

Utilizing an Electronic Health Record System to Improve Vaccination Coverage in Children

L. Au¹; A. Oster¹; G. H. Yeh¹; J. Magno¹; H. M. Paek²

¹Charles B Wang Community Health Center, New York; ²Optmus Health Care, Connecticut

Keywords

Electronic Health Records, pediatrics, childhood vaccinations, immunization registry

Summary

Background: Electronic Health Records (EHR) are widely believed to improve quality of care and effectiveness of service delivery. Use of EHR to improve childhood immunization rates has not been fully explored in an ambulatory setting.

Objective: To describe a pediatric practice's use of Electronic Health Records (EHR) in improving childhood immunization.

Methods: A multi-faceted EHR-based quality improvement initiative used electronic templates with pre-loaded immunization records, automatic diagnosis coding, and EHR alerts of missing or delayed vaccinations. An electronic patient tracking system was created to identify patients with missing vaccines. Barcode scanning technology was introduced to aid speed and accuracy of documentation of administered vaccines. Electronic reporting to a local health department immunization registry facilitated ordering of vaccines.

Results: Immunization completion rates captured in monthly patient reports showed a rise in the percentage of children receiving the recommended series of vaccination (65% to 76%) ($p < 0.000$). Barcode technology reduced the time of immunization documentation (86 seconds to 26 seconds) ($p < 0.000$). Use of barcode scanning showed increased accuracy of documentation of vaccine lot numbers (from 95% to 100%) ($p < 0.000$).

Conclusion: EHR-based quality improvement interventions were successfully implemented at a community health center. EHR systems have versatility in their ability to track patients in need of vaccines, identify patients who are delayed, facilitate ordering and coding of multiple vaccines and promote interdisciplinary communication among personnel involved in the vaccination process. EHR systems can be used to improve childhood vaccination rates.

Correspondence to:

Loretta Au MD
Section Chief of Pediatrics
Charles B Wang Community Health Center
125 Walker St, 2nd Floor
New York, NY 10013
Phone: 212.226.8866
Fax: 212.226.2289
Email: lau@cbwchc.org

Appl Clin Inf 2010; 1: 221–231

doi: 10.4338/ACI-2009-12-CR-0028

received: December 24, 2009

accepted: June 26, 2010

published: July 14, 2010

Citation: Au L, Oster A, Yeh GH, Magno J, Paek HM. Utilizing an Electronic Health Record System to Improve Vaccination Coverage in Children. *Appl Clin Inf* 2010; 1: 221–231
<http://dx.doi.org/10.4338/ACI-2009-12-CR-0028>

1. Background

Childhood immunization rates are used as a measure of quality in pediatric care [1]. Annual recommended childhood and adolescent immunization schedules are approved by the Advisory Committee on Immunization Practice (ACIP) of the Centers for Disease Control and Prevention (CDC) [2]. Under the recommended schedules, all children should receive a total of 19 vaccinations by the age of 24 months. The 2008 National Immunization Survey conducted by the CDC found vaccination completion rates for these recommended 19 vaccinations for U.S. children between ages 19 and 35 months to be 68.4% [3]. In a study of a large cohort of children cared for at health maintenance organizations, 75.4% of children had received 15 of the 19 recommended immunizations by two years of age. The same study found 51% of children had at least one immunization error by two years, with an error defined as a missed opportunity, an invalid immunization, or an extra immunization [4].

Many reasons account for the difficulty in completing the required vaccinations on schedule. The vaccination schedule is complex, requiring 19 vaccinations over a period of two years, with as many as five immunizations in a single visit [2]. Additionally, immunization records for a patient are often not consolidated at one health care facility. One study found that 22% of preschool children received immunizations from more than one health care facility [5]. The study also found that parents often do not bring immunization records making it difficult to confirm previous vaccinations [5]. The use of combination vaccines reduces the number of injections [6] but adds to the complexity of delivery because physicians must confirm that each component of the combination vaccine is indicated for a given child [7]. Finally, occasional shortages of vaccines have added another level of complication to achieving the recommended schedule [8, 9].

