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Abstract

Despite expert guidelines, gaps persist in quality of care for children with asthma. This study sought to identify barriers and potential interventions to improve compliance to national asthma prevention guidelines at a single academic pediatric primary care clinic. Using the plan-do-check-act (PDCA) quality improvement framework and fishbone analysis, several barriers to consistent asthma processes and possible interventions were identified by a group of key stakeholders. Two interventions were implemented using the electronic medical record (EMR). Physician documentation of asthma quality measures were analyzed before intervention and during 2 subsequent time points over 16 months. Documentation of asthma action plans (core group $P < .001$, noncore group $P = .004$) and medication counseling (core group $P < .001$, noncore group $P < .001$) improved substantially by the third time point. A systematic approach to quality improvement using PDCA and fishbone analysis in conjunction with embedded EMR tools can improve asthma care in a pediatric primary care setting.

Keywords

asthma, fishbone analysis, PDCA, electronic health records, quality improvement, pediatric

Asthma is the most common chronic illness in childhood, affecting approximately 9.6% of children in the United States.¹ The cost of asthma is high both to the health care system and in terms of burden of disease for the child and his or her family. Recent guidelines released by the National Heart, Lung, and Blood Institute (NHLBI) have enumerated a number of measures aimed at reducing the morbidity and cost related to asthma.² Implementing these measures in a primary care setting is a high priority for the individual practitioner, both to provide effective care for patients and because recent quality care initiatives have tied reimbursement to implementation of these measures.

Although the NHLBI guidelines clearly delineate a number of quality measures, the traditional structure of patient charts does not always allow for easy tracking of these measures over time. Even electronic medical records (EMRs), which have been noted to have the advantage of being able to mine and track data easily at the patient and population level, do not necessarily allow providers to use this information in a busy clinical setting.

This was certainly the case in the authors' practice. Although an EMR (Centricity; GE Healthcare, Waukesha, WI) was well integrated into the daily activities of the pediatric providers, it was not effective at helping them follow major aspects of the guidelines for managing children with asthma. All the providers were aware of the guidelines but there was no consistency between providers regarding their asthma care, and the actual care being provided was not documented clearly in way that could be consistently monitored.

The authors had an asset in one author (HDD) who had recently received advanced training in quality

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improvement processes with the plan-do-check-act (PDCA) framework, including cause-and-effect or fishbone analysis.³ Fishbone analysis is a method of brainstorming that identifies as many conceivable causes for a specific effect or problem as possible. Although it has been used extensively in the manufacturing and service industries, fishbone analysis is just beginning to make an impact on medical care.^{4,5}

For this reason, a team was established whose goal was to use fishbone analysis to identify the major impediments to improving the care processes related to managing children with asthma in the primary care clinic that could be targeted for intervention. The specific aim was to increase the number of quality asthma measures documented for those patients with asthma that could be monitored for trends that would enable the clinic to improve quality of care.

Methods

Setting

The Michigan State University (MSU) Pediatric Primary Care Clinic is an academic primary care pediatric practice in East Lansing, Michigan. It serves a population of approximately 5800 patients, a high proportion of whom have Medicaid insurance (approximately 47%). Physicians generally see between 12 and 18 patients during each 4-hour clinic. Residents and medical students also spend a portion of their time at the practice as part of their clinical rotations. Residents see patients for 2 half-days each week during their general pediatrics rotation. Students are present and working with attending physicians the majority of the time. In total, students and residents are involved with approximately 20% of patient encounters. However, in all cases it is the attending physician who prints the asthma action plan and completes the appropriate documentation regarding asthma care.

Eight pediatricians saw patients during the course of the study. However, there was significant physician turnover: 2 physicians left and 2 joined the practice during the course of the study. Nursing staff (4 nurses) remained the same during the project period.

Process Framework

The PDCA framework was used to attempt to improve the asthma care process. The first stage of *Plan* involved identifying the problem (improving asthma care), setting measurable goals, and establishing a process for coordinating with and gaining approval of the key stakeholders.

