognitive theory and aims to increase use, participation and efficacy in the target population. We present the results of a pilot study to determine feasibility and preliminary efficacy of the resulting high-fidelity Aspira prototype among four families with asthmatic children living in the Seattle metropolitan area.

Keywords—mHealth; home monitor; behavior change; asthma;

I. INTRODUCTION

Asthma is the most common pediatric medical condition in the United States [1]. Disadvantaged, urban, and minority children incur a disproportionate share of asthma prevalence and morbidity. 12.8% of African-American (AA) children less than 18 years old are diagnosed with asthma compared to 7.9% of Whites [2]. The racial disparity is even greater in terms of morbidity; AA children are almost 7 times more likely to die from asthma than Whites [3]. Environmental pollution is a significant contributing factor to asthma morbidity among urban, minority children [4]. Indoor pollutants such as cigarette smoking, and cooking and cleaning activities such as sweeping the floor have been found to decrease pulmonary function among school age children [5]. These pollutants impact air quality by increasing the amount of particulate matter. Such asthma triggers in the home environment contribute to racial disparities in asthma [6]. Unlike outdoor environmental factors that are less controllable, indoor air pollution is a modifiable factor that can be targeted with interventions. Most existing interventions for reducing environmental pollution involve home visits by trained assessors to identify ways parents can improve indoor air quality [7],[8]. Such interventions are costly, due to personnel resources, and may have limited efficacy because of the relative infrequency of monitoring and potential cultural insensitivity of perceived authority figures identifying “pollutants” in individuals’ private homes.

Our solution, Aspira, allows families to continuously monitor indoor air quality on their own, potentially at lower cost and greater effectiveness relative to existing interventions. Guided by social cognitive theory [9], Aspira sends instant alerts of poor indoor air quality, which are intended to serve as cues prompting positive behaviors to mitigate environmental triggers, thereby improving children’s asthma-related health. We expect the real-time, objective feedback about indoor air quality to overcome knowledge barriers in terms of what asthma triggers are present in inner-city, AA children’s homes in a culturally acceptable way because mobile devices are ubiquitous in this population [10] and enable private, asynchronous information exchange.

Our tool targets other components of NIH asthma care guidelines [11] through features such as reminders for daily controller medication use, because preliminary evidence indicates that such notifications to mobile devices can be effective behavior cues for urban, minority youth with asthma [12][13]. In sum, Aspira is a comprehensive mHealth asthma management ecosystem for urban, minority youth that particularly addresses indoor air quality in order to overcome knowledge barriers regarding environmental exposure, doing so in a way that is culturally and developmentally appropriate, in order to address the disparity in asthma health outcomes.

II. RELATED WORK

An in-home intervention for improving asthma outcomes is relatively novel. A comprehensive list of mobile applications that help improve asthma outcomes is presented in [14]. The study, conducted in 2012, found that out of a total of 103 apps, 56 were providers of information and 47 were tools that helped manage symptoms and care. There were no apps available that combined information and supportive tools for self-management of asthma. Another similar study conducted in 2015 [15], found that the quality of the apps is poor and most are engaged in information delivery and none provide a comprehensive and coordinated approach to improving self-management of asthma. While there are no proper self-management tools specifically designed for asthma, there has been recent work in developing such tools in other areas. In [16], a detailed examination of apps that help
reduce smoking is presented. In [17], analysis is conducted on the usability of mobile apps that help improve pain self-management. In [18], a systematic review of apps that help calculate insulin dosage and improve diabetes outcomes is presented. In [19], research is conducted to suggest the need to create a tailored and optimized intervention to manage asthma outcomes and helps validate the significance of this study and to further echo the current landscape of poorly designed asthma applications. In [20], a web-based application named “Boston Breathes” is evaluated for efficacy and showed significant gains when inner city children used the application via a randomized control trial. This is by far the only attempt to help provide a comprehensive solution, however it requires the caregiver to be present during the intervention and does not have a self-monitoring capability.

