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Improving Diabetes Care Through a Multicomponent Quality Improvement Model in a Practice-Based Research Network

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This article reports the impact of a multicomponent quality improvement intervention on adherence with 13 measures of diabetes care and a summary measure, the Diabetes Summary Quality Index (Diabetes-SQUID). The intervention was conducted between January 1, 2004, and July 1, 2005, within 66 primary care practices in 33 states, including 372 providers and 24 250 adult patients with diabetes. Across all practices, the average Diabetes-SQUID was 50.6% (10th percentile 36.5%, 90th percentile 63.0%) on January 1, 2004, and 58.4% (10th percentile 47.6%, 90th percentile 69.7%) on July 1, 2005, with an average absolute improvement of 7.8% (95% confidence interval, 5.9%-9.7%). Significant improvements occurred for 12 of the 13 individual measures: blood pressure and urine microalbumin monitoring; HDL cholesterol, LDL cholesterol, triglyceride, and glycosylated hemoglobin measurements; prescription of antiplatelet therapy; and blood pressure, HDL-cholesterol, LDL-cholesterol, triglyceride, and glycosylated hemoglobin control. The findings suggest that a multicomponent intervention can have a robust impact on quality of care for diabetes. (Am J Med Qual 2007; 22:34-41)

Keywords: quality improvement; diabetes; primary care; practice-based research network; clinical practice guidelines

There is widespread evidence of inadequate implementation of evidence-based clinical practice guidelines for diabetes care,[1] whether measured in national samples[2] or in primary care settings. Fewer than 60% of diabetes patients receive an annual influenza vaccine, and only 37% meet the target for glycosylated hemoglobin control (<7%). Intermediate targets for low-density lipoprotein (LDL) cholesterol control (<130 mg/dL) and blood pressure (<140/90 mm Hg) are met by only 33% and 59% of patients, respectively.[2]

AUTHORS' NOTE: This study was supported by a grant from the Agency for Healthcare Research and Quality (1 U18 HS013716). Practice Partner Research Network was the grantee; Medical University of South Carolina subcontracted with Practice Partner to do the research. The authors have no affiliation with or financial interest in any product mentioned in this article. This work was presented in part at the North American Primary Care Research Group in October 2005 in Quebec City, Quebec, Canada. An abstract was published in the proceedings of that conference. Loraine Roylance was instrumental in data collection and in manuscript preparation.

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American Journal of Medical Quality, Vol. 22, No. 1, Jan/Feb 2007
DOI: 10.1177/1062860606295206
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Published systematic reviews point to the importance of multifaceted interventions in affecting increased adherence to practice guidelines and patient disease control.[3,4] Little is known, however, about the relative effectiveness of different implementation strategies. More research is needed to develop and validate effective, theoretically sound, and practical strategies for improving the provision of evidence-based medicine in primary care. Particularly important are studies that address common, chronic conditions such as diabetes mellitus, which affect a large proportion of the work of primary care providers.[5]

Large-scale studies specifically focused on diabetes care improvement in primary care settings are scarce. A randomized trial of quality improvement (QI) in Minnesota had recruitment difficulties and minimal impact on a number of process and outcome measures.[6] Another trial, testing the impact of an electronic reminder system on diabetes and coronary artery disease care in 20 ambulatory clinics, found limited and variable improvement and persistent quality gaps.[7] A third study, among primary care physicians in Colorado, showed that computer-assisted activation of patients and physicians plus care management increased diabetes care process measures; however, the study was limited by the self-reported nature of the data and very low rates of participation by eligible physicians.[8]

The present study, conducted in the Practice Partner Research Network (PPRNet), a practice-based research network among users of a common electronic medical record (EMR; Practice Partner Patient Records, Seattle, Wash), evaluated the impact of a multicomponent intervention and improvement model intended to enhance adherence with clinical practice guidelines across 8 broad clinical areas including diabetes mellitus in primary care practice. The multimethod intervention included regular audit and feedback, practice site visits for academic detailing and QI facilitation, and network meetings for sharing best practices. Each intervention, individually and through synergies between them, was designed to help practices adopt a QI model (PPRNet-QI) shown in previous work to improve the translation of cardiovascular disease guidelines into primary care.[9] PPRNet-QI has 5 components: prioritizing performance, involving all staff, redesigning delivery systems, activating patients, and greater use of EMR tools.[10] PPRNet-QI is consistent with the existing literature on QI[3] and is similar to other improvement models.[5,11]

Table 1

Study Indicators

Process measures
Measurement of glycosylated hemoglobin in prior 6 mo
Measurement of blood pressure in prior 6 mo
Measurement of LDL cholesterol in prior 12 mo
Measurement of HDL cholesterol in prior 12 mo
Measurement of triglycerides in prior 12 mo
Measurement of urinary microalbumin in prior 12 mo
Prescription of antiplatelet therapy in patients older than 40 y
Prescription of ACE inhibitor or ARB in patients with hypertension
Outcome measures
Most recent glycosylated hemoglobin <7%
Most recent BP measurement <130/80 mm Hg
Most recent LDL cholesterol <100 mg/dL
Most recent HDL cholesterol >45 mg/dL
Most recent triglycerides <150 mg/dL

LDL = low-density lipoprotein; HDL = high-density lipoprotein; ACE = angiotensin-converting enzyme; ARB = angiotensin receptor blocker; BP = blood pressure.