A team of key players and vested stakeholders was assembled that included the end users (pediatricians and

family medicine physicians), a pediatric pulmonologist, a clinic nurse manager, the department chair, the department manager, a quality expert, a health information expert, and an EMR implementer. This team met regularly for all stages of the project including the intervention stage (details to follow) to provide input and to discuss project progress. The team also engaged other stakeholders within the health care system including the Quality Care Committee and the Health Information Team.

The second stage of *Plan* involved the process mapping and fishbone analysis to analyze the initial systemic barriers to consistent asthma care processes in the study setting (Figure 1) and to gain approval from the key stakeholders as to which of the identified barriers were amenable to intervention. The study was designed to be quasi-experimental, comparing physician documentation of the key variables in the EMR before and after intervention.

Planning the Intervention

Using the fishbone approach, barriers in materials, measurement, people, and procedures were identified. Seven of these barriers that seemed amenable to change were targeted for intervention. These barriers were the following:

- A lack of consistency in asthma action plan materials given to patients. (Target A)
- The asthma form in the EMR was cumbersome and inaccessible during patient care. (Target B)
- Excessive time was required to find historical information to manage patients within the EMR. (Target C)
- Asthma medications were being entered into multiple locations in the EMR with no single source to record all of them. (Target D)
- The lack of a consistent process for documenting counseling about the appropriate use of asthma medications. (Target E)
- Poor accessibility of the most recent pulmonary function test (PFT) in the EMR. (Target F)
- The date of the most recent asthma teaching was not clearly delineated in the EMR. (Target G)

The *Do* phase of the project involved developing potential interventions and implementing them. Two main interventions were designed to target the barriers identified. First, a new asthma form was designed for the EMR that had specific guideline-related information to trigger action by the practitioner (Targets A, B, C, E, F, and G). Second, an asthma action plan was developed that was automatically populated with the patients' current asthma