There has been significant prior research done on the proper design principles that should be employed while developing mHealth applications. In [20] a comprehensive survey of current medical smartphone apps is presented with recommendations on proper use in clinical and home settings. In [21], review of apps that help reduce immune disease propagation is presented and common guidelines as well as future trends in this area are discussed. In [22], the rationale for incorporating a user-centered design process for mHealth apps is presented and [23] provides guidelines on the application of user-centered design process in developing self-reporting mobile applications. [24] describes a user-centered process for the development of an mHealth app for childhood anxiety. Recently a model has been proposed in [25] for designing mHealth applications for use with consumers and provides further insights into the user-centered design process.

Utilizing mobile technology to monitor indoor air quality and improve self-management among at-risk children with asthma in an inner-city population is innovative relative to current home visit-based interventions. In addition, our mHealth system also has important advantages over other mHealth tools for managing asthma. For example, Abriiz® is an app that provides medication reminders to improve adherence and electronic methods of self-tracking asthma care management. However, it does not incorporate tools for monitoring and improving environmental air quality, which is a major trigger for asthma exacerbations among inner-city children [26]. There are also Bluetooth-enabled devices that can be affixed to inhalers and transmit information about medication use to a diary-type app. For example, Gecko Cap is targeted to children, and lights up to indicate when it is time to take controller medications. Each of these mHealth tools addresses a component of the asthma care guidelines; however, they do not help children and caregivers address the indoor air quality, which is likely to impact health outcomes for urban, minority children with asthma [27].

### III. App Design and Development

We present a tool intended to help urban, minority families to both independently identify and address asthma triggers in their homes and improve their child’s asthma self-management. This tool addresses two key recommendations of the recent report from the USA President’s Task Force on Environmental Health Risks and Safety Risks to Children to:

1. Expand the reach of the NIH asthma care guidelines by using innovative technologies to reach, engage and educate patients and families in communities affected by racial and ethnic asthma disparities; and
2. Institute programs to reduce environmental exposures in children’s homes, childcare facilities and schools.

The version we present is a second iteration in the evolution of the app. In the first iteration a “feed your pet” metaphor was used to grow a goldfish in a fishbowl as the child completed tasks (see Fig. 1). This app was implemented on a Windows 8 Samsung Smart PC. A clinical trial was started but did not complete successfully due to changes in support personnel. The project then received new funding from the USA National Institutes of Health to re-envision the user experience. A collaborative team from Mad*Pow Inc., Seattle Children’s Hospital, and Arizona State University then set about a design process for the user experience and system. The design process and implementation of this version of the app is described in this section.

#### Asthma Monitoring!

Fig. 1. Previous version of Aspira application

### A. App Design Process

To ensure a usable, efficient, effective, and satisfying to use app for parents and children, design activities focused on user modeling, interface wireframing, low-fidelity prototype development, and optimizing the user experience. The set of design activities led by Mad*Pow included:

**Key informant interviews.** It was important for the project team to have an unbiased understanding of how care providers, caregivers, and patients execute asthma self-management regimens. Mad*Pow conducted key informant interviews with care providers associated with Seattle Children’s Hospital to gain an understanding of their current and ideal asthma-management techniques and practices.

**User Personas.** From preliminary research and key informant interviews Mad*Pow generated user personas to serve as a guideline for design decisions, illustrate usability guidelines, shape interaction models, and identify required visual aesthetics essential to the evolving prototype.

**Heuristic evaluation.** Mad*Pow examined the previously constructed tablet application design and documentation to understand the evolution of design understanding and to inform a new design conceptualization.
Design studio. Mad*Pow facilitated a charrette-style directed design activity we call a Design Studio conducted with the project team as well as key stakeholders. The one-day workshop featured iterative and collaborative interface design activities geared towards quickly and effectively modifying the tablet application’s interface and interaction schemas. Mad*Pow then codified the day’s results in a series of key screen illustrations and constructed revised interaction designs in an easy to read wireframe format. A gameplay design document evolved from the result of this workshop.

