Grant Final Report

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Abstract

Purpose: We examined the impact of clinical decision support (CDS) tools on the quality and safety of ambulatory pediatric care.

Scope: Health information technology and CDS are promising strategies for improving care. We tested CDS related to 1) weight based dosing, 2) reminders for preventive and chronic illness care, 3) electronic results management, and 4) documentation templates.

Methods: We conducted 9 group randomized controlled trials at 15 pediatric practices. Measured outcomes related to each intervention (dosing errors, guideline adherence, quality of documentation) and surveys assessed the impact of the CDS on physician workflow and satisfaction.

Results: We found CDS significantly improved medication safety, practice efficiency, guideline adherence, and documentation. Improvements were found in all three clinical domains including preventive services, acute illness care and chronic illness care. Low usage of CDS limited the effectiveness of the interventions. The reduction in dosing errors was partially offset by errors resulting from improper use of the CDS. Further improvements in quality and safety are possible through increased physician use of CDS, but this will require physician willingness to change their workflow as well as improvements to EHR software.

Key Words: pediatrics, quality improvement, clinical decision support, medication errors, reminders

Final Report

Purpose

A common thread running through much of the current thinking regarding Healthcare Information technology (HIT) is the centrality of the electronic health record to improving the safety and quality of health care. The electronic health record (EHR) may be conceptualized as the transfer of hard copy (paper and ink) information to electronic media. Health information in electronic format may itself improve health care in several specific ways, most notably with respect to portability of health information. Nonetheless, many if not most of the benefits from an EHR involve computerized clinical decision support (CDS): tapping into the power of organized electronic information to warn, remind and even correct clinicians at the point of care delivery. While significant research has been conducted on EHR decision support, gaps remain. First, relatively little research has addressed decision support in pediatrics. Pediatrics has trailed adult medicine in development and adoption of HIT in general and EHR specifically for reasons related to the epidemiology of child illness (predominantly outpatient and largely preventive care) and the financing of primary care (lower margins, little capital). Second, little work has addressed quantifying the added value of decision support. In other words, what kinds of decision support produce what additional benefits? Without the answer to this question, decisions regarding value and trade-offs of specific EHR functionalities are made in a vacuum.

In order to address the question of added value of electronic CDS, we sought to systematically assess the implementation of CDS tools in pediatric practices as part of the dissemination of an EHR in a large integrated delivery system. The four decision aids included: 1) weight based dosing, 2) documentation templates, 3) test results manager, and 4) reminders for guideline adherence in children with chronic conditions. Taking advantage of the natural experiments associated with the implementation of an EHR and our ability to turn these functions on in different practices at different times, we assessed the added value of these decision aids by measuring the influence of each CDS aid on patient safety and adherence with clinical guidelines. We also determined physician use and their perceptions of the usefulness of these CDSS functions. We addressed the following study questions:

Specific Aim 1a. Assess the influences of decision support for medication prescribing on dosing and selection of preferred agents.

The controlled trial was designed to assess:

a) Effects of an EHR with weight based dosing decision support on rates of dosing errors and adverse drug events (ADEs).

Specific Aim 1b. Assess the influences of decision support for medication prescribing on selection of preferred agents.

The controlled trial determined:

b) Effects of diagnosis based medication recommendations (smart forms) on rates of guideline adherent medication prescribing and physician satisfaction.

Specific Aim 2. Assess the influence of a test results tracking system, Results Manager, on the management of laboratory tests.

This assessment determined:

a) Effects of results manager on the protocol for follow-up of common tests performed in pediatric practice;

b) Effects of results manager on time to follow-up of common tests; and

c) Physician attitudes regarding the value (safety and quality benefits) of electronic results management.