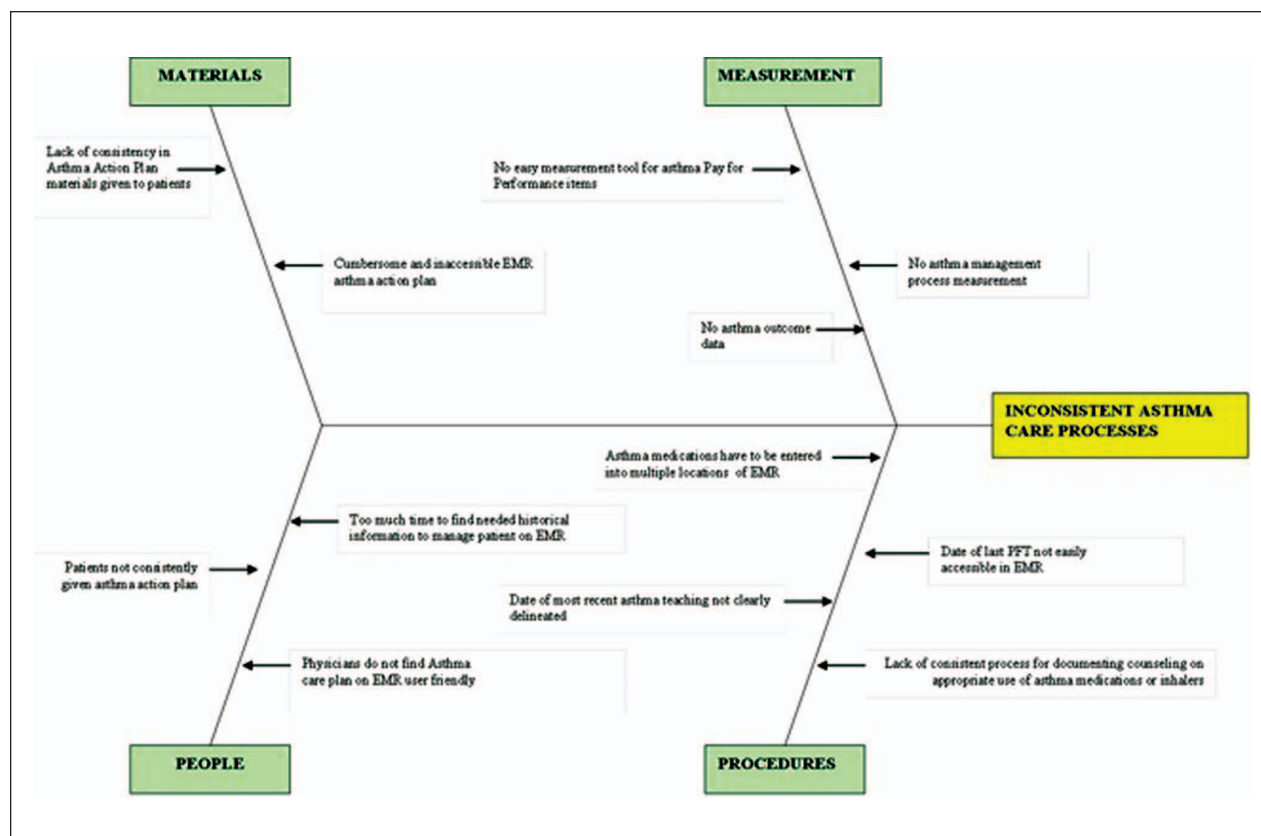


Figure 1. Fishbone diagram.

Abbreviations: EMR, electronic medical record; PFT, pulmonary function test.

medications and could be printed directly from the new asthma form to present to patients (Targets A and D).

The asthma form addressed 3 of the main barriers identified regarding documenting asthma care. It allowed for documentation of (a) whether PFT or spirometry was performed in the past year, (b) whether discussion of appropriate use of asthma medications and delivery devices (eg, inhalers, spacers, masks, nebulizers) occurred, and (c) whether discussion of environmental exposures that may trigger asthma had occurred.

Both the asthma form and the asthma action plan were incorporated directly into the standard office visit for all patients, regardless of whether or not the patient had asthma and regardless of whether the visit was for asthma. The form was designed to automatically record the last date on which each of the quality measures already discussed was completed. Thus, providers easily received feedback at the point of care regarding the extent to which they were meeting asthma guidelines for that patient.

Just prior to implementation, a brief training session was performed for the physicians and nurses working at the clinic at the time (November 2007). No further formal training was done during the course of the study. However,

brief discussions regarding the use and availability of the asthma tools occurred periodically throughout the study period during standard clinic meetings. No formal training session was given to new pediatricians as they joined the practice.

The study was granted a waiver from the MSU Ethics Board.

Methods of Evaluation and Analysis

In the *Check* phase of the project, data were gathered and analyzed to evaluate the results of the intervention. To assess the effectiveness of the intervention, several outcome metrics were chosen that related directly to the target goals. These metrics included the proportion of visits in which providers documented (a) giving patients an asthma action plan, (b) either completed PFTs or an order for PFTs within the past year, (c) counseling about appropriate use of asthma medications or delivery devices, and (d) counseling about exposures that may trigger asthma.

Using a standardized data collection sheet, the same trained member of the pediatric asthma care quality team extracted data on each of these metrics from the EMR at

3 separate time points. The same data were extracted (a) during a 3-month period prior to the intervention being introduced into the EMR (September 1, 2007, through November 30, 2007); (b) during the 3 months immediately after the intervention was introduced (December 1, 2007, through February 29, 2008); and (c) during a 4-month period beginning 16 months after the initial intervention (July 1, 2009, through October 31, 2009). The data were collected from every patient with a past diagnosis of asthma (as determined by *International Classification of Diseases, Ninth Revision* code on the patient's problem list) who was seen during any of the 3 study periods. A total of 811 unique encounters were analyzed during the 3 time periods.

The team also recorded whether the patient was seen for asthma reasons or for some other reason and which provider saw the patient. Because of turnover among some providers in the 16 months between the second and third measurements, 2 groups of providers were determined for the purpose of analysis based on whether or not they were involved for the total duration of the study. The first group (hereafter referred to as the core group) included the providers who provided care during all 3 time points; this group consisted of 4 providers. The second group (hereafter referred to as the noncore group) included all other providers. This group also consisted of 4 providers; 2 were present for only the first 2 time points, and the other 2 were present for only the last time point. Because of the restrictions based on the total sample size, statistical analyses were performed only at the group level (core and noncore) and not at the individual physician level. Before combining the providers into these 2 groups, the information was analyzed to look for heterogeneity within the members of the group; no significant differences were identified among the members. The analyses were performed with data from both groups (core and noncore), but the models allowed for the effects of each group to be different.