B. App Gameplay Design

The new app conceptualized the interactions and self-management of asthma as a space-themed game. The game design embedded the self-management and system events in the game to encourage child participation and compliance. This was a significant intrinsic motivational design concept compared to the previous app version, which used extrinsic feedback (through the growth of the fish). App gameplay was integrated into the child’s daily routine as shown in Fig. 2.

![Fig. 2. Aspira Game Daily Core Loop](image)

The space-themed game involves a personalized character, or *avatar*, traveling between planets and requiring oxygen (O2) to power travel. Originally 7 planets were conceptualized, and 3 were implemented. In this routine, the child was asked to take a scheduled spirometer reading, measuring peak flow and flow volume, twice daily (morning and evening). The child earned rewards for completing tasks and answering questions required by the clinical protocol.

The app design included several features that integrated gameplay with desired clinical interactions, and encouraged overall interest in the game:

- **Secret Code:** a peak flow spirometer reading was a "secret code" the child obtained to facilitate space travel (Fig. 3).
- **Space Locker:** the child was able to accumulate prizes and postcards from visiting alien worlds and store them in the space locker. Prozes could later be gifted to aliens.
- **Avatar Personalization:** the child may choose to change the space gear and uniform the astronaut wears.
- **O2 Alerts:** when air quality gets low (poor readings for 15 of the past 20 minutes), an O2 space alert is issued, asking the child to take action to cancel the alert (Fig. 4) and identify the source of the O2 problem (Fig. 5).
- **Space Story:** the core loop of Fig. 2 is reified through a continuing narrative where the astronaut travels between planets in hypersleep mode, meets aliens, takes photos for postcards, and returns to the Space Command space station.
- **Virtual World Exploration:** 3 planets were implemented in the game, Caketon, Snootoozea, and Technacron. As can be seen from these names, these were themed with the child age range in mind. The child was asked to visit each planet in turn, and then could re-visit any planet of her/his choosing during space travel.

![Fig. 3. Call to action for a dynamic O2 alert](image)

![Fig. 4. Call to action for a dynamic O2 alert](image)

![Fig. 5. Identifying the cause of O2 alerts](image)
Fig. 6 describes some sample interactions of daily missions involving the 3 planets and these activities.

<table>
<thead>
<tr>
<th>Day 1</th>
<th>AM</th>
<th>Questions; Inhaler; Peak Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Dress for the day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Choose planet - Snotoozea</td>
</tr>
<tr>
<td>Day 1</td>
<td>PM</td>
<td>Questions; Inhaler; Peak Flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arrive at Snotoozea, meet alien, optionally give gift</td>
</tr>
<tr>
<td>Day 2</td>
<td>AM</td>
<td>Questions; Inhaler; Peak Flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dress for the day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Explore Snotoozea or go to different planet</td>
</tr>
<tr>
<td>Day 2</td>
<td>PM</td>
<td>Questions; Inhaler; Peak Flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>View landmark postcard (1/3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Return to Space Command for more O2</td>
</tr>
<tr>
<td>Day 3</td>
<td>AM</td>
<td>Questions; Inhaler; Peak Flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dress for the day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Choose planet - Technacron</td>
</tr>
<tr>
<td>Day 3</td>
<td>PM</td>
<td>Questions; Inhaler; Peak Flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arrive at Technacron, meet alien, optionally give gift</td>
</tr>
</tbody>
</table>

The application is a “choose your own adventure” game to self-manage asthma on a daily basis. Gameplay is integrated into the flow of daily activities for asthma management to promote self-efficacy and empower the child to take charge of his or her asthma routine, as well as bring the family’s attention to air quality issues. Assessment questions in morning Fig. 7 and evening differ to be relevant to those times of day, and are kept brief and simple for the child to answer on their own. The questions are derived from the NIH guidelines for asthma control.