Specific Aim 3. Assess the influence of reminders for guideline adherence in the delivery of preventive services and in the care of children with chronic conditions. These controlled trials assessed:

a) Effects of reminders and templates on recorded weights, review of symptoms, and ordering of lipid profiles for children with obesity;

b) Effects of reminders and templates on the frequency of symptoms checks among children with Attention Deficit Disorder;

c) Effects of reminders on lead screening, Chlamydia screening, and anemia screening in eligible patients; and

d) Physician attitudes regarding the value of reminders

While our specific aims were organized using conceptual domains outlined above, our research activities were organized around the practical issues associated with each specific trial we conducted. The trials were then grouped into projects. The trials and their associated project designation included:

1) weight based dosing decision support (project 1)

2) electronic results management (project 2)

3) reminder for lead screening and follow up (project 3)

4) reminder for Chlamydia screening(project 3)

5) reminder for follow up of symptoms in children with ADHD(project 3)

6) reminder for lipid testing in obese children(project 3)

7) interactive template (smart form) for children with acute respiratory symptoms (project 4)

8) documentation template for visits by children with ADHD(project 4)

9) documentation template for children with obesity(project 4)

Scope

Background

While significant research has been conducted on EHR decision support, relatively little research has addressed decision support in pediatrics.[1] Pediatrics has trailed adult medicine in development and adoption of HIT in general and EHR specifically for reasons related to the epidemiology of child illness (predominantly outpatient and largely preventive care) and the financing of primary care (lower margins, little capital)[2]. Second, little work has addressed quantifying the added value of decision support. In other words, what kinds of decision support produce what additional benefits? Quantifying the value of decision support in terms of patient safety and improved quality is part of the solution to overcoming the reluctance of policy makers to fund HIT and clinicians to purchase and use CDS.

Despite the impressive amount of research already conducted or underway in the areas of child healthcare improvement in general, important gaps remain. First, much research in clinical decision support is uncontrolled. Controlled trials are important in quality improvement due to the strong secular trends that may create false positive results. Second, compared to adults, relatively little work has been done in the area of pediatric HIT in general and pediatric CDS specifically. Third, we have yet to quantify the value of pediatric CDS in terms of patient safety and improved quality of care for children. Finally, even though pediatricians and other child care providers are the front lines in the delivery of child care, pediatrician perspectives on the added value of CDS in EHRs remains unclear.

Our controlled trials quantified the added value of three important elements of decision support in the practice of primary health care for children. We addressed three key aspects of child health care delivery: medication safety, test results follow-up, and reminders for guideline adherence for preventive care and children with chronic health conditions. We assessed physician views of the added value of CDS in terms of their experience of care delivery (physicians). The set of interventions, the study design, and the outcome measures employed resulted into a robust assessment of the value of CDS in pediatric practice.

Context

Project 1: Weight Based Dosing. Compared to adults, considerably less information is available regarding the epidemiology and prevention of medication errors and ADEs in pediatric

settings. In 1987, Folli et al. studied two academic pediatric hospitals demonstrating a medication error rate of 0.45 to 0.49 per 100 medication orders using pharmacy-based review.[3] Several case series have demonstrated the frequency of tenfold dosing errors in pediatric inpatients that result from misplaced decimal points in calculations.[4,5]

In 1999, some members of our group performed a prospective cohort study in two academic pediatric institutions.[6] We reviewed 10,778 medication orders and found 616 medication errors (5.7%), 115 potential ADEs (1.1%), and 26 ADEs (0.24%). Of the 26 ADEs, 5 (19%) were preventable. Computerized Provider Order Entry (CPOE) systems ensure that orders are complete, legible and standardized. When coupled with decision support they can provide important, real-time advice about factors such as dose, route, or frequency and drug-drug or drug-allergy interactions. In children, the requirement for weight based dosing makes pediatric prescribing more susceptible to errors. Therefore, we focused on this important piece of weight based dosing decision support in the present study. A weight based dosing decision support module was developed at Partners HealthCare System and was introduced in the pediatric EHR as part of our study.