EHR systems have been shown in several studies to improve immunization rates and delivery of pediatric care. EHR alerts have been shown to decrease missed opportunities for vaccination during both well and sick pediatric medical visits [10]. In another study, EHR alerts helped to increase influenza vaccination rates in asthmatic patients [11]. Some studies have suggested that clinical decision supports embedded into the EHR may aid physicians to follow clinical guidelines [12, 13]. EHR are also known to affect documentation, clinical processes, and patient flow, all of which may improve immunization rates [14, 15].

2. Objectives

In this report, we discuss the use of various applications of EHR to improve childhood immunization processes in a pediatric ambulatory setting.

3. Methods

Charles B. Wang Community Health Center (CBWCHC) adopted the EHR system – General Electric Centricity, Version 5.6 – in 2005. CBWCHC is a large urban community health facility founded in 1971 with a mission to provide high-quality, culturally competent healthcare to the Asian-American community. At CBWCHC there were over 62,000 medical visits with over 12,000 active pediatric patients (age 0-21 years) in 2008. The patients seen in the CBWCHC are from predominantly low income immigrant families. Greater than 70% of the children are covered by Medicaid for their health needs and over 98% are of Asian descent.

At CBWCHC the EHR for each pediatric patient was pre-loaded with relevant medical information including immunizations, past medical history, medications and growth data points, and was available for review by physicians and nursing staff at patient visits.

During 2008-09, a quality improvement program was initiated at CBWCHC that targeted completion of 19 recommended immunizations by two years of age. The 19 childhood vaccinations consist of four DTaP (Diphtheria, Tetanus, Acellular Pertussis), three Hemophilus Influenza Type

B, three Hepatitis B, three Inactivated Polio, one MMR (Measles, Mumps, Rubella), one Varicella, and four Pneumococcal vaccines [1].

3.1 EHR Alerts

EHR reminders and alerts were embedded into the medical and nursing visit forms to remind clinical staff to review the immunization status of the patient at each visit. One of these reminders, the Well Child Immunization Template (►Fig. 1), is included in well and sick visits EHR forms. The template lists on a single screen all the vaccinations that a patient has received and the date the vaccinations were given, and allows the pediatrician to immediately order any missing vaccination. This template was not a standard part of the EHR product but was custom designed by CBWCHC clinical informatics staff.

The EHR system is designed so that the pediatrician can review this template at each visit. The template aids the clinical staff to document vaccine refusal and possible reasons for incomplete vaccinations. Vaccination orders placed in this template automatically link the diagnosis codes to each vaccine ordered (►Fig. 2).

Additional EHR alerts utilizing clinical decision supports are on the Assessment & Plan page of all the medical visits. These reminders are derived from the latest immunization ACIP guidelines [1]. The EHR alerts indicate within an on-screen panel under “preventive care reminders” the patient’s missing or delayed vaccinations, which serve as a reminder for the pediatrician to order these vaccinations (►Fig. 3).

3.2 EHR Desktop

Prior to EHR implementation, patients who missed vaccinations were manually tracked with a paper log. With the EHR implementation, a vaccination recall system was designed to facilitate the follow-up of these patients by nursing staff. This EHR desktop, a standard function of the product used at CBWCHC (►Fig. 4), is designated for immunization recalls and is easily accessible by multiple staff including administrative, reception, nursing and medical staff, to input information as well as to access information to track and schedule patient return visits. This eliminates the need to locate a paper log to flag a patient who needs to be tracked. In addition several staff members can access the log simultaneously. Because the EHR desktop is linked directly to patient EHR records, the patient’s vaccine status can be confirmed before a visit is scheduled.

3.3 EHR Vaccination Completion Reports

To further track vaccination completion, EHR data were used to electronically generate monthly reports (EHR Vaccination Completion Reports) of all children who were 22 months of age and missing one or more vaccinations. These children were targeted as the first priority for catch-up vaccinations since they would not necessarily have had another medical encounter prior to 24 months. These children were recalled to be given the missing vaccinations before they turned two years old. A follow-up report was generated for the recalled children at 24 months of age to determine the extent to which the required vaccinations had been completed by two years of age.

EHR Vaccination Completion Reports were generated monthly for patients who turned 22 months old between December 2008 and October 2009. These reports were repeated for the recalled patients when they turned 24 months of age from February 2009 to December 2009.

