INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a progressive disease that affects up to an estimated 24.5 million Americans, or 95% of all patients with diabetes [1]. Disease prevalence is projected to increase to 45.9 million by 2050 [2]. Patients require lifelong changes in treatment because of worsening pancreatic β-cell function, insulin resistance, hypertension, and dyslipidemias [3]. Despite the development of effective therapies targeting the underlying pathophysiology [4], T2DM is associated with macrovascular and microvascular complications that impose a tremendous burden on patients and the healthcare system. Between 1988 and 2009, the number of hospitalizations for patients with T2DM nearly doubled [5]. In 2007, diabetes-related direct and indirect costs totaled $174 billion in the United States [1]. These findings highlight the critical importance of improving diabetes systems of care, particularly in the hospital setting.

Efforts to improve long-term treatment outcomes in patients with T2DM have...
focused on the hallmark signs of this multifactorial disease. Numerous studies—most prominently the United Kingdom Prospective Diabetes Study (UKPDS)—have demonstrated the value of improved glycemic control, as measured by A1C [6-9]. The relation of A1C to all-cause mortality [10], macrovascular disease [11,12], and microvascular disease [12] is nonlinear, with risk increasing above thresholds that remain as yet vaguely defined. Consequently, guidelines recommend patient-specific A1C goals, with frequent monitoring of A1C levels [13].

Most patients with T2DM also exhibit a dyslipidemic phenotype characterized by small, dense low-density lipoprotein (LDL) particles, elevated levels of LDL-C, low levels of high-density lipoprotein cholesterol (HDL-C), and high levels of triglycerides. LDL-C is the principal target of dyslipidemia therapy [14,15]. LDL-C lowering with statins in patients with diabetes reduces all-cause and cardiovascular mortality, with no evidence of a threshold below which benefit is lost [16]. Guidelines recommend statin therapy in all patients with T2DM who have overt cardiovascular risk factors or are over 40 years of age and have ≥1 additional cardiovascular risk factors [15].

Finally, patient education on safe and effective use of diabetes medications, signs/symptoms of diabetes complications, and a healthy lifestyle improves attainment of A1C and LDL-C goals [17-19]. Thus, attainment of A1C and LDL-C goals and provision of diabetes self-management education (DSME) have become guideline-recommended metrics of optimal diabetes care [15]. However, a survey of US patients with diabetes by the National Committee for Quality Assurance (NCQA) revealed that many are not at A1C (37.7%–53.1%) or LDL-C (47.9%–65.4%) goals [20]. Moreover, approximately 44% of patients report never attending a diabetes self-management class [21]. Even within the more rigorous confines of the UKPDS trial, only 24% to 28% of patients on monotherapy insulin or sulfonylurea achieved A1C levels <7% following 9 years enrollment [22].

Strategies to improve the performance of hospitalists, cardiologists, endocrinologists, and other hospital-based physicians who manage patients with T2DM vary considerably by institution [23]. Yet, a common thread is to track concordance with specific evidence-based recommendations captured in electronic health records [24]. By measuring practice behaviors of individual physicians and addressing performance gaps specific to their institution, hospitals can, in the aggregate, improve the quality of diabetes care, potentially leading to improved long-term outcomes. In this 6-month, multicenter pilot study, we measured and strove to improve the performance of physicians against 3 independently validated metrics of diabetes care—A1C and lipid level measurement along with peri-discharge education—through electronic medical record review.

Performance Improvement Continuing Medical Education (PI-CME) is a new category of CME activity adopted by the American Medical Association (AMA) in 2004 [25]. PI-CME is part of a broader effort that is extending the reach of CME to include improved physician performance as well as the traditional outcomes of improved knowledge or competence [26]. The tripartite structure of this new paradigm involves assessment of current performance (Stage A), design and implementation of strategies to improve performance (Stage B), and evaluation of PI efforts (Stage C) [25]. Participating physicians earn 20 AMA Physician’s Recognition Award (AMA PRA) Category 1 Credits on completion of Stage C. However, data on successful PI-CME structures and on overcoming barriers to physician participation in diabetes are sparse [27,28]. Accordingly, we conducted a diabetes PI-CME program with the participation of physicians from regional hospitals.