Project 2: Results Management. Failure to follow-up on abnormal diagnostic test results represents one of the most problematic safety issues in the practice of outpatient medicine.[7] When test results are not acted on in a timely and appropriate manner, patients' safety and satisfaction are jeopardized. Prior research has shown that both patients[8] and physicians[9] are concerned with this issue, and results from other studies[10-13] further highlight the ongoing need to address this gap in quality. Moreover, this issue is beginning to receive more national attention. The Agency for HealthCare Research and Quality (AHRQ)[14], in a recent set of recommendations issued to patients on how to prevent medical errors, recommends to patients that 'no news (on test results) is not good news', suggesting that existing results follow-up systems are inadequate to protect patients' safety.

While there have been few studies examining the impact of this important safety and quality issue in the pediatric population, studies performed in the adult setting suggest there is significant room for improvement.[15] For example, about one third of abnormal TSH[10], pap smears[11] and mammograms[12,13] do not receive timely follow-up in accordance with established clinical guidelines. Data from malpractice carriers further point out that 30% of office-based diagnosis-related malpractice cases can be attributable to failures in the follow-up system.[16] The changing guidelines on disease management offer yet another layer of complexity to this issue. Clinicians clearly need help: a survey performed within Partners Healthcare (Boston, MA) indicated that 59% of primary care clinicians were not satisfied with their current system of result tracking.[17] Furthermore, the survey results indicate that automated result tracking and patient-letter writing capabilities represent the two most pressing needs of our clinicians. Taken together, these results suggest that the tension for change exist and clinicians are likely receptive to interventions that improves the process of result follow-up.

Projects 3: Reminders and 4: Templates. Because these two interventions were both designed to address the issue of guideline adherence, and the trials were coordinated so that all practices received some reminders and templates, we have grouped them together for this portion of our report.

Conceptual Model of Guideline Adherence and Reminders. Prior studies have examined the reasons why physicians do not always follow guidelines. The Cabana model[18] synthesizes many of these factors and proposes the pathway psychology form the basis of this text. The focus is on improving the design of the man-machine, or human-system, interface to behavior change. Our interventions (results manager and guideline reminders) were designed to address several of the domains identified in the Cabana model:

- Lack of familiarity – by presenting guidelines at the moment decisions about follow-up need to be made, the guidelines were designed to have the maximal impact.

- Lack of awareness – by prioritizing abnormal results over normal ones, clinicians can focus on more critical issues first.

- Lack of agreement – during the development of the interventions, we sought input from practice leaders. This was done to facilitate the process of consensus building and raise the level of agreement about the specific guidelines.

- Lack of self-efficacy – by providing an efficient system to help physicians manage test results with minimal hassle, we aimed to foster a 'can-do' attitude amongst clinicians.

- Inertia – we posited that the introduction of a new system and the associated training and promotion would cause clinicians to reexamine their baseline workflow and system for test result management. We recruited practice leaders in the intervention clinics as our local champions to facilitate the adoption of our systems to improve quality of care.

- Environmental factors – lack of time and resources were addressed through the efficiencies built into the system to facilitate documentation and review of clinical information.

Methods

This study took advantage of a natural experiment occurring within the network of Partners pediatricians. At the start of this grant, the Partners electronic health record, LMR, was being rolled out to the approximately 30 affiliated pediatric practices and had already been successfully piloted and implemented in about 20 pediatric practices.

The 3 specific aims of this project included a total of 4 projects (weight based dosing, results management, guideline reminders, and templates) that had two distinct study designs. Due to the ethical issues surrounding randomization of practices to ACPOE with or without weight based dosing, we took advantage of Dr. Kaushal's ongoing pediatric medication error study to perform a controlled trial that determined the differential effects of weight based dosing. This study utilized data from her study of medication errors in the same practices as the baseline and then used the scheduled roll out of the CDS to prospectively assess the effect of the CDS on dosing errors.

Project 1: Weight Based Dosing

Study Design. We assessed the influence of two different decision support features for electronic medication prescribing on dosing and selection of preferred agents. The study of selection of preferred agents was conducted in the context of our interactive template (Smart form) for children with acute respiratory infections (ARI) and is discussed below in project 4. In our weight based dosing CDS study practices receiving the intervention were compared to the same practice prior to the intervention as well as control practices (without weight based dosing). The controlled trial was designed to determine the affects of an EHR with weight based dosing on rates of medication errors and ADEs.

