Grant Final Report

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Conversational IT for Better, Safer Pediatric Primary Care

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Abstract

Purpose: To determine whether an interactive voice response (IVR) system, the Personal Health Partner (PHP), used by parents before routine healthcare maintenance (RHCM) visits can improve: 1) comprehensiveness of care; 2) medication safety; and 3) parental activation.

Scope: A large gap exists between what is *recommended* and what *actually* takes place in pediatric primary care settings.

Methods: Parents of 4 mo to 11 yr old children in an urban pediatric primary care center called PHP 1-7 days before routine visits and were randomized at the time of the call to either PHP content or the Framingham Safety Survey.

Results: PHP was able to identify and counsel in multiple areas. PHP-parents were more likely to report discussing important issues such as depression and prescription medication use with their clinicians during visits. PHP-parents were also more likely to report being better prepared for visits. 89% of PHP-parents would recommend use of PHP to other parents. Conclusions: Systems like PHP have the potential to improve health-related behaviors, detect concerning patient safety situations, and enhance patients experience and engagement with care.

Key Words: interactive voice response; patient-centered; health information technology; child health; routine health care maintenance; electronic health record

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Final Report

Purpose

For this project, we developed and evaluated an integrated patient-centered health information system, the Personal Health Partner (PHP). The PHP is a fully automated conversational system that uses synthetic text-to-speech (TTS), automatic speech recognition (ASR), and a data-driven multimodal conversational system to gather personal health data and counsel parents before scheduled visits. Patient-reported data is shared with the child's primary care clinician via an electronic health record (EHR) system and combined with decision support and recommendations. PHP is a novel-method to enhance patient-centered models of care and in this study was shown to improve multiple health outcomes, detect concerning patient safety situations, and enhance patients' experience and engagement with care. Our study focused on improving shared decisionmaking and improving patient-clinician communication. In addition, our study focused on supporting medication management, which has been identified as a priority area for transforming health care by the Institute of Medicine.[1]

Project Aims

The specific aims for this project were to:

1. Develop an automated telephony system that uses fully automated conversations to perform pre-visit pediatric primary care assessments, offer counseling (including medication knowledge and use) to parents, and support clinician decisionmaking by incorporating patient assessment with their EHR.

2. Conduct a randomized clinical trial to determine whether: 1) PHP assessment alone (no counseling) with sharing of data with clinicians via an EHR leads to higher quality preventive care (general and asthma) and medication management; and 2) whether addition of interactive telephony-based counseling to PHP assessments is associated with further increases in quality and healthier parental behaviors.

Our primary hypotheses were:

1. PHP assessment with EHR data exchange will lead to improved process and outcome measures, when compared to usual care, in: a) General Preventive Care (tuberculosis risk, passive smoke exposure, dietary choices, screen time, safety, maternal depression and developmental screening); b) Asthma Preventive Care (symptom assessment, medication knowledge and use, and self-management planning); and c) Medication Management (dosing at home, preparation for visit, and adherence).

2. PHP pre-visit counseling with post-visit reinforcement will increase parental activation and be associated with healthier care processes and parental behavior change when compared to parents receiving usual care.

We also planned to explore: 1) use of the PHP system will be feasible for parents and clinicians; 2) parents with low health literacy are able to use the PHP system as effectively as those with higher health literacy; 3) satisfaction with care will increase for parents using the PHP with and without counseling; and 4) parents and clinicians recommend continued use of the PHP in the future.

This project also explored whether patients received appropriate care for prevention, treatment, and management of six of the areas identified as priorities for transforming health care by the Institute of Medicine[1] (asthma, medication management, major depression, obesity, self-management/health literacy, and tobacco dependence); and the impact of patient-centered health IT in low-resourced urban safety net settings where health IT diffusion is likely low.

Scope

Background and Context

A large gap exists between what is *recommended* for effective primary care of children and what *actually* takes place in pediatric primary care settings, especially in the areas of preventive care.[2,3,4,5] Furthermore, although medication management (safety and effectiveness) issues have emerged as an important factor for children, little is known about how medication is actually used by families at home. Patient-centered information systems have been used successfully to gather information and counsel parents. These systems have typically been deployed in waiting rooms or via the Internet and have been limited to use before visits.[6,8,9,10] Data gathered by these systems have not generally been integrated directly with an electronic health record (EHR) system to support clinical decisionmaking at the point-of-care.

Interactive telephony technologies offer a potentially more effective, patient-centered communication modality by guiding parents *at home* through interactive discussions that can gather information and actively reinforce recommendations and treatments. Interactive telephony systems are particularly well-suited for use by vulnerable populations since access to the telephone is nearly universal, and the system does not rely on reading printed text.

Telephony in Clinical Health Applications

Historically, much of primary health care has been provided through a conversation between a trusted, knowledgeable care provider and a patient. While currently available patient-centered technologies ask questions, gather answers, and provide advice, they are not truly conversational. We are not aware of any formal published criteria to assess the "conversationality" of an IT system, but would propose that at a minimum, conversational IT systems should: 1) be capable of speech-based interaction (no typing or visual content required); 2) support bidirectional

information flow (system informs the user and user informs system); and 3) deliver customized responses based on information provided by the user.[14]

We believe that one component of next-generation patient-centered care lies in multi-modal technologies that go beyond users sitting at a computer and answering questions and support actual behavior change. Telephony (voice only) and conversational agents (a visual component linked to an interactive voice system) will be the foundation for these next-generation systems, and will offer a number of special advantages. First, these systems can use the most ubiquitous telecommunications device, the telephone, which is present in almost all homes in the United States. Second, a computer-based telephony encounter is a "conversation" that can simulate the patient-provider or patient-counselor relationship. Third, the use of a human voice (pre-recorded or computer-generated) of a particular age, gender, accent, quality or familiarity allows the user to Imagine that the voice is a particular type of a person, e.g., a peer or provider. Although it is possible to use a human voice in computer-terminal or web-based systems, this rarely occurs. Fourth, computer telephony systems employ spoken language rather than text on a screen, a format that many users, either for literacy reasons or preference, prefer. It has been estimated that retention of spoken language is twice as great as retention of text, and that most people understand spoken language at about two grade levels higher than the level at which they read.