The providers were surveyed regarding their perception of the intervention at the end of the second time period. The survey included questions regarding satisfaction with the intervention and its effectiveness and provided opportunity for comments.

Data for each outcome of interest were analyzed using logistic regression. In each of the models time, type of visit, and group membership of the provider were the explanatory factors of the observed differences in the outcomes and the interaction term of time and group membership were included in the model. Group membership was used to measure the overall group effect, and the interaction term (time by group membership) was used in the model to measure the differences of the time effect for both groups. The data were analyzed by using the first time point (preintervention) as the reference category.

This analysis allowed the determination of whether the intervention had significant effects in the short term (from the first time point to the second time point) and also in the long term (from the first time point to the third time point). Based on the nature of their group, the analysis of the long-term effect of the intervention in the noncore group was interpreted as the effect of the intervention on the new providers that joined the team. All statistics were performed using SAS 9.3 (SAS Institute Inc, Cary, NC). The models were estimated by using the CATMOD procedure; this procedure was used to fit the logistic regression models with categorical predictors.

Results

The percentage of patients of the core group of providers who were documented to have received an asthma action plan during a visit increased significantly ($P < .001$) for each of the postintervention time points compared to preintervention (Figure 2). For the noncore group of providers, the change for the first postintervention time point was not significant ($P = .1215$); however, there was a significant increase in documentation of patients receiving an asthma action plan during the second postintervention period ($P = .004$).

In contrast, the percentage of patients for whom there was documentation of PFT performance by providers (Figure 3) showed a significant increase from the preintervention to the second postintervention time point only for the core group of providers ($P = .003$); the noncore group of providers had a nonsignificant decrease in percentage from the preintervention to the second postintervention time point ($P = .078$).

The percentage of patients with documentation of receiving counseling on the appropriate use of their asthma medication or delivery devices also increased significantly with time ($P < .001$). However, although the core group of providers increased their percentage significantly at each of the postintervention time points compared to the preintervention ($P < .001$; Figure 4), the percentage for the noncore group of providers had not increased by the first time period, and only increased significantly from the preintervention to the second postintervention time point ($P < .001$).

Finally, the percentage of patients with documentation of receiving counseling on exposures that may trigger asthma only showed a significant increase from the preintervention to the first postintervention for the core group of providers ($P = .018$; Figure 5).

When compared to patients who were visiting the clinic for other reasons, patients whose visit was specifically for asthma had a significantly higher probability of having the provider comply with all the outcomes examined ($P < .001$).

