

Performance Measures

Integrating the Home Management Plan of Care for Children with Asthma into an Electronic Medical Record

Shilpa J. Patel, MD; Christopher A. Longhurst, MD, MS; Anna Lin, MD; Lyn Garrett, MHA, MS; Jenny Gillette-Arroyo, RN, BSN; John D. Mark, MD; Matthew S. Wood, PhD; Paul J. Sharek, MD, MPH

The prevalence of asthma in children younger than 18 years of age was estimated to be 9.6% between 2001 and 2009,¹ making it the most common chronic disease of childhood. With approximately 456,000 children hospitalized with asthma in 2007, this condition was the third leading cause of pediatric hospitalization in the United States.² The financial and emotional burdens of asthma hospitalizations are substantial, and efforts to standardize treatment and minimize readmissions are crucial toward establishing a more efficient model of care for children.

To that end, the National Asthma Education and Prevention Program (NAEPP), commissioned by the National Institutes of Health and the National Heart, Lung, and Blood Institute (NHLBI), put forth its latest iteration of evidence-based asthma care guidelines, which emphasized key components of asthma care,³ in 2007. This guideline included the recommendation to provide a home management plan of care (HMPC; also called *asthma action plan*) for all children hospitalized with asthma. The Joint Commission, in an effort to promote higher quality of asthma care for hospitalized children, approved in 2007 its first pediatric core performance measure (now National Hospital Inpatient Quality Measure) set, with three metrics focusing on inpatient asthma care.^{7,8} Two of these quality measures mandate that all pediatric patients admitted with a primary diagnosis of asthma receive systemic steroids and short-acting bronchodilators,⁴ which address basic components of the NHLBI inpatient asthma guidelines. Discharge of such patients with an HMPC, as reflected in the remaining quality measure,⁴ along with asthma education, has been shown to improve such outcomes as emergency room visits and hospital readmissions for children with asthma.³ Other studies show that written asthma action plans can decrease the number of acute asthma events, nocturnal awakenings, and missed school days, while improving symptoms.^{5,6}

Whereas the first two components of the Children's Asthma Care (CAC) performance measure set (systemic steroids and short-acting bronchodilators) were widely and quickly incorpo-

Article-at-a-Glance

Background: Asthma exacerbation is one of the most common causes for pediatric hospitalization. One of the three Joint Commission quality measures—which has proven the most challenging—addresses the provision of a home management plan of care (HMPC) for discharge of pediatric inpatients with a primary diagnosis of asthma. A user-friendly electronic medical record (EMR)-generated HMPC was developed and implemented at Lucile Packard Children's Hospital (LPCH) Palo Alto, California, an HMPC needed to be completed before entry of an inpatient discharge order.

Methods: A cohort study using historical controls was conducted in 2010–2011. Patients were eligible to receive an HMPC if they were between the ages of 2 and 17 years old at discharge, had a length of stay < 120 days, were not enrolled in clinical trials, and had the primary discharge diagnosis of asthma. These patients were identified by the EMR if this diagnosis was listed in the diagnosis list or problem list or if the asthma admit/discharge order set was initiated.

Results: Compliance with the HMPC increased from 65.3% for the 39 months (April 1, 2007–June 30, 2010) before integration of the HMPC into EMR to 93.7% for the 18 months after integration (July 1, 2010, through December 31, 2011); $p < .0001$. Users of the EMR-integrated HMPC found it to be significantly easier to complete, less time-consuming, and less prone to potential errors or omission.

Conclusion: Lessons learned at LPCH included the need for a continuous surveillance and improvement model, which resulted in several iterations of the HMPC; the importance of soliciting user input, which resulted in improvements in work flow; and consistent support from the quality management and information technology departments, which are crucial to eliminating barriers and facilitating improvement.

rated into inpatient pediatric asthma care, compliance with providing the HMPC on discharge has proven more difficult both locally and throughout the United States. Reasons for the difficulty in compliance include a lack of integration into the physician work flow, a lack of time to construct the plan, difficulty incorporating the document into the patient chart, and a lack of sustainability of well-intentioned provider behavior modification interventions. These challenges were further exacerbated by the “all or nothing” definition of *compliance*, in which all five components of the HMPC must be present to achieve full compliance. As a result, as of July 2011, the then-most recent national and California state HMPC compliance rates each averaged 71%, substantially below the recently set Joint Commission target of 85%.⁹