Parental Activation and Patient-Centered Health IT

There is general agreement that engaging patients to be an active part of the care process is an essential element of the quality of care. The PHP system described in this proposal addresses three core areas of patient activation: 1) having the confidence and knowledge necessary to take action, 2) actually taking action to maintain and improve one's health, and 3) staying the course even under stress. The system seeks to engage parents at home, validate the essential role of a parent in the health care process, provide knowledge and reinforcement to build parental confidence, and encourage parents to take action through goal setting and planning.[11]

Setting

The PHP system was evaluated via a randomized trial conducted during 2009-2011 in the Boston Medical Center (BMC) Pediatric Primary Care Center in Boston. BMC is the primary teaching affiliate for Boston University School of Medicine and the largest safety net hospital in New England. The center has over 35,000 patient visits annually for children and adolescents and primarily serves children who are from low-income families with minority ethnicity. A considerable portion of the study also occurred within the child's home before the scheduled visits.

The EHR used in ambulatory settings at BMC is "Centricity Physician Office" from General Electric. The product has been in use since 1999.

Participants

Users of the system were predominately of minority ethnicity and recruited from the population served by the largest safety net hospital in New England (35% African-American,

15% Haitian-American, 30% Latino, 10% Portuguese-Creole, and 10% other groups). The majority of patients were either uninsured or insured by Medicaid.

Methods

PHP System Architecture

The content of the PHP system includes three general areas: routine health care maintenance (RHCM), asthma symptom assessment, and medication safety. RHCM areas include: 1) general health supervision; 2) developmental screening; 3) diet and physical activity; 4) tuberculosis risk assessment; 5) smoking risk assessment; and 6) maternal depression screening. Questions are based on recommendations from the U.S. Preventive Services Task Force (USPSTF), the American Academy of Pediatrics, other published evidence-based guidelines, and the experience of experts at the study site. When available, validated questions and assessment tools are used including: 1) AAP- and Medicaid-recommended health risk questions for tuberculosis, smoke in the home, diet and physical activity, and safety; 2) The Patient Health Questionnaire (PHQ-2 and PHQ-9), a widely used screening tool for adult and adolescent depression; 3) Ages and Stages Questionnaire for routine developmental screening; 4) The Asthma Control Questionnaire (ACQ) a validated self-administered assessment tool for assessing asthma control; and 5) the AHRQ 20 Tips to Help Prevent Medical Errors in Children.

No validated tool is currently available to assess medication safety in the home, nor to assess management of prescriptions and medication following primary care visits. For this area, we have developed new content to assess correct dosing and administration of over-the-counter medication (fever control and cold medication), knowledge of action and indication for asthma medications, and automated review and initial reconciliation of EHR medication lists.

Each content area has been developed as an independent module with a question set, decision rules for directing the conversation, and counseling topics that include activation messages. This modular approach allows the easy addition or removal of new content areas and enhances our ability to extend and share the logic and content of each module with other IT systems.

The PHP System primarily uses computer-generated speech, also called text-to-speech (TTS). TTS systems allow the direct transformation of text (data in a database) to audible speech. TTS voices are available in male and female versions and in nearly all languages. Traditionally, the quality of the speech generated by TTS systems has been low, limiting use in medical applications. However, within the past 5 years remarkably high-quality TTS voices have become available allowing the development of dynamic, data-driven conversational systems. For this project, we were able to leverage this newer TTS in all areas except for medication reconciliation for which TTS accuracy was found to be insufficient. Medication reconciliation was performed by PHP by assembling pre-recorded speech files and playing them during the conversation. Our ability to use TTS substantially improved the flexibility, scalability, and time required to implement the system. Speech recognition is now very accurate – especially for structured responses. The PHP does not require that users touch their telephone keypad after initial dialing.

PHP Conversation Engine

Most conversational systems, particularly those using voice-XML, have used a linear approach to the conversation. With a linear approach, the data and decisionmaking are encoded within an algorithm with minimal reuse of elements and code. While we and others have successfully used this approach in previous applications, the approach can lead to scripts that are difficult to manage, test, and iteratively improve. For the PHP System, we re-engineered our approach by separating the data and decisionmaking for the system from script code. A script shell is used to iteratively move through the script using data stored in a script table. The result is a system that can be directly managed within the database and one that can support a variety of conversational systems including telephony, SMS text messaging, and web-based systems.

PHP conversations are a set of conversational "actions" stored in a single data table to encode data. Within the PHP framework, each core subject area is created as a module. Each interaction with the PHP system is launched from a Shell Module. All modules are composed of a set of 9 core conversational actions: BeginModule, Say, Ask, Decide, PlayList, GetData, SaveData, UpdateData, EndModule.

PHP Software Components

Four software components are used to develop, test, and deliver PHP conversations: 1) Script Builder (to enter and test script code); 2) Script Writer (to generate a readable script document from data); 3) the actual voice-XML Script (voice-XML script hosted within at vXML Gateway); and 4) PHP Manager (to manage users, monitor use, and support EHR data exchange).

The *Script Builder* allows a technical analyst to easily create, test, and edit PHP script modules. Script line actions are configured, potential answers are set, and all possible responses are linked to follow-up questions. The logic can be visually tested within the module for debugging and scripted data is immediately available to any application with appropriate database connectivity and the ability to execute the script.

The PHP *Script Writer* generates a human readable script document from the data in the PHP script table to allow subject matter experts to review content and edit scripts. Each script line is uniquely identified and editors can edit and quickly update date data via the Script Builder application. Conversations are controlled within a single voice-XML script with custom coding for each of the actions.

The *vXML Gateway* is used to host scripts once developed. Scripts are published to an open-source web application server (Tomcat) and conversations occur via analog telephone connections. Data gathered during PHP Conversations are assembled into delimited data and transferred to each patient's record following call completion.