We performed a clustered randomized trial of the introduction of WBD decision support at 6 pediatric primary care practices (35 physicians). Our study sites included 4 inner city health centers, 1 hospital based academic practice, and 1 private community practice. WBD decision support was introduced to the 3 intervention practices in 2006. All the physicians had been using electronic health records for more than a year prior to the introduction of WBD decision support. We allowed at least 6 months after the introduction of WBD before starting data collection for the post intervention period.

We collected all prescription data for two months prior to WBD decision support and for 4 months after the intervention. Rates of dosing errors were compared between the intervention and control clinics both before and after the introduction of WBD decision support (difference in differences analysis). Qualitative evaluations of physician use of WBD decision support were conducted through the use of interviews and direct observation.

Intervention. Weight based dosing applications incorporate a patient's weight to calculate an appropriate medication dose. In pediatrics, dosing is frequently weight based. The intervention we used had both an active and a passive decision aid. The active decision support aid requests the user to choose a total daily dose (mg/kg) and, based on a weight the computer uses from elsewhere in the child's record, the computer provides the correct calculated dose. The passive component simply displayed the total daily dose the child will receive given the dose that the user selected. In addition, often the appropriate dose sometimes varies by age and weight (in addition to indication). For example, a neonate may require XX mg per kg of an antibiotic to treat pneumonia while a toddler may require YY mg per kg of the same antibiotic for the same condition. In addition, liquid preparations come in predetermined combinations so that exact weight based dosing may result in difficult amounts for a parent to dispense (e.g., 1.35 teaspoons). The weight based dosing CDS in the Partners EHR addressed both of these issues.

Project 2: Results Management

Study Design. In this study, we conducted qualitative assessments at 9 pediatric practices where the results manager module was implemented. Semi-structured interviews were conducted before and after implementation of the results management system using a detailed interview guide developed by members of the project team. Interviews were conducted with the practice medical director, administrator, or nurse manager. This assessment focused on the perceptions of physicians and practice managers at each of the sites of the value of an electronic results system. We assessed value using participant's perceptions of safety, efficiency and timeliness.

Intervention. We adapted the existing LMR Results Manager for use in the pediatric ambulatory setting. The LMR Results Manager alerts clinicians when laboratory results are available and indicate the potential need for further action. For example, an alert will be sent to the ordering clinician if a patient has a positive Chlamydia assay. We encouraged physicians to review these alerts by displaying these significantly abnormal results ahead of slightly abnormal test results or normal test results. When physicians review this lab result, they were provided with an explanation of the alert. At the request of the clinician, the system can also generate automatically letters to patients explaining the change in the therapeutic plan. Again, these letters can be generated with minimal efforts using one or two mouse clicks. These letters can also be generated in Spanish if the patient is registered as Spanish-speaking and the clinician is registered as being proficient in written Spanish. For both languages, we ensured that the system generates text at the 8th grade reading level. All actions performed by the clinician were documented in the chart to enable future review.

Project 3: Guideline Reminders

Study Design. We conducted prospective group-randomized trials controlling for baseline characteristics. We collected baseline patient and physician characteristics to control for differences between practices, which often have different office systems and policies. Practices were randomized to intervention (I) or control © in pairs that were matched on community practice type (urban/suburban). Three months after the deployment of the intervention in clinics randomized to the clinic pair, we began 7 months of data collection. While clinics randomized to the control group did not receive the intervention during the data collection period, we collected data through electronic medical record review and manual chart review in an identical manner in both the intervention and control clinics.