After multiple interventions since 2007 yielded suboptimal results at Lucile Packard Children’s Hospital (LPCH), beginning in 2010 we focused on leveraging our comprehensive electronic medical record (EMR) to increase HMPC compliance. Effective use of an EMR has been shown to improve challenging processes such as handoffs,¹⁰ evidence-based guideline implementation,¹¹ chart completion,¹² and to improve emergency department efficiency.¹³ Implementation of an asthma decision-making tool within the medical chart has been shown to increase documentation of asthma severity and use of inhaled corticosteroids,^{14,15} and preliminary data suggested that increased HMPC compliance could be achieved with integration into the EMR.^{16,17} On the basis of these findings, we built a user-friendly EMR-generated HMPC at LPCH and required its completion before entry of an inpatient discharge order. Our institution had extensively used the EMR with great success for other quality improvement purposes.^{10,11,18}

This article describes the details of this intervention, including the construction of the EMR-based HMPC, the reliable integration of the HMPC into the physician work flow, and the outcomes to date associated with its implementation.

Methods

SETTING

LPCH is a 303-bed quaternary care women’s and children’s hospital (Palo Alto, California) affiliated with Stanford University; the main campus houses 225 nonobstetric beds. A satellite site, Packard at El Camino Hospital (PEC), is a 30-bed unit located in a community hospital in Mountain View, California, staffed by the LPCH general pediatric hospitalists. Both the main campus and PEC treat and discharge children with asthma who meet the criteria for inclusion in the Joint Commission quality measure.

STUDY DESIGN

To determine the effect on compliance of integrating an HMPC into the EMR, from July 2010 through December 2011 we conducted a cohort study using historical controls at LPCH. For the care provider satisfaction survey, we used a simple pre- and postimplementation study design administered to eligible care providers at LPCH.

HOME MANAGEMENT PLAN OF CARE COMPLIANCE

As defined by The Joint Commission, HPMC compliance entails documentation that pediatric asthma inpatients or their caregivers were given an HMPC document that addresses all of the following five components⁴:

1. Appointment for follow-up care*
2. Environmental control and control of other triggers
3. Method and timing of rescue actions
4. Use of controllers
5. Use of relievers

However, we required an additional two elements at LPCH, as follows, to help ensure appropriate provision of documentation:

6. Completed document given to the patient/caregiver
7. Completed document present in medical record

PARTICIPANTS

For this study, patients were eligible to receive an HMPC if they were discharged from LPCH from April 1, 2007, through June 30, 2010 (pre-EMR-based HMPC), and from July 1, 2010, through December 31, 2011 (post-EMR-based HMPC); were between the ages of 2 and 17 years old at discharge; had a length of stay < 120 days; were not enrolled in clinical trials; and had the primary discharge diagnosis of asthma. These patients were identified by the EMR in one of the following three ways on entering a discharge order:

1. If the diagnosis of “asthma” was listed in the diagnosis list
2. If the diagnosis of “asthma” was listed in the problem list
3. If the asthma admit/discharge order set was initiated

ABSENCE OF A HOME MANAGEMENT PLAN OF CARE

In each of these scenarios, if no HMPC form is initiated on the current encounter, the system generates a pop-up message stating, “An Asthma Home Management Plan of Care has not been documented by a provider. Would you like to enter new data now?” This message also provides a link to the electronic HMPC form. These methods captured all our asthma dis-

* Component 1 is worded differently in the quality measure: “Arrangements for follow-up care.”

charges, as confirmed by the asthma compliance officer using independent audits of all LPCH discharges to ensure that all Joint Commission quality measure–eligible patients were identified.

HEALTH CARE PROVIDERS

All health care providers at LPCH during the survey time frames of May 1, 2009, through June 30, 2009 (representing the pre-EMR intervention experience), and May 1, 2011, through December 31, 2011 (representing the post-EMR intervention experience), with the responsibility to provide a complete HMPC at discharge were eligible for the survey. These health care providers included pediatric residents, pediatric pulmonary and critical care medicine fellows, and faculty (including pediatric hospitalists, intensivists, pulmonologists, and allergists). Most asthma patients at LPCH are cared for by the general pediatric hospitalists, pulmonologists, and intensivists, as well as the pediatric residents. The small percentage of asthma patients at LPCH who are cared for by community pediatricians are always comanaged by Stanford pediatric residents.