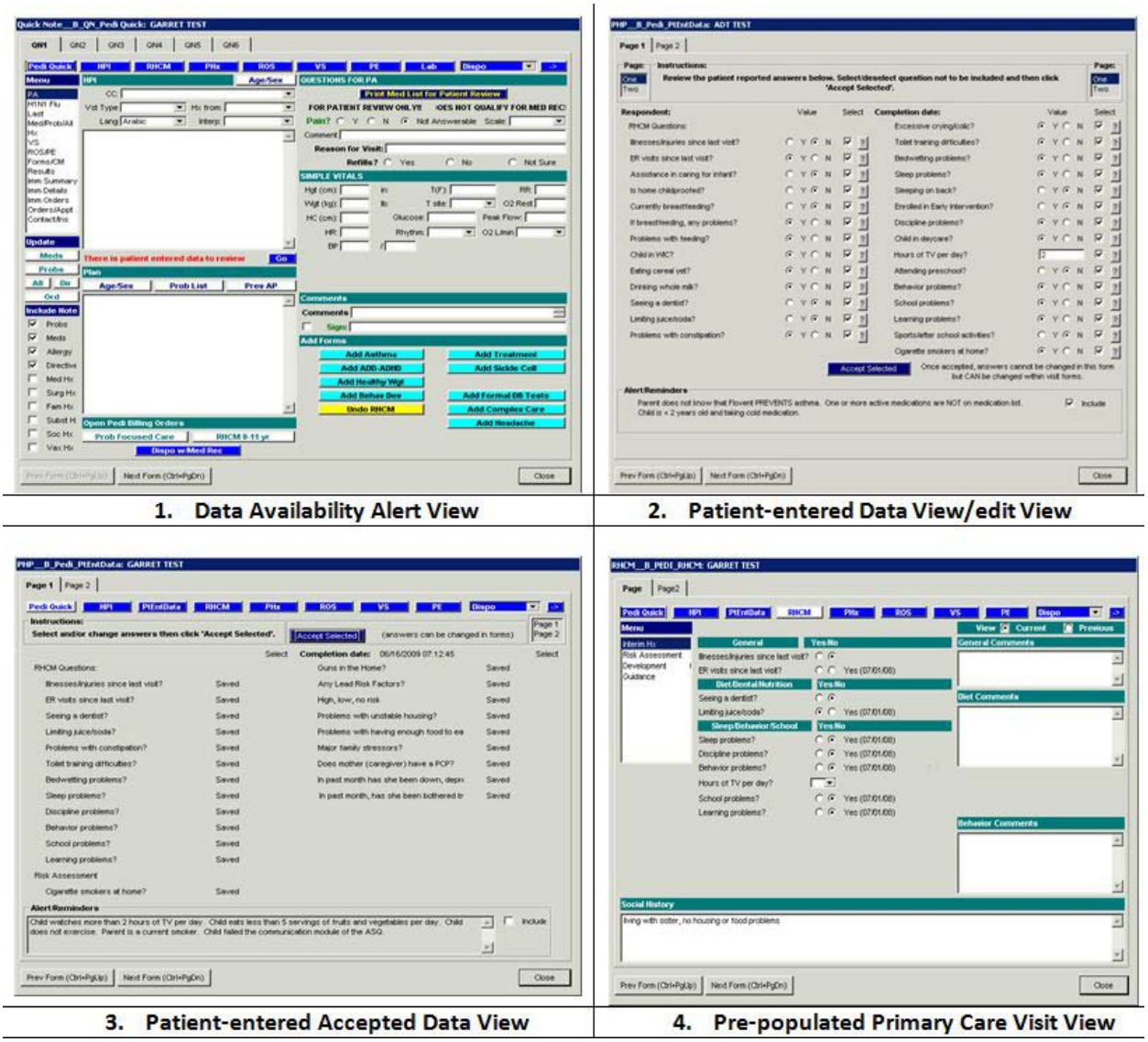
EHR Integration of Patient-Entered Data

The PHP System allows clinicians to review patient-entered data before incorporating the responses into their EHR documentation. To support this program, new coding was added to the core EHR documentation set to monitor for recent patient-entered data. When found, The Patient Entered Data (PED) Review Form (Figure 3) is automatically added to the visit form set. Clinicians review the data, confirm or update any uncertain answers, and accept the patient

entered data into the EHR data system. Once accepted, the data pre-populates the primary care forms for the visit (Figure 1).

For each question in the PED Review Form the target question (exact text from EHR) is displayed, but the source text (exact text of question from source system) is available via a "?" button beside each answer. The PED Review Form also has the ability to display evidence-based recommendations and alerts to the clinician. Clinicians review the PED Review Form as part of an RHCM visit and with by clicking the "Accept Selected" button can automatically add all data to the EHR database. These data are editable within the RHCM form that triggered the initial data review.

Figure 1. EHR-based patient-entered data review forms



Procedure and Design

The Personal Health Partner (PHP) was evaluated in a randomized trial in an urban academic medical center in Boston, Massachusetts. Calls were tailored to each caller based on the patient's age and whether or not the child was on at least one asthma medication. Call topics included RHCM content such as, diet and activity, parental smoking and depression, tuberculosis screening, developmental screening, and home safety. Content was based on AAP- and Medicaid-recommended health risk questions for tuberculosis, smoking in the home, diet and physical activity, and safety. The parental depression questions were based on the Edinburgh Postnatal Depression Scale, a ten-item questionnaire designed to screen for postpartum depression for parents of infants 0-6 months old and the Patient Health Questionnaire (PHQ-2 and PHQ-9), a widely used screening tool for adult and adolescent depression. The safety assessment was based on the Framingham Safety Assessment.

Each call also addressed medication safety examining: 1) what medications on the EHR medication list the child was actually taking; 2) age appropriate medication use; and 3) if taking asthma medication they were using controller and reliever medication properly. No validated tool is currently available to assess medication safety in the home, nor to assess management of prescriptions and medication following primary care visits. The PHP development team used questions developed by our research team and expert guidelines (AHRQ 20 Tips to Help Prevent Medical Errors in Children) [7] to develop counseling messages to promote parental behavior change.