Intervention. The guideline reminders used in the LMR appeared in two different operational forms. Visit based reminders were displayed as red flashing bars when a clinician opens up a patient's record. Non-visit based reminders were delivered to the clinician via email. The dual approach permitted both real-time point of care decision aid during an office visit, but also covers situations when the patient fails to follow-up or come in for a visit. This combination decision aid has worked well in adult primary care practices with regard to (among others) use of lipid lowering agents, beta blockers and aspirin in patients with coronary artery disease. Importantly, these reminders can be triggered by the physician's problem list, billing codes in administrative systems, or clinical data (test results) housed in the Partners clinical data repository. The system does not therefore depend solely on the physician adherence to keeping an accurate problem list.

The specific reminders we use for this study were determined by the pediatric leaders within Partners. Plans were developed during a monthly unit chief meetings with a group that oversees guideline development and quality improvement initiatives. The reminders we introduced for the pediatric setting included: 1) reminders for checking weights and providing dietary and exercise counseling for obese children, 2) reminders for checking symptoms for patients with persistent asthma, 3) reminders for lipid screening for obese children, 4) reminders for checking symptoms for patients with ADD/ADHD, 5) reminders for Chlamydia screening, 6) reminders for influenza vaccinations among patients with asthma, and 7) reminders for lead screening. These conditions and services are known to have significant gaps in longitudinal follow-up both

nationally and locally and thus represent promising targets for an IT guideline adherence solution. The precise triggers (logic) for the reminders were determined from guidelines and local consensus and are currently available on the AHRQ website.

Project 4: Templates

Study Design. In collaboration with Partners IS, we designed an interactive template ("Smart Form") to assist in antibiotic dose and choice for the pediatric patients presenting with acute upper respiratory illness (ARI). We also developed templates for the documentation of ADHD symptoms and obesity management. Clustered randomized trials were conducted over a 6 months study period from October 1st, 2006 to April 4th, 2007. This evaluation included 146 general pediatric providers practicing at 14 ambulatory practices. These practices were randomly assigned to either the control or intervention group. Usage of the Pedi ARI Smart form by physicians was captured electronically by provider and clinic. We collected data on antibiotic prescribing rates, ICD9 codes and patient demographics for all ARI visits during the study period.

All doctors and nurse practitioners practicing at study sites throughout the study period were included in the study. We collected data for all patients <18 years of age presenting with the diagnosis of an acute respiratory illness. Based on analysis of the data gathered, we assessed the overall effects of an EHR with smart forms on rates of antibiotic prescribing and choice of antibiotic.

Intervention. We developed smart forms to assist physicians in antibiotic choice and dosing for ARI with otitis media, and dosing of acetaminophen and ibuprofen for URIs. Because Smart Forms automate documentation while they promote uniform treatment, we anticipated that this interactive template would improve the quality of care and efficiency for pediatricians who were evaluating patients with acute URIs and would be rapidly accepted.

To develop these smart forms, we first referenced published national guidelines for the treatment of acute otitis media (AOM), and upper respiratory infections (URIs). We identified the elements of the history and physical that were important for the decision making process. We also referenced algorithms for the appropriate prescribing of antibiotics and antipyretics and decongestants in these three conditions. Study investigators then built prototypes of the smart forms using Microsoft Access and solicited feedback from seasoned pediatricians on the usability and appropriateness of these smart forms. Once the prototypes were finalized, we worked with our colleagues in Partners Information Systems to implement the smart forms and their associated antibiotic-prescribing decision support features. Towards the end of the development of the smart forms and prior to their release, we solicited further feedback from our pediatrician community to ensure that the smart forms fit into their daily workflow. Appropriate modifications were made prior to releasing these tools to our intervention clinics. We used a similar approach to the development of the ADHD and obesity templates. All three are available on the AHRQ website.

Limitations. The fact that these evaluations were part of a natural experiment occurring within a larger healthcare system rendered them vulnerable to a number of methodological limitations enumerated below.