SURVEY

A 16-item survey included multiple-choice and free-response questions about changes in the tool and process for HMPC creation (survey available from the authors by e-mail request). The survey, developed by the three of the authors [S.J.P., A.L., J.D.M.], was administered via an anonymous Web-based questionnaire. It was sent to all eligible LPCH medical staff to assess attitudes regarding pre- and post-EMR–based HMPC and process.

ELECTRONIC MEDICAL RECORD

LPCH uses a vendor-based EMR system. The EMR was rolled out in stages, starting with computerized provider order entry and electronic notes at the main hospital in fall 2007, followed by PEC in summer 2009, and culminating in electronic physician notes at both sites during summer 2010. The HMPC was integrated into the EMR in July 2010 as an English-language electronic form that could be printed in either English or Spanish.

DATA COLLECTION PERIODS

HMPC Compliance. Compliance regarding the HMPC was tracked between April 1, 2007, and June 30, 2010 (pre-EMR intervention) and from July 1, 2010, through December 31, 2011 (post-EMR intervention).

Survey. The survey was administered pre-EMR intervention

between May 1, 2009, and June 30, 2009, while the survey administration post-EMR intervention occurred between May 1, 2011, and June 30, 2011.

INTERVENTION

The pre-EMR time frame contained two separate approaches to the HMPC, as described below.

Paper Form. Between March 9, 2007, and August 30, 2009, the HMPC consisted of a triplicate paper form, which was filled out by hand. This form, patterned after commonly used HMPC models,³ incorporated all components required by The Joint Commission for full compliance. On completion of this form, the patient was provided a copy, and the form was scanned into the patient's EMR.

Web-Based Form. In the second approach, used between September 1, 2009, and July 18, 2010, the paper-based HMPC was translated into a Web-based form with drop-down menus and made available on the hospital intranet. This form was filled out on the Web, printed in multiple copies (for the family and the chart), and scanned into the patient's EMR. The physician was required to to handwrite the document in the follow-up appointment information and sign when completed.

Post-Electronic Medical Record Time Frame

The post-EMR time frame began on July 19, 2010, when the HMPC was fully integrated into the EMR as a form that required all essential fields to be completed before saving the form. On December 14, 2010, an EMR–based notification began to alert prescribers at discharge for all patients with the primary diagnosis of asthma to further ensure completion of the HMPC; in addition, the HMPC had to be completed for the discharge order to be entered. This EMR–based version of the HMPC, available in English and Spanish, incorporated suggestions from the pre-EMR intervention user survey (Table 1, page 362) such as prepopulated fields for commonly used medications and dosing as well as a drop-down list of names and phone numbers of local pediatric practices. Follow-up physician name and contact information was available for the provider completing the form to view on a "Patient Information" screen with information collected and entered at admission registration. This information is confirmed before discharge by the physician referral liaison, a service that coordinates communication between referring physicians and medical groups, including updating of unknown or incorrect registration data.

This document was generated from the patient's EMR and therefore automatically became a permanent part of the record of care, with all finalized versions viewable by any provider in

Table 1. Sample Input from Users of the Paper-Based and Web-Based Home Management Plan of Care (HMPC) Forms and Actions Taken*

Input from Users	Actions Taken to Improve HMPC forms
"Emphasize triggers and prevention more."	Triggers placed at top of form
"Most frustrating part is getting the form in the patient's chart."	EMR-generated form automatically stored in patient's chart
"Don't know how to write out instructions in Spanish."	Computer automatically generates translated instructions from radio button choices.
"Easy to forget required items."	All required items mandatory to save form
"Pull-down menu for meds would save time."	Provided by the EMR-generated form
"Computerized system that is prepopulated but has option for changing meds would be easier."	Provided by the form, including drop-down menus of commonly used medications
"If it had patient's info, PMD name, and phone number automatically prepopulated, it would save a lot of time."	EMR-generated form pulls forward key identifying information, as well as PMD name and phone number.
"Takes too long to write out."	Computerized form with radio buttons
"Takes too long to print extra copies."	Computer prints as many copies as needed instantly.

* EMR, electronic medical record; PMD, primary physician.

any affiliated location at any time. Further EMR-based supports required providers to document review of the HMPC and distribution of it to the caretaker.

EDUCATION

Education on the use of this new EMR-based HMPC was tied to the simultaneous rollout of physician documentation in the LPCH EMR (a one-hour hands-on computer lab session) and was required of all providers. Refresher education occurred in the forms of screen savers, resident conferences, and division meetings. Since March 2007, compliance was tracked by provider, with each noncompliant provider being contacted by physician leadership to remind him or her of the LPCH and Joint Commission expectations for HMPC completion.