3.4 Electronic Reporting to New York City Immunization Registry

The New York City Department of Health and Mental Hygiene provides free vaccines through a program called Vaccines for Children (VFC) to children less than 19 years of age who do not have health insurance or who are underinsured. The VFC program is linked to the New York City Immunization Registry (CIR) and tracks childhood vaccinations. Prior to EHR implementation, all reporting of vaccines used in VFC were manually uploaded. After EHR implementation, a report was generated by the EHR system that allowed CBWCHC to directly report the vaccinations administered to the CIR in accordance with the CIR Universal Provider Interface Format. This batch

report is generated biweekly and has facilitated accurate and timely reporting as well as vaccine ordering for the vaccine gratis program.

3.5 Implementation of Barcode Technology

To facilitate accurate and efficient documentation of vaccinations, a barcode scanning system was adopted at CBWCHC. Prior to barcode implementation, vaccine documentation required manual entry of vaccine lot numbers, expiration dates, brand name and vaccine type. For children who require as many as five vaccines in one visit, a significant amount of data entry is required, slowing down the nursing staff and increasing patient cycle time. The barcode technology allows for rapid and accurate input of this information via scanning of the vaccine barcode.

The CBWCHC computer informatics and information technology staff created a custom data entry form allowing administrative staff to link the individual vaccine barcode with a manually entered vaccine lot number, manufacturer, brand name, and expiration date as shown in ►Figure 5. The information was stored in a separate vaccine database outside of the EHR and tagged to the associated vaccine barcode. Each vaccine barcode was then printed on an index card. When a nurse administered a vaccine, she simply scanned the barcode from the index card into the EHR and all associated information was pulled from the vaccine database and auto-populated in the respective fields in the EHR. Instead of the nurse entering the vaccine lot number with each dose of administration, the manual data entry was limited to once per vaccine lot. Additionally this manual entry could take place separately from patient care.

The time spent on vaccine documentation and the accuracy of the documentation in the EHR were measured for quality improvement purposes before and after barcode technology implementation. The amount of time spent on vaccine documentation was collected before barcode implementation in September 2008 and after barcode implementation in May 2009. The time spent was derived from time stamps created in the EHR during the actual documentation process at patient visits. The number of vaccines given for that visit was also collected.

The accuracy of data entry for vaccine documentation was measured by comparing the vaccine lot numbers entered into the EHR by nursing staff before and after barcode implementation against the actual vaccine lot numbers. A trained clinical assistant reviewed the accuracy of all the vaccine documentation entries made during 9 days in September 2008 (before barcode implementation) and 16 days in May 2009 (after barcode implementation).

Pre- and post-barcode implementation, anonymous staff satisfaction surveys were distributed to the six nursing staff involved in the use of barcoding. They were asked to use a likert scale (0 = very satisfied to 5 = not satisfied) to report their perception of the accuracy of the data entry and their satisfaction with the barcode technology.

3.6 Statistical Analyses

All statistical analyses were performed with de-identified patient data using STATA 11.0 (Stata-Corp., College Station, TX). A McNemar's chi-square test was used to test whether the proportion of children who were up to date with recommended vaccines differed significantly at 22 and 24 months. Mean time of vaccine documentation before and after implementation of barcode technology was compared using a two-tailed t-test. Chi-Square testing was used to assess the probability that documentation errors were significantly different before and after barcode implementation. Kruskal-Wallis equality of population rank test was used to test for significance in the change in staff perception of data entry accuracy and satisfaction with barcode use in vaccine documentation.

4. Results

4.1 EHR Vaccination Completion Reports

There were 267 patients identified in the EHR Vaccination Completion Reports who were tracked from 22 months of age to 24 months of age. The completion rate for the 19 recommended vaccines increased from 65 % at 22 months of age to 76% at 24 months of age ($p < 0.000$) (►Table 1).

4.2 Barcode Technology

There were 150 vaccines administered in the pre barcode sample and 132 in the post barcode sample. Mean EHR documentation time per vaccine decreased from 86.4 seconds (SD = 46.9) to 25.5 seconds (SD = 33.3) ($p < 0.000$) (►Table 2).