1. Investigators did not have complete control of the system they were studying. This limitation presented two separate issues. First, Partners medical management fundamentally controls the EHR implementation in Partners pediatric practices. This is a common problem in the evaluation of HIT. Factors that mitigate this concern under the current circumstances included a) the medical management of the Partners integrated delivery system strongly endorsed the project and did not perceive any conflict with their agenda, b) the P.I. for the proposed project was both a researcher and director of quality measurement for Partners pediatrics (i.e., part of the medical management for the IDN), c) the assembled research team has considerable experience and success working under these conditions. Second, ability to determine outcomes from DS in HIT is dependent on the usability and use of the specific decision support function. In other words, design flaws or limitations in a specific IT application could reduce the potential effectiveness of a specific decision support function. While potentially limiting the efficacy of the interventions, it also reflects the reality of the dissemination of HIT and means the results of our trials may more appropriately reflect "real world" effectiveness rather than a more tightly controlled efficacy.

2. We used administrative data, chart reviews, and survey data to determine the main outcomes for this project. Therefore, any conclusions we drew have the limitations inherent in using these data sources. For example, we had limited ability to detect drug-drug interactions that might occur with over-the-counter medications. However, given the large number of observations, our past experience with administrative and survey data, and the expertise that went into developing and testing our methods, we believe the changes associated with each of the DS functions accurately portray trends and variations.

3. Ceiling effects: The current emphasis on quality and safety has resulted in many generalized and specific efforts to improve safety and quality. The research environment we chose for this study was therefore subject to several confounders, some of which we attempted to address through study design. Nonetheless, demonstrating improvements from a high baseline performance is more difficult than demonstrating improvements from a low baseline. We have specific evidence, cited above, that performance in the areas we propose to study has significant room for improvement. This observation applies to medication errors and ADEs, follow-up of children with chronic conditions, and patient reports of experience of care.

4. Additional CDS applications in pediatrics: Our study aimed to assess CDS in ambulatory practice for prescribing, results tracking and follow-up, and reminders for guideline adherence in children with chronic conditions. We acknowledge that there are other CDS possibilities for pediatrics. We considered the ones chosen for this study to have particular salience for both clinicians and patients, but we did not study CDS in pediatric specialty practices.

Results

Our results have been presented in numerous presentations and we have 4 manuscripts (one already published). The completed and draft manuscripts have been included with this report. The summary below reflects only the higlights of our results.

Project 1: Weight Based Dosing

We found a significant reduction in weight based dosing errors in the intervention clinics, particularly for antibiotics. Rates for dosing errors fell 37% overall in the intervention group. Additionally, there was a 57% decrease in the frequency of antibiotic overdoses following the introduction weight based dosing decision support. Antibiotics were the class of medications most frequently prescribed (70% of all prescriptions) and were associated with the highest frequency of dosing errors (21 per 100 prescriptions). One fifth (22%) of prescribing errors were attributed to incorrect use of the electronic prescribing software and the majority of dosing errors (58%) were judged to be correctable with decision support. The active form of weight based dosing decision support was used for only 10% of eligible prescriptions. No dosing errors occurred when the active form of CDS was employed.

We also identified a number of barriers to use of the weight based dosing decision support through qualitative interviews conducted with providers at the intervention clinics. These included user interface difficulties, complaints regarding incomplete or innaccurate dosing information for pediatric patients, and general mistrust of the module.

Project 2: Results Manager (ERM)

Although usage of the module was relatively low overall, in practices where providers did use the module, there were consistent reports of improvements in quality and patient safety, specifically related to the ability to view test results in a more timely manner. Despite a number of workflow/design-interface flaws, overall providers felt that proper use of the module would improve quality of care, specifically in the areas of patient safety and efficiency.

There was considerable variability among practices regarding the extent to which they adopted ERM. Practice managers appeared to gauge adoption according to two criteria: 1) continued use of paper for lab results, and 2) extent to which physicians were independently handling all lab result related issues. Two practices had removed all paper charts and test results within six months of ERM implementation. Four practices had removed paper charts but continued to manage paper based test results, and two practices were still using paper charts and test results.