The calls were designed to be interactive and conversational. PHP captures answers and uses the answers to ask new questions or provide activation messages, if appropriate. For example, when a parent screens positive for depression, PHP reminds the parent that pediatricians are ready to discuss parental feelings of sadness and then asks whether the parent could agree to bring up her feelings of sadness during the visit.

Participants were recruited form a busy pediatric primary care at Boston Medical Center. Weekly exports from the electronic health record system (EHR) each week were used to identify patients with a scheduled annual well-child exam in 14-21 days. A letter was electronically generated and signed by the child's PCP, then sent to the family inviting them to participate. Parents were allowed to call PHP anytime before the day of the appointment. If they had not called during the first week, a research assistant called the parents to remind them of the appointment, to answer questions, or assist with using PHP. Study staff called participants to complete a follow-up call 5-7 days after the RHCM to assess research outcomes.

Attending pediatricians at Boston Medical Center's pediatric clinic were introduced to the study with a brief presentation at the monthly clinic provider meeting or briefed individually by the principal investigator or the project coordinator. The pediatricians who agreed to participate in the study were also asked to complete a post-study survey about their experiences. Recruitment activities occurred during a 22 month period during April 2009 to February 2011.

Participants

Subjects were recruited from an urban, lower-SES, ethnically diverse pediatric primary care population. Children aged 4 months to 11 years and primary care patients at Boston Medical Center were eligible for the study. Both parents and children had to speak English. Exclusion criteria included plans to move away from the Boston area in less than 3 months or participating

in another primary care research project with content that overlaps the content within this study. There were no studies being conducted that lead to this exclusion. A list of potentially eligible patients was extracted from the EHR. Parents, primary caregivers, or legal guardians were also participants in this study; therefore, eligibility criteria included a primary caregiver who agreed to participate.

Intervention

All patients with a primary care visit between June 2009 and February 2011 were invited to participate via a mailed brochure. The brochure was written at a 6th grade reading level and includes 1) a description of the study, 2) the written consent form, 3) incentives to complete the study, 4) the study password to complete the call, and 5) staff contact information. Receipt of consent was confirmed and accepted during the PHP call. The PHP was designed as an "inbound" system meaning that participants were asked to call the system at a time convenient to them. Study staff monitored use of the system and contacted eligible participants to remind them to call in. The study had 3 arms; participating families were randomized at the time of each call via computer algorithm to PHP, PHP-without counseling, or a safety assessment (usual care (UC). The PHP-without counseling group was discontinued after the first 50 callers to maximize the sample sizes in the PHP and UC groups. UC and PHP participants were randomized at a 1 to 2 ratio to maximize the number of PHP users. For the PHP group, data reported by users and alerts generated by the system could be reviewed within the EHR in a "Patient-entered Data" Form and once accepted pre-populated the Routine Health Care Maintenance (RHCM) template in the EHR during the well-child visit. A week after the appointment, participating parents completed a follow-up assessment over the phone with trained research assistants. Participating providers completed a follow-up assessment via email survey at the end of the study.

Measures

Outcome Measures. Our principal analyses of the clinical effectiveness of the intervention focused on analysis of parent outcome data obtained from parents during the post-visit interview (gathered over the telephone by the research assistant) and review of EHR data. The primary outcome measures for evaluating efficacy of PHP are shown below (Table 1).

Parent- and provider-reported feasibility and acceptability was assessed via questionnaires developed by the study group and focused on usability, perceived value and effectiveness, and recommendation to others.

Parent activation was assessed using a modified version of the 13-question Patient Activation Measure (PAM) instrument. The instrument was modified to reflect activation from the point of view of a parent. For example, the question "I am confident I can tell a doctor concern that I have even when he or she does not ask." Was changed to "I am confident that I can tell a doctor concerns about my child even when he or she does not ask" and I" know what each of my prescribed medications does" will be changed to "I know what each medication that has been prescribed for my child does." [11]

Parental health literacy was assessed using the REALM, a valid test of word pronunciation that has been shown to correlate well with tests that evaluate a range of literacy skills. Three categories of literacy were defined based on the REALM: literacy levels of 6th grade and below

(REALM score 0-44), 7th to 8th grades (REALM score 45-60), and 9th grade and above (REALM score 61-66). [12,13]

All of the above outcome measures were (and are) being use to assess whether patients are receiving the appropriate care for prevention, treatment and management in the IOM's priority area related to: 1) patients reported experience with their care; and 2) the impact of projects in low-resourced rural and urban safety net settings where health IT diffusion is likely low.