Additionally, vaccine lot number data entry accuracy improved from 95.4% in the pre-barcoding period to 100% after barcoding implementation (►Table 3). Staff surveys did not show any difference in staff's perception of their own accuracy ($p = 0.60$). However, staff were more likely to be satisfied with barcode data entry ($p = 0.02$) (►Table 4). In addition, written comments from the staff survey included high approval of the new technology and reported improved workflow. Staff felt that the barcode technology was convenient, efficient, and easy to use.

5. Discussion

In this report, CBWCHC implemented various EHR-based interventions that employed clinical decision support tools, system design components, and clinical informatics tracking reports targeting childhood immunizations. The EHR system enabled multiple levels of staff to work together in improving the quality of care for a pediatric department at a community health center setting.

In a study by Fiks et al, the use of EHR alerts increased the overall completion of 15 recommended vaccinations for children at 24 months of age after controlling for a variety of socio-demographic factors and medical conditions [11]. Although we were able to demonstrate a significant increase in the completion of 19 recommended vaccines for children at 24 months, our report is limited in its ability to establish a causal relationship for this increase. The quality improvement initiative described in this report targeted many aspects of the immunization process which may all have contributed to improved rates.

Even with the variety of strategies used, the CBWCHC vaccination completion rates at 24 months of age still did not reach the 90% goal set by Healthy People 2010 [1]. We suspect that this was due to factors such as the transient nature of patients between various health care facilities, vaccine shortages, and the child aging out of the recommended vaccination. This suggests that in the future we should use EHR reports to recall patients at a younger age who are not up to date with their immunizations to allow more time for catch-up.

We recognize that the proposed strategies in our report have limitations and cannot be easily adopted in all settings. For the immunization template as well as the barcode technology described, our clinical informatics team at CBWCHC customized the EHR product. Similarly, the EHR alerts for clinical decision support needed to be upgraded yearly with changes to the yearly ACIP guidelines [2]. This may be an added cost or inconvenience for practices that do not have internal staff to make these customizations.

In a survey conducted of pediatric practices by Kemper et al, the major barriers for physicians to EHR adoption included the cost and increased workload of implementing and maintaining an EHR system [12]. The EHR applications discussed in this report can be used to offset cost through various ways. The EHR alerts can help to reduce missed immunization opportunities and thus decrease unnecessary visits. The immunization template and its facilitated vaccine order module provide an example where automatic diagnosis coding can save physician time. The pre-linked diagnostic codes are more accurate and will increase the likelihood of higher reimbursements. Barcoding can improve workflow and efficiency to allow staff to do other patient care activities.

While we were limited in our ability to demonstrate higher reimbursements from more accurate coding, the EHR has helped our health center in the tracking and reporting to the VFC program. This improved communication with the VFC program has increased our vaccine supply which has increased our ability to vaccinate more children. For general pediatric practices, the use of EHR can promote access to governmental programs such as VFC, which may help to decrease financial barriers for vaccine reimbursement.

6. Conclusion

The ongoing incorporation of the EHR with other health information technology shows great promise in the various ways it can be used to improve childhood immunization coverage. Vaccination requires a large amount of paperwork, scheduling and tracking, with input from many staff members and oversight from providers. Errors in the vaccination process include invalid immunizations and extra vaccinations due to reasons such as improper timing of vaccine intervals and missing records. These errors may contribute to additional costs and adverse effects for patients. EHR systems can support physicians to avoid these errors.

EHR systems can aid in quality improvement processes by providing population data for certain types of medical information such as vaccination coverage rates. In the past, this type of data was not easily available due to the complexity and degree of detail of the data. EHR can also improve the quality of the data collected. In this report, for example, the improved accuracy of the vaccine lot numbers facilitates rapid identification of patients in the event of product recalls for ineffective vaccines.

In the future, it will be important to develop electronic interfaces between local health departments and physician offices to improve childhood vaccinations. Many patients receive health care from more than one health care facility and if centralized immunization records can be easily accessed, there will be fewer errors and delays in the vaccination process.

Our aim in this report is to share best practices in our use of EHR applications for childhood vaccinations and contribute to the collective design of better EHR systems to ultimately improve patient care.

Clinical Relevance

The uses of EHR described in this report may help practicing pediatricians see how EHR systems can improve vaccinations for children. The EHR systems can be designed to support improved team communication internally and externally with agencies such as with a local health department. EHR has the potential to reduce workload for staff and improve patient outcomes in health care settings serving pediatric populations.