Only two practices reported that all of the providers in their practice were using the results manager module on a regular basis. These practices indicating full adoption of ERM reported gains in efficiency, reliability, timeliness, and provider satisfaction, while some partial adopters reported decreased efficiency and increased risk of lost test results. Barriers to ERM adoption included lack of inclusion of all ordered tests in the ERM system, user-interface design issues, and lack of sufficient pediatric customization. Survey results (response rate 62%) found that

pediatricians thought ERM improved quality and efficiency of care, with 72% of pediatricians reporting safer care and 63% reporting more effective care.[19]

Project 3: Guideline Reminders

ADHD. During the study period, a higher proportion of patients in the intervention group had an ADHD visit compared to those in the control group (71% vs. 54%, p=0.04, odds ratio 2.2, [1.2, 4.0],). The higher proportion of assessments of ADHD care occurred in both well child (28 % vs. 22%) and non well child (44% vs. 34%) visits, but the differences were not statistically significant. Similarly, ADHD symptoms and treatment were discussed more often during well child visits for patients in the intervention group (78%) than the control group (63%), but this difference was not statistically significant (p=0.07).

Chlamydia. For our Chlamydia reminder trial, patients in the intervention group were twice as likely to have a screening test as patients in the control group (48% vs. 24%, p<.001). 61% of screening tests were ordered by the patient's primary care physician. Patients in the intervention group had more visits during the study period than control group patients (3.6 vs.3.0, p=.05). Patient age, race, insurance, status, and number of visits during study period were not predictors of receiving a screening test.

These results indicate that an EHR-based point of care reminder improved screening for Chlamydia in an integrated group of ambulatory practices and that further improvement appears possible if physicians other than the PCP would also respond to the reminder. This synchronous reminder was an effective means of promoting guideline adherent preventive care in the primary care setting.

Obesity. Throughout our controlled trial of guideline reminders for lipid screening and nutritional counseling for obese children (BMI >99th percentile for former and 95th percentile for latter), 75% of patients in the intervention group had a visit where nutritional habits were reviewed compared to 71% in the control group (p<.05)). Only 23 of 200 eligible patients received a lipid profile. There was no significant difference between the control and intervention groups (13 intervention vs.10 control). Reports were not viewed during the study period, however, since its close, they were viewed at 4 of the 12 clinics.

Synchronous reminders were minimally effective for promoting nutritional counseling visits, but not for cholesterol screening.

Project 4: Templates

The ARI smart form was used during 561 visits to treat 522 individual patients. It was used by 39 providers (average use per physician = 18). The pattern of adoption was consistent with other research on technology adoption with a gradual increase and subsequent leveling off during the study period.

For individual bacterial illnesses, in comparison to the control clinics, intervention patients were less likely to receive a prescription for antibiotics for diagnoses of otitis media (67.7% versus 76.6% of Otitis media visits; p<.0001), sinusitis (71.1% versus 84.7%; p<.0001), but were more likely to prescribed macrolides (14.8% vs 7.6% of otitis media visits; 23.8% versus 14.2% of sinusitis visits; p<.0001).

There was no significant difference found in total antibiotic prescriptions between the intervention and control group (p=0.58). However, use of the Pedi ARI SF was associated with a decrease in antibiotic prescriptions (p <.0001). There were significantly more macrolide prescriptions dispensed during the intervention clinic visits (p<.0001), however the increased macrolide use was for visits in the intervention group where the smart form was not used. Use of the ARI SF was associated with a significant reduction in macrolide use (p <.0001).

In the intervention group, the ADHD visit template was used by 14 physicians (33% of eligible) with a median use of 2 per physician (range, 1-6). There were no instances in which the template was used during anything but a visit specifically to discuss ADHD symptoms and treatment. In other words, the ADHD template was not used to supplement documentation provided in a non-ADHD visit. Intervention physicians with ADHD decision support used the ADHD documentation template for 32% (29/90) of the non well-child visits. There were no well child visits documented both with the ADHD documentation template in addition to a well child template. Within the intervention group, notes in which the template was used were more likely to document any assessment of symptoms (100% vs. 61.3%), treatment effectiveness (96.6% vs. 54.8%), and treatment side effects (96.6% vs.40.3%) (P<0.001 for each).