Table 1. Primary outcome measures

Table 1a. Preventative care

Category	Type	
1. Tuberculosis Screening(0-11 yrs)	Assessment	Assess risk using USPTF/CDC guidelines
1. Tuberculosis Screening(0-11 yrs)	Counseling	*If positive*: Discuss risks and recommendations, encourage discussion with clinician. *If PPD recommended*: remind family to return for reading if done
1. Tuberculosis Screening(0-11 yrs)	Outcome(s)	% of children with recommended screening. If PPD done, % of children with follow-up reading
2. Second-hand Smoke Exposure (0-11 yrs)	Assessment	Assess exposure to second-hand smoke
2. Second-hand Smoke Exposure (0-11 yrs)	Counseling	*All:* Inform family of risks and recommendations, *If positive:* Counsel parent to discuss with clinician, counsel parent to make a quit plan or call quit line
2. Second-hand Smoke Exposure (0-11 yrs)	Outcome(s)	% of visits with smoking assessed, % of smoking parents who called Quit Line or have a quit plan
3. Obesity Prevention: Fruit and veg./day, screen time hrs/day, physical activity hrs/day (3-11 yrs)	Assessment	Assess diet, screen time, and physical activity behaviors
3. Obesity Prevention: Fruit and veg./day, screen time hrs/day, physical activity hrs/day (3-11 yrs)	Counseling	*All:* Inform family of risks and recommendations. Inform family of BMI percentile. *If positive:* counsel parent to discuss with clinician, counsel parent regarding diet and PA strategies
3. Obesity Prevention: Fruit and veg./day, screen time hrs/day, physical activity hrs/day (3-11 yrs)	Outcome(s)	Mean portions of fruits/veggies, mean hours of TV time, participation rate in physical activity
4. Maternal Depression Screening (0-11 yrs)	Assessment	Assess with Edinburgh, PHQ-2 and/or PHQ-9 if indicated
4. Maternal Depression Screening (0-11 yrs)	Counseling	*If positive:* counsel parent to discuss with clinician, counsel parent about benefits of treatment
4. Maternal Depression Screening (0-11 yrs)	Outcome(s)	% of parents screened for parental depression, % of parents with depression who receive care
5. Developmental Screening (0-8 yrs)	Assessment	Assess using Ages and Stages Questionnaire
5. Developmental Screening (0-8 yrs)	Counseling	All: Inform parent of results, *If positive: c*ounsel parent to discuss with clinician; counsel parent about EI or Head Start or School resources based on age
5. Developmental Screening (0-8 yrs)	Outcome(s)	% of children with structured developmental screen, % of delayed children in Head Start or EI
6. Safety: SIDS (sleep position), car seats/seat belts, smoke detectors, bike helmet use (0-11 yrs)	Assessment	Assess age-specific risk
6. Safety: SIDS (sleep position), car seats/seat belts, smoke detectors, bike helmet use (0-11 yrs)	Counseling	*If positive:* Inform family of risks and recommendations, counsel parent to discuss with clinician
6. Safety: SIDS (sleep position), car seats/seat belts, smoke detectors, bike helmet use (0-11 yrs)	Outcome(s)	% of families with unsafe behavior, % of families with knowledge of safe behaviors

Table 1b. Medication management

Category	Type	Action
1. Fever and cold medication use and dosing of liquid medication (0-11 yrs)	Assessment	Assess indications for use, assess dosing of liquid medications, assess dosing decisions
1. Fever and cold medication use and dosing of liquid medication (0-11 yrs)	Counseling	*If positive:* Counsel parent to discuss with clinician, counsel family to ask about what each medication does, counsel about syringe use
1. Fever and cold medication use and dosing of liquid medication (0-11 yrs)	Outcome(s)	% of families with inappropriate medication use, Number of medication errors detected by PHP, number of medication errors, % clinic encounters with discussion of proper home med use
2. EHR medication reconciliation (0-11yrs)	Assessment	Assess whether current med list (including doses) is correct, assess current medication allergies, *If positive*: counsel family to tell MD that med list is inaccurate and/or about allergies
2. EHR medication reconciliation (0-11yrs)	Counseling	Inform family of importance of accurate medication list, Counsel family to bring all medications to visit
2. EHR medication reconciliation (0-11yrs)	Outcome(s)	% of families with accurate EHR med list, % of families with accurate EHR allergy list, % of families who brought medications to visit,
3. Asthma medication use	Assessment	Assess current reliever and controller use, assess knowledge of medication mechanisms of action *If on reliever medication or controller medication:* assess use (including spacer)
3. Asthma medication use	Counseling	*If positive:* Inform family of action of reliever medication with clinician and over-use problems. If on a controller medication: Inform family of action of controller medication with clinician and under-use problems
3. Asthma medication use	Outcome(s)	% of families who understand reliever action, % of families with correct reliever use, % of families on controller medication who understand controller action, % of families with correct controller use

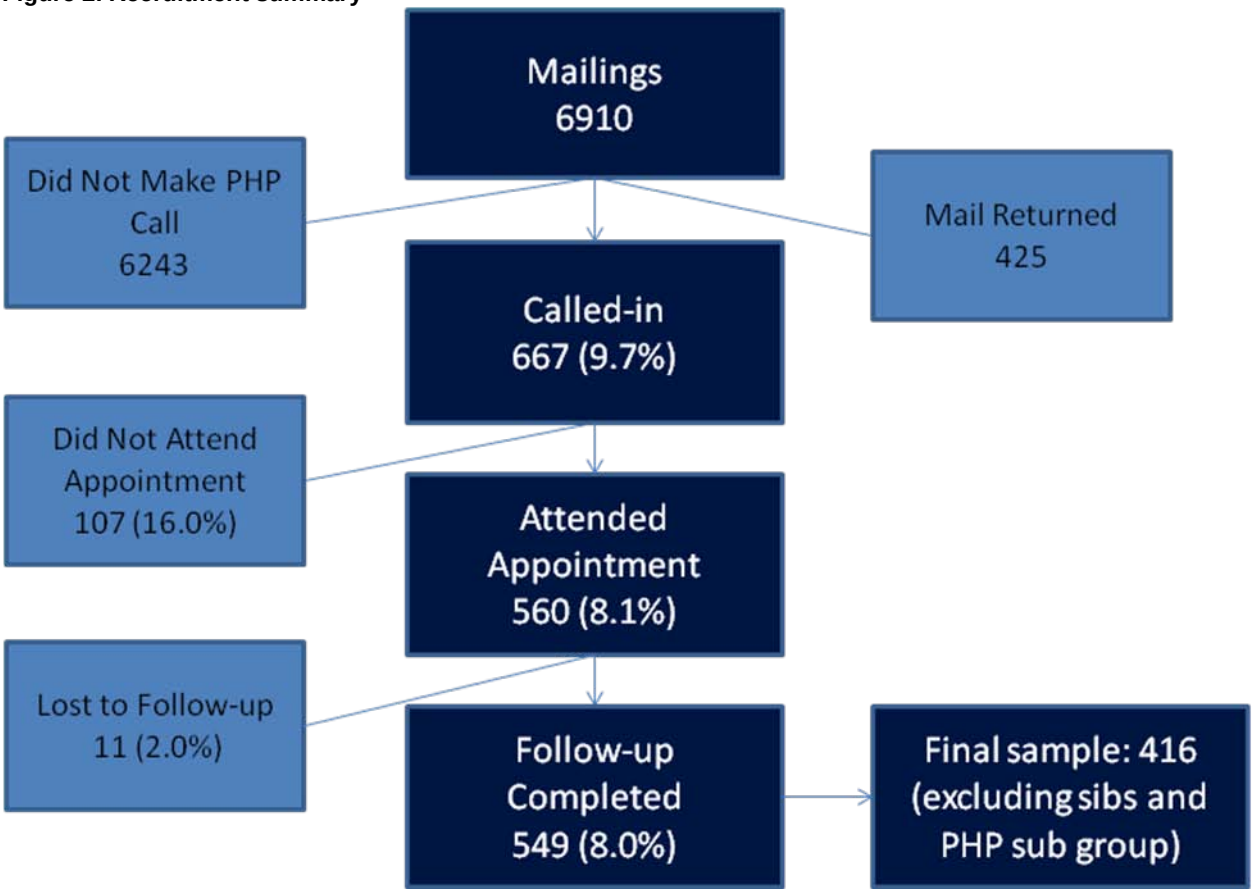
Data Analysis. The effects of the PHP intervention were assessed by using independent t-tests and chi squares tests comparing PHP users to UC users. Post-visit assessments focused on: 1) parent recall of visit content, 2) parent willingness to commit to activation message, 3) parental activation, and 4) parental satisfaction. Parent activation was assessed using a modified version of the 13-question Patient Activation Measure (PAM) instrument. The instrument was be modified to reflect activation from the point of view of a parent. Primary clinician-focused measures were 1) clinician-reported satisfaction and feasibility, and 2) completeness of medication list after each visit.