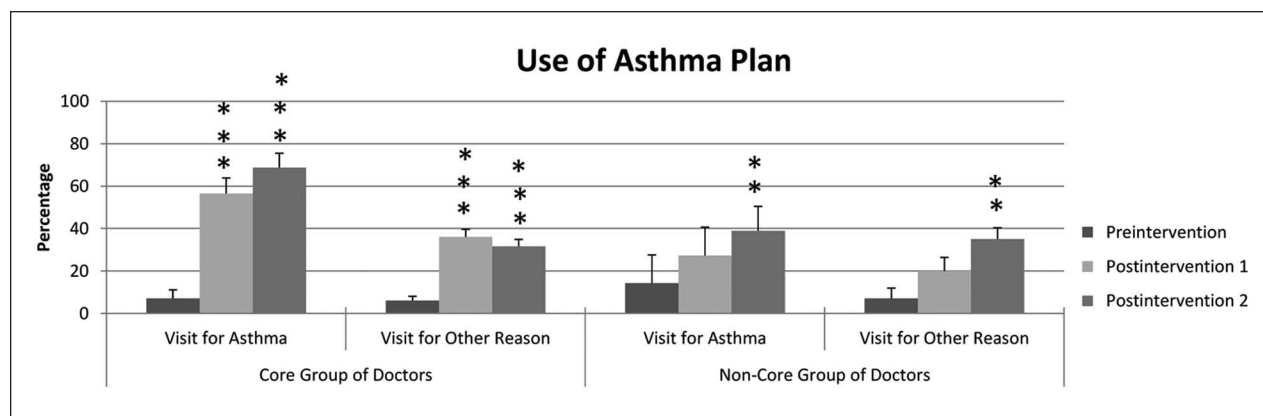


Figure 2. Percentage of patients who received an asthma action plan. The markers indicate the postintervention percentages that are statistically different from the corresponding preintervention percentage. Significance levels: *** $P < .001$, ** $P < .01$.

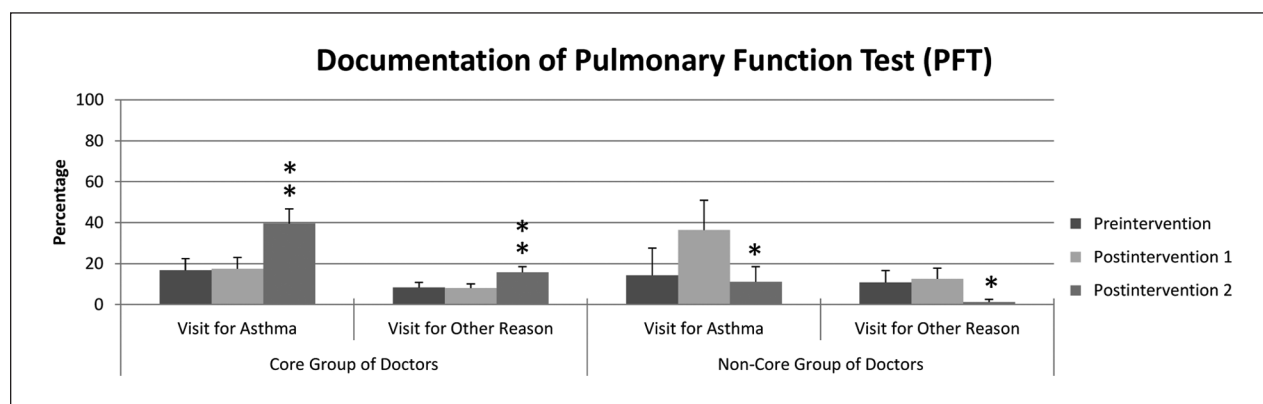


Figure 3. Percentage of patients who received a pulmonary function test. The markers indicate the postintervention percentages that are statistically different from the corresponding preintervention percentage. Significance levels: *** $P < .001$, ** $P < .01$.