METHOD

We selected regional hospitals according to the following criteria:

- Demonstration of organizational commitment to diabetes-related performance or quality improvement
- Willingness to identify and nurture physician champions to help engage physician peers
- Internal resources to support the initiative
- Willingness to participate in the internal communications and reporting elements of the program

Between May and November 2011, we audited charts of patients discharged with a secondary diagnosis of diabetes from participating hospitals for compliance with the following predetermined performance metrics: (1) measurement of A1C; (2) measurement of LDL-C; (3) provision of diabetes self-management education. Chart reviews during May/June provided data for Stage A, and reviews during October/November provided data for Stage C. The primary outcome measure was the percentage of patients for whom each metric was ordered. The secondary outcome measures were achievement of prespecified performance goals for each metric, namely, A1C and LDL-C measured in at least 90% of patients and provision of education in at least 95%.

In the design and implementation of this program, we applied recognized PI principles and developed a dedicated working group to evaluate, monitor, and disseminate data, provide timely feedback, monitor outliers, attend to project management details, and maintain support of institutional leadership. We encouraged physicians’ engagement by minimizing their time requirements, soliciting their input throughout the initiative, sharing meaningful data, and taking an “improvement-oriented” approach rather than “mandating change.”

Patient Selection

We included all patients discharged with an ICD-9-CM secondary diagnosis code for T2DM.
PI Specialist
Each participating hospital identified and trained a nurse to serve as a PI specialist; their primary charge of these PI specialists was to implement specific PI interventions at their respective institutions. These individuals reviewed the electronic medical records of each patient discharged with a secondary diagnosis of T2DM for compliance with 3 predetermined performance metrics and incorporated these data locally into a dedicated portal. They anonymized private patient information and submitted these data monthly to a secure master server. The PI specialist at each hospital also facilitated correspondence between all physicians and relevant stakeholders.

Educational Strategy
The PI specialists had a number of available resources designed to increase performance and overcome institutional barriers, as follows:

- Monthly tracking report that visually illustrated the hospital team's PI progress on the selected performance measures. The report also reviewed performance gaps and ongoing and future interventions designed to improve performance
- Dear Doctor emails to reinforce top performers and encourage outliers
- "PI Pitch" to help PI specialists deliver specific feedback and updates about the initiative to individual physicians
- Internal newsletter highlighting ongoing PI initiatives at the hospital with a focus on quality and safety
- PowerPoint presentation on the PI-CME program
- Poster board placed in the physician's lounge or similar location to showcase overall program success, top performers, and enlist the support of other hospital personnel

Coaching/Mentoring Sessions
During each of 5 monthly coaching/mentoring sessions, the PI specialists reviewed performance data with the team, discussed relevant gaps (Stage A), identified barriers, and selected interventions based on the literature and unique circumstances of each institution (Stage B).

Statistics
Statistical analyses used the Statistics Package for the Social Sciences (IBM SPSS Statistics 19; Somers, NY, USA). We compared the corresponding A1C and LDL-C results using the Pearson Chi-square test, with alpha set at 0.05 and $P$ values of less than or equal to 0.05 considered statistically significant. We compared education results from Stage A to Stage C using the independent samples t-test. We calculated effect size (ES) for the education results using Cohen's $d$, where a value of 0.2 indicates a

<table>
<thead>
<tr>
<th>Table 1. Performance Gaps and Interventions</th>
<th>Hospital 1</th>
<th>Hospital 2</th>
<th>Hospital 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Gaps</td>
<td>Hospital 1</td>
<td>Hospital 2</td>
<td>Hospital 3</td>
</tr>
<tr>
<td>1. Need to have diabetic order set.</td>
<td>1. Need more focus on patient education, making certain that diet and lifestyle are included.</td>
<td>1. Disconnects with diet in some records. Diet instructions must be given to those in outpatient settings.</td>
<td></td>
</tr>
<tr>
<td>2. Better documentation in medical records specific to why physicians are not ordering A1C and/or lipid profiles.</td>
<td>2. Post-discharge follow-up appointment should be made with diabetic educator.</td>
<td>2. Better documentation in medical records. Need general admission order set with A1C.</td>
<td></td>
</tr>
<tr>
<td>3. Better access to outpatient medical records.</td>
<td>3. Need for a diabetic patient protocol/checklist to specify patient-specific education needs.</td>
<td>3. Better access to outpatient medical records.</td>
<td></td>
</tr>
<tr>
<td>4. Should include orders/reminders for A1C and lipid profile on general admission order set.</td>
<td>4. Poor documentation in medical records.</td>
<td>4. Discharging instructions written by discharging physician who may be focused on diabetes.</td>
<td></td>
</tr>
<tr>
<td>5. Physician attitude toward evaluating A1C and lipid profile (chronic versus acute disease).</td>
<td>5. Poor access to outpatient medical records.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Should include orders/reminders for A1C and lipid profile on admission order set.</td>
<td>6. Should include orders/reminders for A1C and lipid profile on admission order set.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Improve communication with patients regarding need to get lab work done regularly.</td>
<td>7. Improve communication with patients regarding need to get lab work done regularly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of interventions implemented to address performance gaps (total number)</td>
<td>13</td>
<td>16</td>
<td>13</td>
</tr>
</tbody>
</table>
small effect, 0.5 a medium effect, and 0.8 a large effect [29]. For the A1C and LDL-C results, we first determined Cramer’s V (a statistic measuring the strength of association between 2 categorical variables), then converted this value to Cohen’s d using standard conversion tables.