Results

There were 6,910 potentially eligible pediatric patients that were mailed a letter inviting the patient's parent or primary caregiver to participate, 6% of the letters were returned. A total of 667 (10%) people called the PHP system to participate (Figure 2). Of those that called, 560 (84%) attended their appointment within 3 weeks of calling the PHP system and of these 549

(82%) completed the follow-up interview. Participants were randomized into PHP-limited (n=74), PHP (n=290) or UC (n=185). The PHP-limited group is not included in this report and only one sibling per family was included yielding a total sample of (n=416).

Figure 2. Recruitment summary



Of those that completed the follow-up survey, most parents were females, approximately 50% were African American, and approximately 45% of parents had a college degree (Table 2). The mean ages for children were 4.9 and 4.6 years old. Approximately 50% of parents were employed (p=0.07). Refer to the Appendix for Final Enrollment Table.

Table 2. Demographics

	UC (n=163)	**PHP (n=253)**
Parents: Mean (sd) Age (yrs)	35 (8.7)	34 (8.5)
Parents: No.(%) female	147 (91%)	232 (92%)
Parents: College degree	55 (46%)	83 (42%)
Parents: Employed	73 (52%)	103 (46%)
Children: Mean (sd) Age (yrs)	4.9 (3.6)	4.6 (3.5)
Children: No.(%) female	89 (55%)	110 (44%)
Children: African American	107 (66%)	177 (71%)

Alert Rates

PHP was able to detect a variety of important health issues and generated clinician alerts based on parental responses. Parents varied in their willingness to "contract" with PHP (Table 2). For dietary measures, 39% of children had an alert for watching greater than two hours per day of television (TV) and 10% of parents agreed to try to reduce TV time. Eighty-seven percent of parents reported that their children consumed less than 5 fruits and vegetables per day. Seventeen percent of parents screened positive for smoking and 18% agreed to call the local or national "quit line". Twenty-two percent of parents were positive for depression and 13% of these parents agreed to bring up their feelings of sadness during the child's RHCM visit. Twenty-four percent of children were at increased risk for TB and 75% of the parents agreed to talk to the child's doctor about TB screening. Nineteen percent of parents reported incorrect cold medication use and 42% of parents with asthmatic children reported misuse of asthma medication. Sixty-six percent of parents reporting misuse of asthma mediation agreed to bring their medications to the child's visit. Eighty-four percent of parents reported that the EHR medication list read to them included at least one medication their child wasn't taking (Table 3).

Table 3. PHP alerts and activation response

PHP Alerts	Alert No. (%)	Activation Message	Agreed No. (%)
Child Watches >2 hrs. of TV	98 (39%)	Agree to reduce TV time	10 (10%)
< 5 Fruits and Veg.	190 (87%)	N/A (physician notified)	-
Parent Smokes Cigarettes	61 (17%)	Call local/national quit line	11 (18%)
Parent is Depressed	78 (22%)	Call PCP/discuss feelings w/ MD	10 (13%)
TB risk assessment needed	56 (24%)	Remind clinician to do PPD	42 (75%)
Misuse Fever Medicine	25 (21%)	Bring medication to visit	16 (64%)
Misuse of Cold Medicine	30 (20%)	N/A (physician notified)	-
Misuse of Asthma Medication	36 (42%)	Bring medication to visit	24 (66%)
Extra Medications in EHR	162 (84%)	N/A (physician notified)	-

Parent Reported Visit Content

PHP and UC parents did not differ significantly in reporting that their child's PCP discussed TV viewing and juice intake (Table 4) during their scheduled visit. However, PHP parents were significantly more likely to report discussion of depressive symptoms when the parent was depressed and TB risk when the child was at risk. For children taking prescription medications, PHP parents were also more likely to report discussing medication and to have brought their medication to the visit. PHP and UC children did not differ with regard to EHR medication list accuracy following the visit, however.