OUTCOMES MEASURES

Compliance. The primary outcome for this study was percentage of eligible patients with a fully compliant HMPC. Beginning with April 1, 2007, discharges, compliance with the HMPC was measured quarterly, reviewed by multiple oversight committees, and integrated into the robust peer review process in place at LPCH. Exceptions were identified manually during the nonautomated process of quality reporting. Compliance was defined dichotomously: If all seven components were completed, this was considered a compliant HMPC; completion of fewer than seven components resulted in a noncompliant score.

Survey. The secondary outcomes in this study were generated by the 16 elements in the provider satisfaction survey. Of particular interest, decided a priori, were perceptions on ease of HMPC use, perceptions on time to complete the HMPC, and estimates of time to complete the HMPC and explain it to the

family. Metrics associated with the survey were compared pre- and post-EMR HMPC implementation.

DATA ANALYSIS

HMPC compliance rates for the pre-EMR intervention period were compared with those of the post-EMR intervention period by means of Fisher's Exact Test of Proportions (two-sided). The survey questions focusing on "ease of completion," "perceptions of how time-consuming it was to fill out," and "perception of errors resulting in necessary HMPC revision" had ordinal responses. The median response for the pre-EMR intervention period was compared with that of the post-EMR intervention period by means of the Wilcoxon Rank-Sum Test (two-sided). The survey questions for "the estimated number of minutes to complete the HMPC" and "the estimated time to explain the HMPC to the family" had numeric responses with the option to respond with time ranges (for example, 0–10 minutes; 11–20 minutes). If a range was provided as a response, the mid-point of that range was used as a numeric response. As a result, we were not able to convert time estimates into average times. The mean response for the pre-EMR intervention period was compared with that of the post-EMR intervention period using Student's *t*-test (two-sided, unequal variance). All analysis was performed using R Statistical Software version 2.10.0 (The R Project for Statistical Computing, Berlin). Free-text data elements ("comments") from the survey were not analyzed but rather compiled and used for process improvements.

Results

COMPLIANCE

Compliance data for all eligible discharges were tracked monthly

from April 1, 2007, through December 31, 2011 (Figure 1, right). In the preintervention period (April 1, 2007–June 30, 2010), there were 262 eligible asthma discharges, of which 65.3% were compliant with all seven components. In the postintervention period (July 1, 2010–December 31, 2011), there were 171 eligible asthma discharges, of which 93.7% were compliant with all seven components of the HMPC ($p < .0001$; Table 2, page 364).

PHYSICIAN SATISFACTION

The secondary outcomes were physician satisfaction with the HMPC and with the work flow associated with completing it properly. In the pre-EMR provider survey, a total of 100 physicians were surveyed during a four-week period, with 45 (45%) responses. In the post-EMR provider survey, a total of 154 physicians were surveyed for a four-week period, with 77 (50%) responses. There were statistically significant improvements in ease of completion ($p < .0001$), perceptions of how time-consuming it was to fill out ($p < .0001$), perception of errors resulting in necessary HMPC revisions ($p = .001$), and the estimated number of minutes to complete the HMPC (6.2 minutes in 2009 versus 4.8 minutes in 2011; $p = 0.033$). The difference in the estimated time to explain the HMPC to the family was not statistically different (9.1 minutes in 2009 versus 8.7 minutes in 2011; $p = .738$), as would be expected given the intervention addressed the process, not the content, of the HMPC.

Discussion

LPCH devoted substantial effort to improve compliance with the three Joint Commission asthma quality measures from their inception in 2007. As other hospitals have reported, the HMPC proved to be the most challenging of the three measures. Lessons learned at LPCH included the need for a continuous surveillance and improvement model, which resulted in several iterations of the HMPC; the importance of soliciting user input, which resulted in improvements in work flow; and the importance of consistent support from the quality management and

Mean Compliance with All Seven Components of the Home Management Plan of Care (HMPC), Pre- and Postintegration into the Electronic Medical Record, April 1, 2007–December 31, 2011