RESULTS
Three mid-sized regional hospitals participated in this PI-CME program. A total of 57 physicians participated in Stage A, with 54 completing Stage B and 50 completing Stage C. The PI specialists reviewed 894 medical records submitted by these physicians.

The number of performance gaps identified in Stage A ranged from 4 to 8 (Table 1). Approximately 20% of the gaps were common to all institutions, including omission of A1C and lipid tests on general admission or preoperative order sets. We included these metrics in order sets and structured transition-of-care protocols (“interventions”) common to all 3 participating institutions. The number of interventions identified to address the performance gaps ranged from 13 to 16. Five of these were identical for the 3 institutions. Other more general interventions to improve the management of this diabetes program were also identified by the individual hospitals. The number ranged from 3 to 12. Examples include “Conduct monthly one-on-ones with physicians providing performance feedback” and “Create Diabetes Admission Order Sheet to accommodate education, A1C, and lipids.” “Cross-institutional” collaborative learning based on experiences and feedback from each site took place.

Table 2. Percentage of Performance Goals Achieved From Stage A to C

<table>
<thead>
<tr>
<th>Performance Measure (Goal)</th>
<th>Hospital 1</th>
<th>Hospital 2</th>
<th>Hospital 3</th>
<th>Combined Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1C (90%)</td>
<td>47% - 99%</td>
<td>57% - 72%</td>
<td>76% - 99%</td>
<td>58% to 91%</td>
</tr>
<tr>
<td>Lipids (90%)</td>
<td>16% - 96%</td>
<td>42% - 75%</td>
<td>82% - 102%</td>
<td>42% - 92%</td>
</tr>
<tr>
<td>Education (95%)</td>
<td>91% - 103%</td>
<td>87% - 96%</td>
<td>95% - 103%</td>
<td>91% - 101%</td>
</tr>
<tr>
<td>Overall means</td>
<td>51% - 99%</td>
<td>62% - 81%</td>
<td>84% - 101%</td>
<td>64% - 95%</td>
</tr>
</tbody>
</table>

For all 3 hospitals combined (Figure 1A), measurement of A1C improved from 51.8% to 82.2% (P < .001) with a medium to large ES (d = 0.69). Percent achievement of the A1C performance goal (90%) increased from 58% to 91% (Table 2). Measurement of LDL-C improved from 37.5% to 82.5% (P < .001) with a large ES (d = 1.04). Percent achievement of the LDL-C performance goal (90%) increased from 42% to 92% (Table 2). Diabetes education was already being provided quite often at Stage A (86.0%). Despite this, education at discharge improved to 95.8% (P < .001) with a medium ES (d = 0.46). Percent achievement of the diabetes education goal (95%) increased from 91% to 101% (Table 2). The extent to which A1C and LDL-C were measured and education provided varied by hospital at baseline (Stage A) and at study end (Stage C), as illustrated in Figure 1B-D. Of note, each institution individually demonstrated statistically significant improvement in all metrics (P ≤ .006) with the exception of A1C at 1 hospital (Figure 1C).

At the study’s end, no hospital met all 3 performance measures—that is, measurement of A1C and LDL-C in at least 90% of patients and provision of diabetes education in at least 95% of patients. One institution, however, did come within a percentage point of doing so. A second hospital met the education performance measure and came within a percentage point of meeting the A1C performance measure.

DISCUSSION
The program met its primary objective of improving measurement-based diabetes care as defined by increased frequency of A1C and LDL-C testing and provision of patient education. The consistent and significant improvement in all 3 metrics at each participating hospital demonstrates the value of undertaking a collaborative PI initiative. We achieved substantial improvement in all 3 metrics after only 6 months, which should encourage healthcare professionals at other institutions to implement similar programs.
Of note, the PI specialists at all 3 participating hospitals saw marked improvement once order sets included the metrics. Delay in this key step at 1 of the hospitals likely accounted for differences in performance relative to the other 2 institutions.