Table 4. Parent-reported visit content and outcomes

Topic	n	UC: No.(%)	n	PHP: No.(%)	p
TV discussed	117	42 (35.9)	166	69 (41.6)	0.34
TV discussed: ≥ 2 hrs TV/day (Excessive TV)	116	40 (33.6)	167	48 (28.7)	0.38
TV discussed: Excessive TV, issue discussed	40	13 (32.5)	48	317 (35.4)	0.77
TV discussed: Excessive TV, tried to cut down	38	22 (57.9)	47	32 (68.1)	0.33
Juice/soda intake discussed	116	69 (59.5)	166	110 (66.3)	0.24
Juice/soda intake discussed: > 2 portions/day (Excessive)	115	41 (35.7)	165	50 (30.3)	0.35
Juice/soda intake discussed: Excessive intake, issue discussed	41	23 (56.1)	50	34 (68.0)	0.24
Juice/soda intake discussed: Excessive intake, plan to reduce	41	30 (73.2)	50	35 (68.6)	0.63
Smoking discussed	161	72 (44.7)	248	135 (54.4)	0.06
Smoking discussed: Parent smokes	163	19 (11.7)	253	47 (18.6)	0.06
Smoking discussed: Parent smokes, issue discussed	19	12 (63.2)	47	31 (66.0)	0.83
Smoking discussed: Parent smokes, plan to quit	19	12 (63.2)	47	38 (80.9)	0.13
Depressive symptoms discussed	**162**	**38 (23.5)**	**251**	**106 (42.2)**	**< 0.01**
Depressive symptoms discussed: Parent is sad, down, depressed	163	56 (34.4)	251	77 (30.7)	0.43
Depressive symptoms discussed: Parent w/ symptoms, discussed	**56**	**15 (26.8)**	**76**	**39 (51.3)**	**< 0.01**
Depressive symptoms discussed: Parent w/symptoms, referred to services	56	9 (16.7)	76	22 (28.9)	0.13
TB discussed	**162**	**31 (19.1)**	**247**	**88 (35.6)**	**< 0.01**
TB discussed: Positive TB risk assessment, Got PPD	159	9 (5.6)	245	20 (8.1)	0.62
On medication *	163	57 (35.0)	253	94 (37.2)	0.65
On medication: issue discussed	**57**	**41 (71.9)**	**94**	**80 (85.1)**	**0.05**
On medication: brought to visit	**57**	**5 (8.8)**	**94**	**19 (20.2)**	**0.06**
EHR med list correct after visit	163	39 (23.9)	253	53 (21.0)	0.49

UC call content was limited to enrollment and the Framingham Safety Survey. The average UC call was 17.6 minutes. PHP calls included more extensive content as well as medication reconciliation. The average PHP call duration was 29.4 minutes.

Medication Safety

Most PHP and UC parents whose children were taking prescription medications reported that they spoke to their child's doctor about medications during the visit. Of the parents whose children were on prescription medications, 20.2% of PHP parents reported that they brought their child's medications to the visit compared with 8.8% of the UC parents. The majority of PHP and UC group parents had incorrect medications lists in the EHR (79% and 76% respectively). Twenty two percent of PHP and 17% of UC parents reported that the EHR list did not include all of their child's medications. In addition, 75% of PHP and 72% of UC parents reported the EHR list had medications their child wasn't taking anymore.

Across both the PHP and UC groups, twenty percent of parents of children less than 2 years of age reported giving their children cold medicine. Sixteen percent reported intentionally giving their children less fever medicine than indicated and 2% reported intentionally giving more fever medicine. Sixty-one percent of parents have never asked the pharmacist, doctor, or nurse for any measurement instrument to measure liquid medicines and 86% have never brought their medicines to the doctors (both are behaviors recommended by AHRQ).[7]

Activation

We used the modified PAM (P-PAM) to measure parent activation and both groups of the parents showed a high activation level. There were no differences between groups on this measure.

Parent-User Satisfaction

The majority of parents gave very favorable reviews of both the PHP and Safety-only (UC) IVR systems (Table 5). Eighty-nine percent of both parent groups would recommend use the system they used before scheduled visits. Parents liked each system because it could be used at home and was telephone-based. An important question regarding the target population for this system is whether the approach (IVR) is better suited than web-based systems. When asked, fewer than half (approximately 40 percent) of parents would have preferred a Web-based approach. Fewer PHP parents felt the length of the call was reasonable compared with UC parents. However, PHP parents were significantly more likely to report feeling "more prepared" for the visit. PHP-parents were also significantly more likely to report that use of PHP reduced their visit time. Nearly all parents in both groups would use the IVR systems in the future.

Clinician-User Satisfaction

PHP participating clinicians were very positive about the PHP system (Table 6). Eighty percent of clinicians that used PHP said they would like it to be continued as a normal part of the primary care practice, the other twenty percent were unsure about doing so. Participating clinicians also felt that the alerts for parental smoking and depression, and asthma medication misuse were the most helpful. The clinicians noticed that some parents were better able to use the system than others, and that speaking English as a second language seemed to be a limiting factor for ease of use.

Table 5. Parent-reported satisfaction

Parent Satisfaction: Topic	No. (%) Agree: UC (n=163)	No. (%) Agree: PHP (n=253)	p
Thought differently about health after PHP	59 (37.6%)	79 (32.1%)	0.40
Reduced visit time	**69 (43.9%)**	**151 (61.6%)**	**0.001**
Liked using PHP because telephone-based	131 (83.4%)	205 (84.0%)	0.89
Would have preferred website	61 (38.9%)	105 (42.9%)	0.63
Length of call was reasonable	**141 (89.8%)**	**181 (73.9%)**	**0.001**
Felt more prepared for visit	**106 (67.5%)**	**198 (80.8%)**	**0.009**
Would use PHP in the future	144 (91.7%)	216 (88.2%)	0.48
Would recommend PHP to others	139 (88.5%)	218 (89.0%)	0.99

Table 6. Clinician-reported satisfaction (n = 20)

The PHP system:	Strongly Agree	Agree	Neutral	Disagree
Is easy to use	**40%**	**50%**	10%	
Increases completeness of my documentation	**50%**	**50%**		
Reminds me to do things I might forget to do	**40%**	**50%**	10%	
Improves my efficiency during visits	**30%**	**50%**	20%	
Integrates well into my clinical work flow	**40%**	**40%**	20%	
Improves the quality of care that I deliver	**40%**	**60%**		
Identifies important problems	**50%**	**30%**	20%	
Helps with medication management	**10%**	**30%**	50%	10%
Improves medication safety	**10%**	**20%**	60%	10%

Conclusions

The great majority of American parents (94%) report unmet needs for parenting guidance, education, or screening by pediatric clinicians. Only one in five (20%) of Medicaid-insured children receive adequate preventive and developmental services. More than one-third of parents of young children (36%) report not discussing significant child health issues with their pediatricians. Forty percent of parents of Medicaid-insured children are not asked by pediatricians about concerns related to their children's learning, development, or behavior. Some of the nation's most vulnerable children are those who live in urban settings. Nearly 20% of all American children live in urban neighborhoods. Most of the families of these children are poor, and most are racial and/or ethnic minorities.