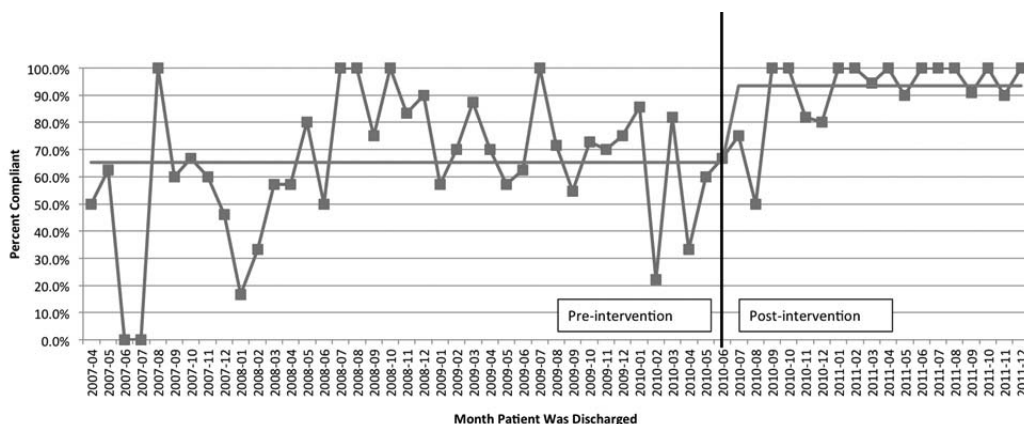


Figure 1. Compliance data for all eligible discharges were tracked monthly from April 1, 2007, through December 31, 2011. While only 171 (65.3%) of the 262 eligible asthma discharges were compliant with all seven components of the HMPC during the intervention period, 119 (93.7%) of the 127 eligible asthma discharges in the postintervention period were compliant.

information technology (IT) departments, which are crucial to eliminating barriers and facilitating improvement. After stabilization of the EMR–integrated HMPC intervention, we observed 12 continuous months of > 90% compliance with the HMPC, levels of which were only sporadically attained at LPCH previously.

Four aspects, as follows, of the EMR–based HMPC were crucial to increasing compliance LPCH:

1. We were able to force completion of all required fields by not allowing the EMR–integrated HMPC form to be signed unless all required fields were completed.
2. We created automated logic in the EMR–integrated HMPC form that linked certain selections with additional prepopulated fields. For example, when an asthma trigger was selected, avoidance instructions relevant to that particular trigger were automatically entered in the “avoidance instructions” section of the HMPC form.
3. Our EMR–integrated HMPC allowed us to autopopulate several key fields, making omissions less likely. For example, “Prevention Medication #1” is autopopulated with “No controllers prescribed”; if the provider chooses a medication from the drop–down list, conditional and required logic opens the dosage and scheduling fields with predefined responses.
4. The EMR–integrated HMPC allowed us to establish the forcing function tying the discharge order to the completion of the HMPC for any eligible patient. On entering a discharge

Table 2. HMPC Compliance for Pre- and Postintervention Periods*

All Cases ($p < .0001$)		
	Cases	% Compliant
Pre	262	65.3%
Post	171	93.7%

* Preintervention, April 1, 2007–June 30, 2010. Postintervention, July 1, 2010–December 31, 2011.

order for an eligible patient, the EMR determines if the HMPC has been completed; if incomplete, a pop-up warning to document an HMPC is shown.

One-hundred-percent HMPC compliance became increasingly easy to achieve, although occasional noncompliance occurred primarily from entering “Other” into the follow-up clinic location field and then not properly completing the clinic name and phone number requirement.

In addition to improved compliance, we observed increased physician satisfaction with the process used to generate an HMPC. Several of these work-flow improvements were the direct result of suggestions made by the users (Table 1). For example, physicians commented that the original paper HMPC was time-consuming to complete and that, even when completed, was often illegible or inaccurate, thus requiring a rewriting of the entire document. Several of these issues were addressed with the next Web-based iteration of the HMPC, which featured drop-down menus. In addition, use of prepopulated fields, a specific suggestion from users in the pre-survey, was incorporated into the final iteration of the HMPC, in which the EMR was used to automatically populate the provider’s name and phone number, patient’s name and date of birth, and name of attending physician at the time of HMPC completion. Finally, physicians suggested minimizing redundant actions in generating the HMPC, a recommendation that was also incorporated into the final EMR-based iteration of the HMPC. Minimizing redundant data entry resulted in increased provider satisfaction, improved work-flow efficiency, and ultimately substantially improved HMPC compliance.