Our study both confirms and extends the literature on PI-CME in diabetes care. Stowell et al [27] and Brown et al [28] reported successful programs in which clinicians self-developed performance improvement plans. Our study demonstrated that use of PI specialists to encourage clinician change is an alternative approach. Brown et al also reported several barriers to participation, ranging from time constraints to low awareness of PI as a valid CME platform and resistance to accepting the paradigm of performance improvement [28]. Notwithstanding an overall low awareness of PI-CME within our network, we noted considerable interest from institutions and individual clinicians in participation following our announcement of the program.

The strategies we used to overcome barriers—order sets, transition-of-care protocols, and prompt feedback to physicians, among others—are well established in the PI literature. In particular, Schnipper and colleagues reported that inclusion of a diabetes order set resulted in improved inpatient glycemic control [30]. Additional strategies reported by other investigators to overcome barriers to optimal diabetes care include clinical reminders such as flow sheets, registries, and electronic medical records (reinforcing); in-house clinical protocols (predisposing); and audit and feedback discussion of patient care data by a local colleague (enabling) [28]. Of note, the hospital with the largest number of performance gaps also had the smallest increases in performance measures. Effective
treatment of diabetes is complex and varies considerably by institution based on a unique set of performance gaps and requires a unique set of interventions.

In general, direct costs associated with this type of program include the additional A1C and lipid tests, PI specialist time, mentor time, and development of educational materials. Indirect costs include that of treatment (medication costs or healthcare professionals’ time spent counseling on lifestyle modification) resulting from the additional tests. However, documentation of elevated A1C and LDL-C levels in patients with diabetes is a necessary first step toward better metabolic control, and reduced long-term diabetes-related costs. Strict glycemic control to patient-specific goals reduces microvascular and macrovascular events and associated hospitalizations and medication usage. Wagner et al found that reduction in A1C of ≥1% was associated with lower per-patient yearly healthcare costs ranging from $950 (if baseline A1C was 8%-10%) to $279 (if baseline A1C was <8%) [31]. A second research group reported similar findings, with savings of $805 (baseline A1C of 10%) to $218 (baseline A1C of 8%) [32]. LDL-C reduction has an even greater impact on healthcare costs. For every 39 mg/dL reduction in LDL-C, there is a 20% reduction in macrovascular disease among patients with T2DM [33]. Prevention of macrovascular disease in patients with T2DM would save an estimated $7065 per patient per year [34]. We cannot estimate how much of these potential savings would accrue to participating hospitals and which would accrue to community-based clinicians or third-party payers. Nevertheless, our findings suggest that PI-CME programs in diabetes educational interventions, by improving physician knowledge and practice behaviors, may yield significant disease management savings, which may outweigh their associated costs.

Our study is not without limitations. This was a pilot study with a few participating institutions. Expansion to a larger network of hospitals nationwide would be desirable. Moreover, the study design did not allow for monitoring patients’ A1C and LDL-C levels after discharge. We acknowledge that measurement of A1C and LDL-C are necessary but not sufficient to achieve good metabolic control. In addition, A1C and LDL-C are only part of comprehensive T2DM care [15]. Blood pressure control and weight reduction are also important. Finally, diabetes is largely a self-managed disease with support provided by an interdisciplinary healthcare team increasingly guided by individualized treatment goals and plans [13,15,35]. However, we believe our study further supports a core principle regarding PI-CME: namely, that healthcare institutions and their physician staff can demonstrate marked improvements when measured against pre-defined validated metrics, adherence to which facilitates measurement-based diabetes care.

CONCLUSIONS
This multicenter, collaborative PI-CME initiative demonstrated that hospital-based physicians can be effectively targeted with a PI-CME program designed to improve adherence to 3 validated and guideline-recommended metrics of diabetes care: measurement of A1C, measurement of LDL-C, and provision of diabetes self-management education. By demonstrating the value of consistent behavioral reinforcement and structured redesign of clinical workflow and systems, our study substantiates the evidence base supporting the value of PI-CME in improving physician performance and warrants further assessment nationwide.

ACKNOWLEDGMENTS
The authors thank Angela Bidleman, Lori Carlton, and Mary Manning for their work as PI specialists at participating hospitals and David Franklin Clark for his dedicated project management.

REFERENCES