The obesity template was used 83 times by 11 providers and showed similar improvement in documentation to our results in the ADHD study described above.

Significance

Many pediatric practices in the U.S. have not adopted an electronic health records, in part due to costs but also because of limited information on the value of clinical decision support. Relatively little research has been done to quanitify the value of computerized decision support systems (CDS) in pediatrics. Additionally, many who use EHR have not adopted CDS features due to lack of data demonstrating added value of CDS as well as lack of availability of pediatric-specific CDS features. The projects in this grant 1) developed pediatric-specific CDS components and 2) measured the value to patients and clinicians resulting from these features.

Overall our results were mixed. The CDS were partially adopted, and the lack of complete adoption was due to a number of factors including both IS factors (e.g., data availability, user interface design, etc.) as well as clinician factors (production pressure, resistance to change, distrust of system, etc.). When the systems were used we found signficant improvements in care. For example, we found a 37% decrease in medication dosing errors, a 23% increase in follow care for patients with ADHD, and a 43% increase in screening for chlamydia among eligible girls. We also found new problems created by the CDS, including both new types of errors as well as increased safety problems associated with partical adoption. And the CDS never fully closed the gap between the measured rates of care delivery and “perfect” care. The collective experience quantifying the value of CDS for pediatrics in these trials will assist policy makers by helping to better frame expectations around the value of CDS as well as address important barriers to effective use of CDS. Clinicians and practice managers can use this information to evaluate their own practices and determine the optimal role for CDS for improving quality of care through their investments in HIT.

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List of Publications and Products

Project 1: Weight Based Dosing

Posters were presented at the both the NICHQ annual conference in Miami, FL in March 2008 and the AMIA Spring Congress in May 2008 in Phoenix, AZ. The results of this project were also presented as a platform presentation at the annual meeting of Pediatric Academic Societies in Honolulu, HI in May 2008 and the 2008 AHRQ HIT meeting in Washington DC. A manuscript has been completed and will be submitted for publication in February 2009. A draft is available upon request.

Project 2: Results Manager

Ferris TF, Johnson SA, Co JT, Backus M, Bates DB, Perrin J, Poon, EG. Implementation of an Electronic Results Management System in an ambulatory pediatric practice: a qualitative study. *Pediatrics (2009)* 123: S85-91. Available at http://pediatrics.aappublications.org/content/vol123/Supplement_2/index.shtml

Project 3: Guideline Reminders

Obesity. A poster was presented at the NICHQ Annual Forum in Miami, FL in March 2008, detailing the use of our templates, reminders, and reports (all part of the guideline reminders project) for diagnosis and assessment of pediatric obesity.

ADHD. The results of our ADHD reminders and template study were presented as a platform presentation at the annual meeting of the Pediatric Academic Societies in May 2008. A manuscript has been submitted and is available upon request

Chlamydia. These findings were presented in a poster at the annual meeting of the Pediatric Academic Societies in May 2008. A manuscript is in preparation.

Project 4: Templates

The usage data and smart form template was presented at the Annual Meeting of Pediatric Academic Societies in May 2007. A manuscript is in preparation and will be submitted for publication in February 2009. A draft is available upon request.

Other Project-Generated Resources

The products developed as part of this grant included several decision support tools useful for ambulatory pediatric care. These tools included the logic for the reminders as well as the templates. These resources will be helpful to other providers and institutions, particularly those attempting to develop similar tools for use in the pediatric setting. Our group worked closely with key personnel at AHRQ and NORC to organize webpages to showcase the tools that we

have developed, to enable others to learn from our research, and to use our work to facilitate the development of IT applications geared specifically towards use in the pediatric setting. The links to these resources are below.

http://healthit.ahrq.gov/portal/server.pt?open=512&objID=919&&PageID=13771&mode=2&in_hi_userid=1248&cached=true

http://healthit.ahrq.gov/portal/server.pt?open=512&objID=919&&PageID=13852&mode=2&in_hi_userid=1248&cached=true