In addition to improved compliance and user satisfaction, our EMR-integrated HMPC facilitates high-quality longitudinal care, including an effective care transition between hospital-based care to that of the ambulatory-based primary care physician and/or specialist, in the following three ways:

1. A consistent asthma education message to the patient from all providers throughout the health care continuum reinforces behaviors that effectively prevent or address exacerbations.

2. Affiliated users of the EMR can track what caretakers were advised on discharge without relying on the multiple steps of faxed or verbal communication alone.

3. Physicians can review HMPCs from prior hospitalizations in order to gauge previously given asthma advice and make adjustments to the patient’s asthma plan in the step-wise approach recommended by NAEPP guidelines.

Replicating an Electronic Medical Record–Integrated Home Management Plan of Care Elsewhere

The ability of other hospitals to successfully implement this type of EMR-integrated HMPC solution is dependent, first, on their requiring a comprehensive and universally adopted EMR to optimize the embedded decision support and field prepopulation. Second, they would require access to appropriate IT resources (time, coding) to develop and modify the EMR-integrated HMPC template. Third, to achieve optimal results, they would require ongoing monitoring of usage and compliance, with resultant identification of gaps or loopholes to allow midcourse corrections such as forcing functions and updating of physician contact information. Indeed, at LPCH, the organizational aspects of our vendor-based EMR system that contributed to success of this project included (1) utilization of the EMR by 100% of the inpatient providers; (2) linkage of the HMPC to the discharge order via the problem list, diagnosis list, or the activation of the asthma order set; (3) embedding of forcing functions within the EMR-integrated HMPC that required all fields to be completed before saving the HMPC form; (4) prepopulation of the HMPC with accurate patient and provider information and commonly used asthma medications and step-up therapy; (5) easy availability and automatic recording of the HMPC in the patient’s EMR; and (6) ease of ability to print in other languages. Although we customized this work into our vendor-based EMR, our experience should encourage vendors to consider standardizing these successful features/tools into their standard EMR product. It is reassuring to note that compared to the only known report on evaluating the value of an EMR on HMPC compliance,¹⁷ our study illustrates that increased HMPC compliance can be accomplished on a commercial, as opposed to a homegrown, EMR system.

LIMITATIONS

There are multiple limitations to this study. First, the pre-post intervention study design limits assigning causality of increased HMPC compliance to the EMR solution. Unmeasured or unrecognized interventions across LPCH may have con-

tributed to the improvement in compliance, although we are not aware of any such interventions. Second, secular trends such as improved patient/caretaker and provider awareness regarding asthma education may have influenced compliance; The Joint Commission's asthma focus since 2007 has resulted in an increase in compliance to the HMPC.¹⁹ Third, differences in staff/provider groups pre- and postintervention such as familiarity with HMPCs or preference for EMR-based forms may have made the postintervention group more likely to comply. Finally, this is one center's experience, and therefore the results cannot necessarily be generalized to other pediatric hospitals.

Conclusion

Using the LPCH EMR for construction of the HMPC resulted in a statistically significant and sustained increase in HMPC compliance and an increase in provider satisfaction regarding this process. **I**

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Shilpa J. Patel, MD, formerly Clinical Instructor, Division of General Pediatrics, Department of Pediatrics, Stanford University School of Medicine, Stanford, California, and Pediatric Hospitalist at Lucile Packard Children's Hospital, Palo Alto, California, is Assistant Professor and Associate Program Director, Pediatric Residency Program, University of Hawaii John A. Burns School of Medicine, Honolulu. **Christopher A. Longhurst, MD, MS**, is Chief Medical Information Officer, Lucile Packard Children's Hospital; and Clinical Assistant Professor of Pediatrics, Stanford University School of Medicine. **Anna Lin, MD**, is Clinical Instructor, Division of General Pediatrics, Department of Pediatrics, Stanford University School of Medicine. **Lyn Garrett, MHA, MS**, formerly Quality Manager, Lucile Packard Children's Hospital, is Director, Quality Management, Good Samaritan Hospital, San Jose, California. **Jenny Gillette-Arroyo, RN, BSN**, is Analyst, Department of Information Services, Lucile Packard Children's Hospital. **John D. Mark, MD**, formerly Medical Director, Respiratory Care Department, Lucile Packard Children's Hospital, is Clinical Professor, Division of Pulmonary and Critical Care, Department of Pediatrics, Stanford University School of Medicine. **Matthew S. Wood, PhD**, is Senior Clinical Analyst, Lucile Packard Children's Hospital. **Paul J. Sharek, MD, MPH**, is Associate Professor of Pediatrics, Stanford University School of Medicine; and Medical Director, Center for Quality and Clinical Effectiveness, and Chief Clinical Patient Safety Officer, Lucile Packard Children's Hospital, and Division of General Pediatrics, Department of Pediatrics, Stanford University School of Medicine. Please address correspondence to Shilpa J. Patel, Shilpa.patel@kapiolani.org.