Acknowledgements

The authors acknowledge the staff of the Pediatric and Clinical Informatics Departments at Charles B. Wang Community Health Center for their teamwork in making the EHR a success. We also thank the Information Technology Department for the development and implementation of the barcode system.

Protection of Human Subjects

This study was approved by the CBWCHC Medical Advisory Review Board.

Conflict of Interest

The authors of this report do not have any conflict of interests with the content or its publication.

Well-Child - Immunization: KK TEST

Immunization

Immunization Records Reviewed
 Immunization Card verified

Add Immunization List to Note

DTaP: 07/10/2009 08/23/2006 10/09/2007 12/31/2008 04/20/2009 04/13/2010
H. Influenza: 10/07/2008 11/03/2007 10/09/2007 12/31/2008
Hib Brand: Pentacel Comvax TriHIBit Pentacel
H1N1: 11/12/2009
IPV: 10/07/2008 02/13/2009 04/20/2009 03/20/2009 01/01/2009
OPV:
MMR:
Hepatitis B: 02/11/2009 02/11/2009 08/06/2004 06/19/2006
Hepatitis A: 04/07/2009 03/04/2009 04/20/2009
Varicella: 03/24/2009 04/07/2009
Tdap: 04/20/2009
Td: 09/10/2009
Prevnar(PCV7): 04/07/2010 04/13/2010
Prevnar(PCV13): 05/03/2010
Rota: 03/20/2009 04/02/2009 04/07/2009
Rota Brand: Rotarix Rotarix RotaTeq
HPV: 05/08/2007 04/20/2009
Meningococcal: merck 06/16/2009

DTaP
 Flu Vax
 FluMist
 Pedvax HIB
 Act HIB
 H1N1 IM
 H1N1 mist
 IPV
 MMR
 Hep B
 Hep A
 Varivax
 Tdap
 Td
 PCV13
 RotaTeq
 Rotarix
 HPV
 Menactra
 Pediarix
 Kinrix
 Pentacel

Add Orders

Hep B Carrier HepB immunity status: Negative (02/29/2008 12:50:58 PM)

Varicella status: **Immunity, (11/13/2008 10:59:46 AM)**
 Immunization records not available. Unable to review Add'l note:

Add Immunization Records **Immunization Refusal**

Single series immunization

Days	12/05/2009	10/30/2009	10/21/2009	09/29/2009	09/16/2009	09/08/2009
FLU VAX	done	done	done	done	done	done
FLUMIST						
PNEUMOVAX						
MEASLESVAX						
MEASLE VAX#2						
MUMPSVAX						
RUBELLAVAX						
MENINGOC VAX						
MENING#2 VAX						