Clearly, the "well-child" encounter, as it now exists, has many missed opportunities for parents and clinicians. There is growing evidence that the EHR can enhance clinician adherence to guidelines and improve the availability of needed patient information when used effectively; however, there is also recognition that the capacity of clinicians to provide all recommended primary care services has been exceeded. Given the number of potential topics available for discussion, topics strongly supported by evidence may not be included. Furthermore, parents infrequently set the agenda for well-child visits and often leave without the information that they originally sought.

In this study, we assessed a patient-centered system tailored to the challenges of a vulnerable urban population. The use of speech as the primary communication channel rather than written text lowered the literacy requirements for parental use of the system. The use of IVR rather than an Internet-connected computer leveraged a ubiquitous technology, the telephone, and allowed users to communicate with their medical home from virtually anywhere – particularly from home. Integration with the EHR at the point-of-care supported the sharing of parent-reported information with their child's clinician at the point-of-care, improving communication, quality, and efficiency.

The PHP system was able to assess a wide range of topics, detect important issues, engage parents in pre-visit behavior change efforts, share information and alerts with clinicians and actually change the content of the primary care encounter. In the area of medication safety, PHP was able to detect misuse of common over-the-counter medication and asthma medication and the fact that most children had inaccurate medication lists in the EHR. While use of PHP by parents was associated with increasing the review of use of prescription medication for children on prescription medication, use of PHP was not associated with a more accurate medication list in the EHR after the visit. This later issue highlights the complexities of the EHR medication list

in pediatric primary care. We hypothesize that clinicians can easily determine which medications are no longer in use (i.e. an antibiotic prescription for otitis media 14 months ago) and do not always remove the medication from the list since their inactivity is obvious. Further research will be necessary in this area to better understand how clinicians view the medication list and decide to reconcile inaccuracies.

Parents welcomed participating in both of the IVR calls. PHP-parents felt better prepared for visits compared with UC parents, but more UC parents felt that the duration of calls was reasonable compared with PHP-parents. In the future we will limit our call duration to less than 20 minutes.

This study provides evidence that patient-centered IVR systems are feasible, well-accepted, and effective in vulnerable populations such as the ones in this population. Systems like PHP addresses multiple national health care priorities 1) the need for evidence-based assessment and counseling in pediatric primary care settings; 2) the increased risk of minority and low SES children, and 3) the use of EHR in the health care system. Primary care clinician counseling, which is customized based on patient-entered information to promote and encourage healthy behaviors, has enormous potential in our nation's efforts to address multiple evidenced-based primary care topics.

There is a pressing need to provide better, safer care in an affordable, sustainable, and effective manner. Although effective medication management has not traditionally been included as a core preventive service, current evidence suggests it should be to assure that parents provided optimal medication management for their children. Computer-based telecommunication technology which has been successfully used in adults and children with asthma has the potential to be such a resource. Until recently, IVR systems have been used primarily as home-based interventions (e.g., not connected to an EHR). The PHP System is the first telephony-based system that we know of that supports pediatric primary care assessment and counseling and clinician communication during office visits. The system is a model for future integrated computer-based systems for primary care and chronic disease management in children.

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List of Publications and Products

1. Adams, WG, Phillips, BD, George, M, Watson, BL, Walsh, K, Anand, S, Lozinski, G, Elder, H, Paasche-Orlow, MK, and Shanahan, CW. The Personal Health Partner: Conversational IT for Better, Safer Pediatric Primary Care. Presented at the American Medical Informatics Association Symposium, November 4, 2010.

2. Adams, WG, Phillips, BD, George, M, Watson, BL, Walsh, K, Anand, S, Paasche-Orlow, MK, and Shanahan, CW. Randomized Trial of an Automated Pre-visit Telephony System for Better, Safer Pediatric Primary Care. Platform Presentation, Annual Meeting of the Pediatric Academic Societies, Denver, CO May 2, 2011.

3. Adams, WG, Phillips, BD, George, M, Watson, BL, Walsh, K, Anand, S, Paasche-Orlow, MK, and Shanahan, CW . The Personal Health Partner: Automated Conversational Assessment and Counseling Before RHCM Visits for Better, Safer Pediatric Primary Care. Presented at the AHRQ 2011 Annual Conference, September 19-21.

Manuscripts in Preparation

1. "Randomized Trial of an Automated Pre-visit Telephony System for Better, Safer Pediatric Primary Care"

2. "Medication Reconciliation and Safety Assessment Using an Automated Pre-visit Telephony System in an Urban Pediatric Primary Care Center"

3. "Health Literacy and Parental Satisfaction with an Automated Pre-visit Telephony System in an Urban Pediatric Primary Care Center"

Appendix

Updated Enrollment Table: Number of Child-subjects

Ethnic category

	Sex/Gender: Females	**Sex/Gender: Males**	**Sex/Gender: Total**
Hispanic or Latino	27	27	54
Not Hispanic or Latino	236	259	495
Ethnic Category: Total of All Subjects *	263	286	549

Racial categories

	Sex/Gender: Females	**Sex/Gender: Males**	**Sex/Gender: Total**
American Indian/Alaska Native	0	1	1
Asian	3	0	3
Native Hawaiian or Other Pacific Islander	1	0	1
Black or African American	187	186	373
White	32	51	83
Mixed Race	29	28	57
Other	11	20	31
Racial Categories: Total of All Subjects *	263	286	549