References

1. Zahran HS, et al. Vital signs: Asthma prevalence, disease characteristics, and self-management education—United States 2001–2009. *MMWR Morb Mortal Wkly Rep*. 2011 May 6;60(17):547–552.
2. Akinbami LJ, Moorman JE, Liu X. Asthma prevalence, health care use, and mortality: United States 2005–2009. *Natl Health Stat Report*. 2011 Jan 12;(32):1–14.
3. National Heart, Lung, and Blood Institute. Guidelines for the Diagnosis and Management of Asthma (EPR-3). Jul 2007. Accessed Jun 29, 2012. <http://www.nhlbi.nih.gov/guidelines/asthma/>.
4. The Joint Commission. Specifications Manual for National Inpatient Quality Measures. Version 4.1.1 Accessed Jun 29, 2012. http://www.jointcommission.org/specifications_manual_for_national_hospital_inpatient_quality_measures.aspx.
5. Agrawal SK, et al. Efficacy of an individualized written home-management plan in the control of moderate persistent asthma: A randomized, controlled trial. *Acta Paediatr*. 2005;94(12):1742–1746.
6. Zemek RL, et al. Systematic review of randomized controlled trials examining written action plans in children: What is the plan? *Arch Pediatr Adolesc Med*. 2008;162(2):157–163.
7. US Department of Health & Human Services. Hospital Compare Quality of Care Page. Accessed Jul 2, 2012. <http://hospitalcompare.hhs.gov/>.
8. The Joint Commission. Accountability Measures: A New Concept to Promote Quality Improvement: List of Accountability Measures. Aug 2011. Accessed Jun 29, 2012. http://www.jointcommission.org/accountability_measures/.
9. US Department of Health & Human Services. Hospital Process of Care Measures Graphs: Children's Asthma Process of Care Measures. (Updated May 17, 2012). Originally accessed Jul 19, 2011. <http://www.hospitalcompare.hhs.gov/hospital-compare.aspx?hid=053305&lat=37.3867729&lng=-122.07522240000003&stype=GENERAL&&stateSearched=CA>. Process of Care tab, Graphs tab.
10. Bernstein JA, et al. Improved physician work flow after integrating sign-out notes into the electronic medical record. *Jt Comm J Qual Patient Saf*. 2010;36(2):72–78.
11. Longhurst C, Turner S, Burgos AE. Development of a Web-based decision support tool to increase use of neonatal hyperbilirubinemia guidelines. *Jt Comm J Qual Patient Saf*. 2009; 35(5):256–262.
12. Bennett KJ, Steen C. Electronic medical record customization and the impact upon chart completion rates. *Fam Med*. 2010;42(5):338–342.
13. Bauml KM, et al. Clinical information system and process redesign improves emergency department efficiency. *Jt Comm Qual Patient Saf*. 2010;36(4):179–185.
14. Davis AM, et al. Using the electronic medical record to improve asthma severity documentation and treatment among family medicine residents. *Fam Med*. 2010;42(5):334–337.
15. Shapiro A, et al. Putting guidelines into practice: Improving documentation of pediatric asthma management using a decision-making tool. *Arch Pediatr Adolesc Med*. 2011;165(5):412–418.
16. Tolomeo C, Shiffman R, Bazzzy-Asaad A. Electronic medical records in a sub-specialty practice: One asthma center's experience. *J Asthma*. 2008;45(9):849–851.
17. Nkoy FL, et al. Sustaining compliance with pediatric asthma inpatient quality measures. *AMIA Annu Symp Proc*. 2010 Nov 13;547–551.
18. Longhurst CA, et al. Decrease in hospital-wide mortality rate after implementation of a commercially sold computerized physician order entry system. *Pediatrics*. 2010;126(1):14–21.
19. Morse RB, et al. Hospital-level compliance with asthma care quality measures at children's hospitals and subsequent asthma-related outcomes. *JAMA*. 2011 Oct 5;306(13):1454–1460.