Fig. 1 Well-Child Immunization Template

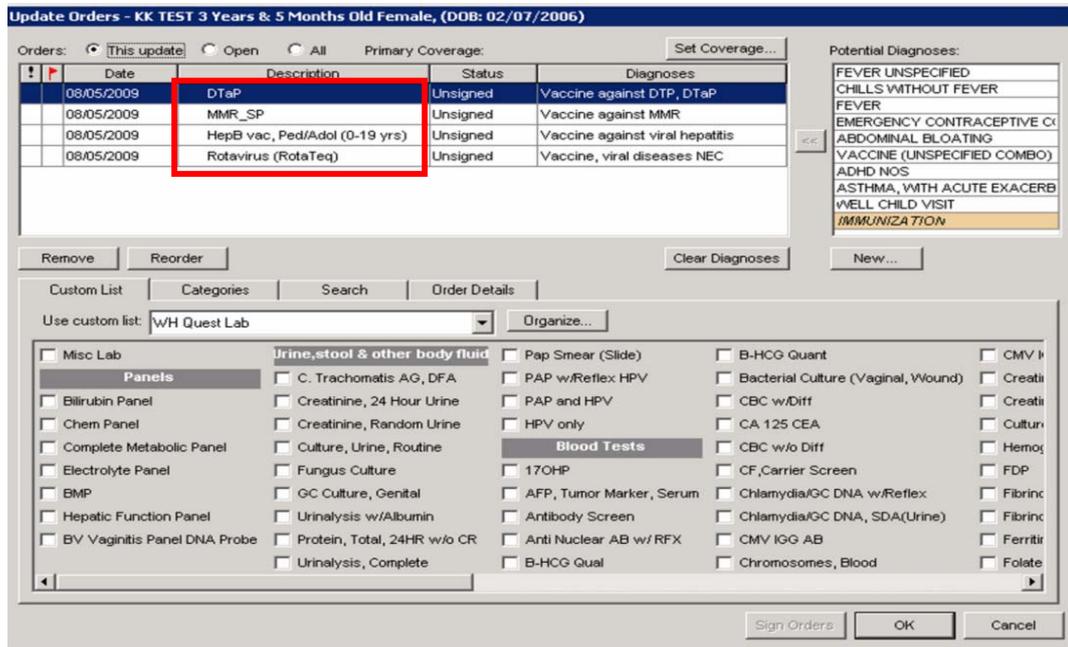


Fig. 2 Vaccine order module

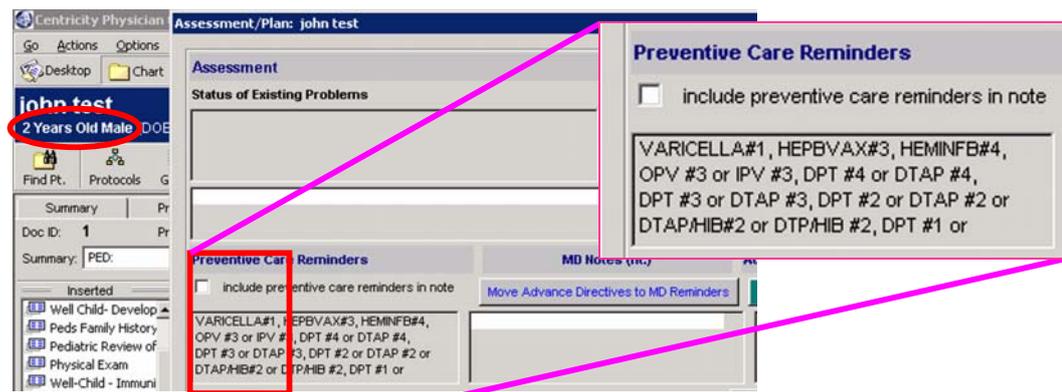


Fig. 3 Immunization reminders corresponding to the age-appropriate recommended schedule

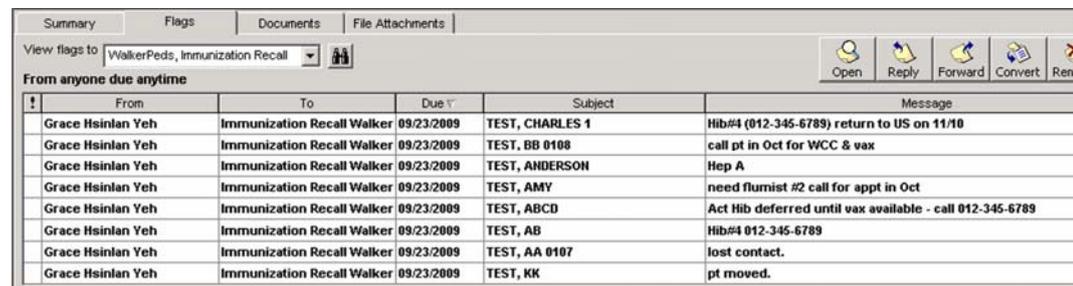


Fig. 4 EHR desktop for recall of patients with incomplete vaccines

Registration (Barcode Test 2): BARCODE (NOT FOR TEST) ZZONLY

Immunization Barcode Registration

Barcode > 0100349281545054

X - Required

Immunization: HIB

Dose: Optional

Manufacturer: Sanofi Pasteur

Brand: ActHIB

Lot Number: Type in Lot #

Expiration Date: 05/31/2008

Quantity (in doses):