C. System Design

The system requirements focused on using low-cost COTS tablets, spirometers, and air quality monitors in the home. The tablets used a home internet connection to push event data to a cloud-based server. The components of the system were:

- **Android Tablet**: A DragonTouch X10 tablet running Android 5.1. This tablet was selected for its low price-point and full USB port (needed to connect to the Dylos monitor).
- **Air Quality Monitor**: A Dylos DC1100 laser indoor air quality monitor. The Dylos monitor measures large and small particulates in the air. It was chosen for its low price-point, simplicity, and reasonably precise measures. The Dylos is kept running all the time to check the air quality levels in the home.
- **Microlife PF100 Asthma Analyzer**: The spirometer device used by the patients. It is not connected to the system, but rather used to enter the "secret code" for the astronaut.
- **AWS Cloud Server**: A t2.micro instance running Ubuntu Linux with a MySQL database backend was sufficient for this small pilot. The tablet application pushed de-identified data to this server as JSON through a REST API. A simple NodeJS web app was written and installed on this instance so CRAs had the means to monitor patient engagement.

IV. METHODOLOGY

A pilot study was conducted under IRB approval at Seattle Children's Hospital. This section describes the protocol and is followed by a summary of the pilot study results.
A. Study Participants Eligibility

Families were eligible to participate if (1) the child is 7 to 12 years old, inclusive, (2) the child has been diagnosed with asthma by a physician and prescribed a controller medication, (3) the family has broadband internet connectivity in their home, (4) the child is Medicaid insured, and (5) the parent identifies child as African American.

Families were excluded if (1) their child has moderate to severe medical conditions requiring more than one hospitalization per year or care by more than one subspecialist (e.g., severe developmental delay, cerebral palsy, sickle cell anemia), (2) they were enrolled in another asthma research study, (3) the primary language of the parent is not English, (4) they have private health insurance, (5) the child will be residing outside the participating parent’s residence for the majority of the study period, and (6) the child resides more than 20 miles from Seattle Children’s Hospital.

B. Recruitment Strategy

The study coordinator reviewed electronic health records to identify patients who had a scheduled visit at Seattle Children’s and met the eligibility criteria. The coordinator met these families at their clinic appointment, described the study and completed further eligibility screening in person. If they were eligible, consent/assent to participate was obtained for both parent and child. The coordinator then scheduled a home visit at which time she set-up the Aspira system and administered the baseline surveys.

C. Home Environment Setup

During the initial home visit, a clinical research assistant (CRA) oversaw the parent’s completion of an online survey instrument (using the provided tablet computer) and set up the home monitoring devices in a location in the home frequently utilized by the target child. The CRA provide instruction on device use and data recording. For the remainder of the study period, the CRA conducted bi-weekly phone calls to determine whether the ecosystem is functioning properly. Also, parents were given a contact number to report any issues concerning the device and we helped troubleshoot as needed for any device malfunction concerns. At the end of the study period, we return to the family’s home to collect the devices, re-administer the online survey instrument, and conduct a semi-structured in-depth interview with parent and child to collect user feedback. Interviews were audio-recorded for later analysis and coding, documenting themes that suggest ways that the technology should be modified.

D. App Data Collection

The app continuously collects data in the following areas:

- **Tool Utilization:** Usage of the app measured by ‘clicks’ (clicktracing). This data is logged and buffered locally for a short period of time (configured in the administration screens, default 15 minutes) and pushed to the cloud server. Once pushed it is removed from the tablet. This data also includes recordings of when events, such as scheduled and dynamic alerts for spirometer readings, occur.

**Asthma Self-Management Behaviors:** The app captures daily peak flow monitoring, manually entered as the "secret code" from the digital spirometer, and also gathered for verification at the end of the trial from the flash memory of the spirometer (limit, 256 values). Indoor environmental air quality management, captured by tablet application input of behavior in response to particulate matter increases (O2 alerts) are also pushed to the server.