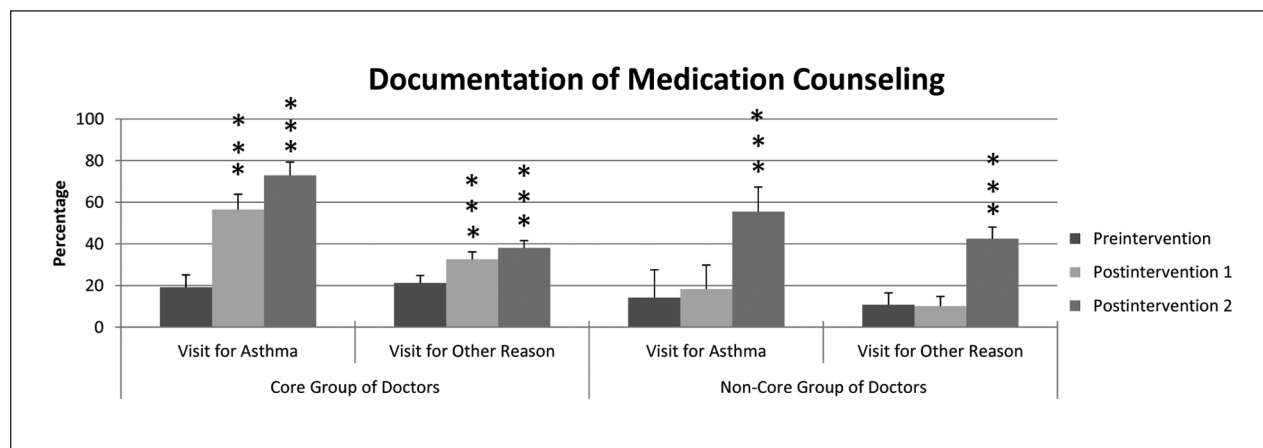


Figure 4. Percentage of patients who received asthma medication counseling. The markers indicate the postintervention percentages that are statistically different from the corresponding preintervention percentage. Significance level: *** $P < .001$.

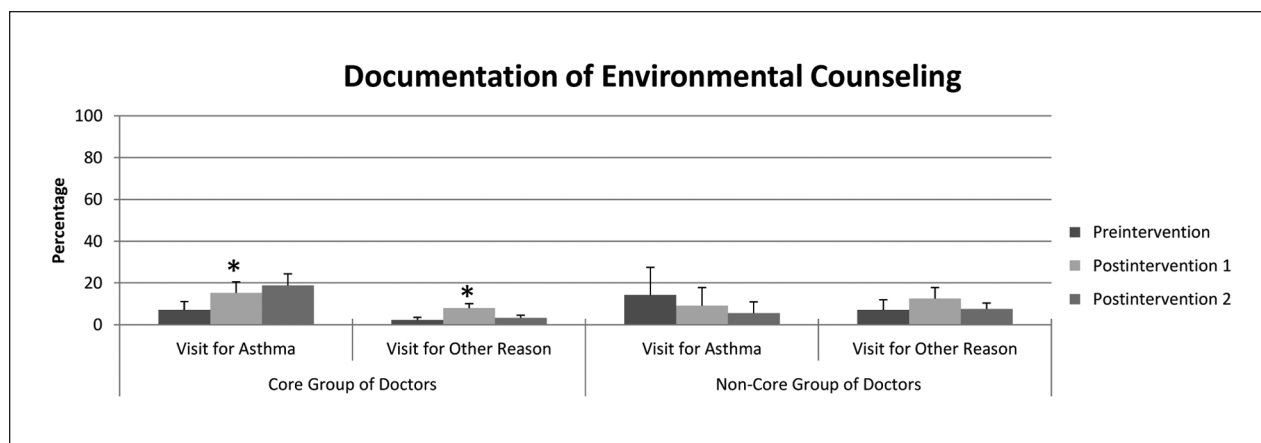


Figure 5. Percentage of patients who received environmental counseling regarding asthma.

The markers indicate the postintervention percentages that are statistically different from the corresponding preintervention percentage. Significance level: * $P < .1$.

The *Act* component of the process framework used involves standardizing the solution, identifying systemic changes and training needs for full implementation, and seeking opportunities for incremental improvements. Provider feedback obtained at the end of the second time period demonstrated overall satisfaction with the asthma form, with 6 out of 7 providers (85.7%) indicating that it was a significant improvement and that they used it for most or every patient. The same proportion believed it helped them communicate a clear asthma action plan to their patients with asthma and that it improved information retrieval, documentation, tracking, and management of patients with asthma.

Written comments from providers after the second time period reflected many of these themes. Clinicians appreciated the simplicity of the form and the fact that it pulled asthma medications from the patient's chart directly into the asthma action plan for ease of use. They also appreciated the availability of evidence-based handouts that could be given directly to patients.

There were still some issues that interfered with clinician use, many of which were inherent in the EMR structure/function. There were concerns that the EMR's list of asthma medications was not always up to date and therefore the correct information was not always pulled into the asthma action plan. There were concerns that one had to exit the form to view previous PFTs (this was an issue inherent in the EMR and not with the form). There were minor complaints about the physical appearance of the asthma action plan (eg, size, color).

Discussion

The development and implementation of an asthma form for the EMR by a group of key stakeholders improved documentation of key components of the asthma

guidelines. These improvements persisted over 16 months and involved all members of the practice despite a relatively high rate of provider turnover during the study period. These findings suggest that a practical and useful tool will be adopted quickly and maintained even without initial buy-in or extensive training.