VFC / Private: DOH VFC Private

Scan barcode from vaccine vial

One-time manual entry

Reset

SAVE

Fig. 5 Vaccine barcode registration – data entry fields

Table 1 Childhood immunization status at 22 month vs. 24 months of age

Satisfaction		Status at 22 Months		
		Up to Date	Not Up to Date	Total
Status at 24 Months	Up to Date	174	28	202 (76%)
	Not Up to Date	0	65	65 (24%)
Total		174 (65%)	93 (34%)	267 (100%)

p<0.000 by McNemar's chi-square test

Table 2 EHR Vaccine data entry pre- vs. post-barcode implementation

	Mean (seconds)	(SD)	95% CI
Pre-barcode (n = 150)	86.4	(46.9)	78.8 - 94.0
Post-barcode (n = 132)	25.5	(33.3)	19.7 - 31.2

p<0.000 by t-test

Table 3 Data entry accuracy pre and post-barcode implementation

	Pre-Barcode (ttl = 303)		Post Barcode (ttl = 265)	
	n	%	n	%
Pre-barcode	289	95.4	265	100

p<0.000, by chi-square

Table 4 Staff satisfaction with barcode technology

Satisfaction	Pre-barcode		Post-barcode	
	n	%	n	%
Dissatisfied	2	33	0	0
Neutral	3	50	1	17
Satisfied	1	17	3	50
Very satisfied	0	0	2	33
Total	6	100	6	100

p = 0.012 by Kruskal-Wallis rank sum test

References

1. U.S. Department of Health and Human Services. Healthy People 2010: Volume I. Conference ed. Washington, DC: US Department of Health and Human Services; 2000.
2. Centers for Disease Control and Prevention. Recommended immunization schedules for persons aged 0-18 years: United States, 2010. *MMWR Morb Mortal Wkly Rep* 2010; 58 (51&52): 1-4.
3. Centers for Disease Control and Prevention. Recommended immunization schedules for persons aged 0-18 years: United States, 2009. *MMWR Morb Mortal Wkly Rep*. 2009; 58 (33): 921-926.
4. Mell LK, Ogren DS, Davis RL, Mullooly JP, Black SB, Shinefield HR, et al. Compliance with national immunization guidelines for children younger than 2 years, 1996-99. *Pediatrics* 2005; 115: 461-467.
5. Stokley S, Rodewald LE, Maes EF. The impact of record scattering on the measurement of immunization coverage. *Pediatrics* 2001; 107: 91-96.
6. American Academy of Pediatrics, Committee on Infectious Disease 1998-1999. Recommendations on combination vaccines for childhood immunization. *Pediatrics* 1999; 103: 1064-1077.
7. Luman ET, McCauley MM, Stokley S, Chu SY, Pickering LK. Timeliness of childhood immunization. *Pediatrics* 2002; 110: 935-939.
8. Klein JO, Myers MG. Vaccine shortages: Why they occur and what needs to be done to strengthen vaccine supply. *Pediatrics* 2006; 117: 2269-2275.
9. Kempe A, Babbel C, Wallace GS, Stokley S, Daley MF, Crane LA, et al. Knowledge of interim recommendations and use of Hib vaccine during vaccine shortages. *Pediatrics* 2010; 125: 914-920.
10. Fiks AG, Hunter KF, Localio AR, Grundmeier RW, Bryant-Stephens T, Luberti AA, Bell LM, Alessandrini EA. Impact of electronic health-based alerts on influenza vaccination for children with asthma. *Pediatrics* 2009; 124(1): 159-169.
11. Fiks AG, Grundmeier RW, Biggs LM, Localio AR, Alessandrini EA. Impact of clinical alerts within an electronic health record on routine childhood immunization in an urban pediatric population. *Pediatrics* 2007; 120(4): 707-714.
12. Kemper AR, Uren RL, Clark, SJ. Adoption of electronic health records in primary care pediatric practices. *Pediatrics* 2006; 118 (1): e20-e24.
13. Spooner SA, Classen DC. Data standards and improvements in quality and safety in child healthcare. *Pediatrics* 2009; 123(2): S74-S79.
14. Samaan ZM, Klein MD, Mansour ME, DeWitt TG. The impact of the electronic health record on an academic pediatric primary care center. *J Ambulatory Care Management* 2009; 52(3): 180-187.
15. Adams WG, Mann AM, Bauchner H. Use of an electronic medical record improves the quality of urban pediatric primary care. *Pediatrics* 2003; 111(3): 626-632.