**Air Quality:** The Dylos monitor does continuous monitoring of indoor air quality and these values are also periodically sent to the server. The results are compared with changes in air quality management behavior during analysis.

V. RESULTS

Four families participated in the pilot study during May-June 2016. Data collected included qualitative responses to exit interviews and app data as described above.

A. Exit Interview Findings

Children gave the app an average letter grade of ‘B’. When asked whether they’d want to keep using it, 2/4 said yes and 2/4 said maybe.

On average, children rated the app “somewhat fun” (3/4 on a 4-point Likert scale). Exploration was enjoyable for all as the primary game mechanic. The space theme resonated with 3/4 kids (2 girls, 1 boy); the 4th (boy) said he would’ve preferred a basketball theme.

On average, adults rated the app “somewhat helpful” (3/4 on a 4-point Likert scale). Routine checkpoints were seen as the most helpful aspect for 3/4 participants to encourage kids to be aware of their breathing using the peak flow meter, and take their medication.

“Helpful to see some days it was real good, some days it was just kinda okay ... just having to blow and record it, you pay a little more attention to it ... kept on your toes a little more, interesting to know each day it could vary, if it was a hotter day or a colder day, made me more aware of the change of weather ... helped him be responsible, sometimes even when we would forget, he would remember” – P5 adult

“Makes her get up and check her lungs every day” – P2 adult

“Importance of taking his inhaler every day ... when you set the timer, helped him with some type of schedule.” – P7 adult

The 4th participant found the air quality alerts the most helpful aspect and would’ve liked more information about what was causing them.

“Curious about what was actually in the air that was causing the alert... maybe it’s too hot or something? Would it detect dust or...? ... more about the air quality [would be helpful] - it did make me think about it, what was causing it...we have a gas stove, I’d walk around and see if everything’s off ... did change behavior a little bit” – P4 adult
For the others, air quality alerts were not mentioned in the interviews. Based on the log data, one participant (P7) did not receive any air quality alerts and had gaps in air quality data, indicating the sensor may have become disconnected or powered off. Logs of the other two (P5 and P2) indicated many air quality alerts triggered, but few responses were logged. Possible explanations include: family may not have been home at the time of alert; alert may not have been noticed; alert may have been ignored; application may have crashed upon attempting to respond to alert (at least one family encountered this issue).

B. Click and Event Stream Log Results

The app air quality logs show that for all 4 users, a total of 197 dynamic O2 alerts should have been raised, yet event logs indicate only 4 O2 alerts were responded to by end user families. While the logs do not show whether the O2 alert was issued and dismissed by the user, our suspicion due to data from error logs is that the USB reading routine between the Dylos and the DragonTouch tablet was unstable.

Regarding gameplay, Table 1 shows the number of interactions with components of gameplay over the 2-week usage period for each user outside of the times when the child was called to the game by an alert. This figure represents spontaneous game play, and shows the children particularly enjoyed flying their astronaut to different planets, but did not engage in other aspects of the game as much.

<table>
<thead>
<tr>
<th>Event name / User</th>
<th>User 2</th>
<th>User 4</th>
<th>User 5</th>
<th>User 7</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traveling to planets</td>
<td>4</td>
<td>13</td>
<td>19</td>
<td>24</td>
<td>60</td>
</tr>
<tr>
<td>Present Gift</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Stay on Planet</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Save Photo</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Visit Spacelocket</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>10</td>
</tr>
</tbody>
</table>

Table II shows that users did engage with the game fairly frequently over the 2-week period. While there is room for improvement, we hypothesize that the tethered kiosk mode of the tablet on a device distinct from a personal device may have dampened enthusiasm for the game.