Significant improvements were made in documentation of an asthma action plan being given to patients. This can be attributed to the ease of access to the EMR form that actually allowed the clinician to print the form to give the patient at the same time that he or she was documenting that this was being done, all with a single click. It supports the notion that in places where an intervention adds value for the clinician and the amount of additional work is minimal, the adoption rate will be higher and will persist.

Significant improvement also was noted in the documentation of teaching regarding medication technique and/or delivery device counseling. Although the form did not provide added value to the clinician in this case, this teaching often occurs in conjunction with discussion of the asthma action plan in the clinical setting. Although it is conceivable that the clinicians simply clicked both buttons at the same time when printing the asthma action plan, it seems more likely that the form served as a memory trigger to the provider.

Documentation of PFTs was low across all 3 time points. This deficit likely is related to deficiencies in the authors' particular EMR and work setting. PFTs are not typically done at the time the form is being completed, nor do they communicate with the EMR directly. Instead, the PFT results are scanned into the EMR as a separate document. Therefore, to document PFT results and the date, the clinician must exit the form, review the document, and then go back into the form to document that the PFTs had been done. This likely results in

too many clicks in the busy clinical practice setting, resulting in decreased acceptance of this component of the form.

For those areas of documentation that were well integrated into the practice workflow or added value to the patient (the asthma action plan and medication counseling), the response was almost as robust for the newer clinicians as for those who had been in the practice longer. There was no formal training for the newer physicians; however, it is likely that informal teaching of best practices occurred between clinicians. Conversely, the areas that were not valued by the experienced clinicians also were not valued by the newer physicians. It is possible that future practice improvements that are easily implemented and highly valued also will benefit from similar peer-to-peer informal training. Alternatively, formal training of new physicians on specific quality improvement measures that have been introduced for the EMR may enhance their earlier buy-in and more timely compliance.

To the authors' knowledge, this is the first publication describing the use of the fishbone analysis to improve quality of care in a pediatric primary care setting. This study demonstrates that these methods can be effective in improving quality of care in a primary care setting.

Several publications examine the use of EMRs in improving care quality, both in conditions other than asthma⁶⁻⁸ and in asthma.⁹⁻¹⁴ These studies use a variety of methods to improve quality, including clinical decision support and didactic sessions on EMR features. The publications related to asthma focus largely on the accurate classification of severity and appropriate medication management. However, none of these studies address other measures of asthma quality such as the use of an asthma action plan or the appropriate teaching of medication technique. In addition, none approach the problem from an organizational viewpoint or gear the intervention toward the needs of providers.

Limitations of this project included the fact that only provider process and satisfaction were measured rather than patient outcomes related to asthma. In addition, this intervention occurred at only 1 clinical site with a small number of practitioners; therefore, generalizability must be confirmed.

A number of lessons were learned regarding the planning and implementation of a quality improvement project during this time period. First, the simple presence of an EMR does not necessarily mean that evidence-based data related to patient care are easily accessible at the point of care. Instead, the extraction of such data for clinical use involves careful planning and investment of time, financial resources, and human capital.

Second, even seemingly small projects are best planned and implemented through teams of key stakeholders and constituents. Without the involvement of key

participants, including clinical experts, quality experts, and information management experts, the project never would have been successfully implemented. Even those who were not directly involved in the planning or implementation of the project, such as department or division heads, health system administrators, and clinical quality review committees, needed to be aware and accept the validity of the project to prevent unanticipated roadblocks. It was in the process of stakeholder consultation that the importance of simple deterrents to compliance such as "too many clicks" were identified and minimized during planning.

Third, quality improvement is best defined as a process rather than an outcome. Even with the most careful planning and discussion with all stakeholders, there were still barriers to the effectiveness of the intervention. Regular meetings of the key stakeholders to work through these barriers were essential to allowing the project to continue to evolve and reach the point at which it became clinically useful.

Declaration of Conflicting Interests

The authors declared no conflicts of interest with respect to the research, authorship, and/or publication of this article.

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