<table>
<thead>
<tr>
<th># of times game played</th>
<th>#different events accessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 2</td>
<td>4</td>
</tr>
<tr>
<td>User 4</td>
<td>12</td>
</tr>
<tr>
<td>User 5</td>
<td>8</td>
</tr>
<tr>
<td>User 7</td>
<td>10</td>
</tr>
</tbody>
</table>

VI. DISCUSSION AND FUTURE WORK

Technology issues were the biggest barriers in this project. The three major issues were:

Reliance on a tethered connection – When we started this project, there were no air quality sensors on the market of proven quality that used Bluetooth or WiFi. The air quality sensor used in this study was the Dylos DC1100 Air Quality Monitor with PC Interface, which has a 9-pin serial cable that is hooked into a tablet using a USB adaptor. The serial connector does not have screws, leading to a less-than-secure connection that was the most likely reason for gaps in our air quality data. Over the course of the project, a number of new wireless sensors have come to market from Kickstarter projects and various startups, so we are hopeful that a better sensor setup could be achieved in a future phase.

Android tablet – There were a few issues here. First, there are a very limited number of tablets on the market with a full-sized USB that support host mode, which was required to connect with the air quality monitor. Within those options, we selected a low-cost tablet to keep cost per setup low. We conducted extensive quality assurance testing in the lab during development using a Dragon Touch A1X tablet, which seemed to work fine. When it came time to order tablets for in-home use, this model was no longer available, and the new model (A10) we ended up using was significantly less stable. The Android tablet market is constantly shifting and quality varies widely, so future efforts should consider spending more time to ensure quality hardware. Further, we believe engagement will increase if the game can be deployed on the families’ personal devices, which will be possible if we use wireless air quality monitors in the future.

Peak flow meter issues – When we started this project, there were no peak flow meters or spirometers of proven quality that used Bluetooth or WiFi and were available at an affordable price point. We selected an affordable and reputable digital peak flow meter, the Microlife PF 100 Peak Flow Meter for Spirometry with FEV1. This meter holds readings in internal storage, which could be offloaded by the researcher at in-home visits. This gave us a log to compare against the readings kids manually keyed into the app, but was not ideal for gameplay. Manual entry is burdensome and not always accurate. One participant received a defective peak flow meter, and even after we replaced it he continued to have issues entering accurate numbers. While there is not as much activity in the peak flow/spirometry market as there is in air quality sensors, startups such as Sparo Labs (www.sparolabs.com) and Cohero Health (www.coherohealth.com) have promising connected spirometers recently approved by the FDA.

Despite technical challenges, we still believe the concept has merit. Based on participant feedback, there were a few opportunities for improvement in the game itself:

More interactivity – Interactivity was limited in the prototype due to the fragility of the hardware setup and the limited number of user goals and virtual worlds implemented for this feasibility study. In a more stable and complex setup, we could support more robust and engaging inputs and interactivity with the avatar and other game elements.

More game content – Game content was limited based on budget for this phase, though it should also be noted that the game is not supposed to be played forever. Ideally the amount of content would be designed for a targeted intervention of at least one month to help children who are newly diagnosed or
experiencing difficulty managing their condition. Areas for expansion include mini-games that could be played any time between check-ins incorporating asthma education concepts, and more planets appealing to a variety of children’s interests.

**More information about what’s actually in the air** – To our knowledge, this is currently not possible with a particulate matter sensor alone, since it can only detect quantity of large (PM10) and small (PM2.5) particles. PM sensors do not distinguish between different contaminants. Combination sensors that track PM, VOCs, NO2, and CO could provide insights into gaseous pollutants. New sensors such as ChemiSense (www.chemisense.co) show promise in providing more specific data about what is in the air. For the prototype, we relied on a question prompting the user to identify for possible triggers in the environment, but automating this would be better since users may not always be present and able to investigate alerts.

Along with improving the technology, creating deeper content, and running a large sample randomized controlled trial, future efforts should include finding an appropriate price point, payment model, and distribution model to make this accessible to low income families. All adults said they would be willing to use if loaned for free from a doctor or insurance, and some said they might be willing to pay for it if it had an impact on the child’s breathing, depending on the cost. Some combination of hardware borrowed from a clinic and bringing your-own-device could be a strong option.

**ACKNOWLEDGMENT**

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