RESEARCH DESIGN AND METHODS

The study is a subanalysis of a larger demonstration project intended to improve adherence with clinical practice guidelines for a broad spectrum of conditions and preventive services recommendations in more than 100 primary care practices across the United States. The demonstration project is termed Accelerating the Translation of Research Into Practice (A-TRIP) and was approved by the Institutional Review Board at the Medical University of South Carolina. This report will focus on the diabetes care components of A-TRIP.

Study Indicators

The study indicators for the diabetes care component of A-TRIP, listed in Table 1, are based on recommendations of the American Diabetes Association[1] and others.[12,13] Eight indicators are process measures, reflecting whether recommended tests were performed or appropriate medications prescribed. Five are outcome measures, reflecting whether patients achieved recommended treatment goals.

Audit and Feedback

Each quarter, beginning April 1, 2003, PPRNet staff sent practice-level performance reports for all A-TRIP indicators to participating practices. To determine performance, participating practices extracted patient activity during the previous

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quarter from their EMR. To protect patient confidentiality, the extract program assigned a unique, anonymous numerical identifier to each patient. The extract program obtained demographic information such as age, race, gender, diagnoses, medications, laboratory data, and vital signs. The texts of progress notes, consultation reports, and discharge summaries were not extracted.

The data were sent electronically via a secure server through the EMR vendor to PPRNet. In the PPRNet offices, project investigators applied standard data dictionaries to the raw data and used SAS (Statistical Analysis System, Cary, NC) for data set maintenance and report preparation. The reports showed, for each measure, a practice's historical performance, current performance, the median performance of all PPRNet practices, the PPRNet benchmark, and, when available, national benchmarks. Reports used statistical process control techniques to help practices assess time trends.

PPRNet benchmarks were based on achievable benchmarks of care (ABCs).[14] ABCs roughly correspond to the 90th percentile among all practices; however, they are not unduly influenced by practices with relatively small numbers of patients. PPRNet staff mailed printed practice-level reports and electronically posted each report on a secure Web site for practices to access. Beginning in October 2004, patient-level reports also were provided on the secure Web site. These reports included tools to find patients with diabetes who were not current with process indicators or at clinical targets for outcome measures. Since the PPRNet reports do not include patient identifiers, practices were provided with an EMR-based utility to identify specific patients.

Practice Site Visits

Beginning in October 2003, interested practices hosted half-day practice site visits by 1 or more members of the research team. One site visitor was a physician (SO or STC) or clinical pharmacist (AMW) with expertise in clinical care, academic detailing,[15] and the use of the Practice Partner EMR. At some site visits to larger practices, a nurse (LSN) who is a QI expert also attended. Practices were asked to have all members participate in the site visit including providers, nurses, medical assistants, receptionists, and administrative personnel. Because of vacation or hospital coverage responsibilities, some providers from multiprovider practices were occasionally absent, and some practices involved only a few staff members. At the initial site visit, a detailed introduction to the project, the rationale for QI in primary care, and the PPRNet-QI model were introduced. The site visitors then reviewed the practice's most recent performance report and worked with practice members to identify indicators they wished to target for improvement and aspects of the PPRNet-QI model they wanted to adopt to effect improvement. Subsequent half-day site visits were held approximately every 6 months. Most of the visits were conducted in person, although some were held using Internet-based conferencing tools (Live Meeting; Microsoft Corporation, Redmond, Wash). At each visit, brief project updates and academic detailing information were provided, but most of the visit was dedicated to participatory planning activities. These activities included review of the most recent practice report, highlighting successful improvements, and opportunities for future improvement. The planning session also involved practice members identifying specific clinical indicators they wished to work on and improvement activities to conduct before the next site visit.

Network Meetings

In July 2003 and 2004, network meetings were held. Two major activities occurred at these meetings. The first activity was best practice presentations by network members who had been particularly successful in implementing the PPRNet-QI model and improving their performance on practice reports. The second activity was small-group workshops, in which participants with similar roles in their practices (eg, clinicians, nurses, office staff) met to exchange useful approaches. The network meetings were intended to promote rapid diffusion of successful techniques as the different sites shared ideas.

SETTING/PARTICIPANTS

Study Practices

Practices included in this report are those that sent complete diagnostic, laboratory, and vital sign data for both the January 1, 2004, and July 1, 2005, reporting periods. Some of these practices joined PPRNet after January 1, 2004, and did not receive their first performance report at that time but had data for this time period at the time of their initial data extract.

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Study Patients

The analyses for this report are for all active patients at least 18 years of age with a diagnosis of diabetes. An active patient was defined as one with a progress note in the EMR associated with an office visit within the prior 12 months. A diagnosis of diabetes included more than 6000 different terms listed in the EMR on the major problem list, other problem list, or diagnosis list. These terms included standard diagnostic nomenclature but also abbreviations such as "AODM," "DM," "DM2," and others.

MEASUREMENTS

All outcomes used in the analyses were expressed at the practice level. For each practice, 13 proportions were calculated that corresponded to the 13 study indicators. For each study indicator, the proportion corresponded to the percentage of diabetes patients in that practice who had met that study indicator's target. In addition to the 13 specific study indicator outcomes, a summary measure was constructed for each practice. This summary measure, called the Diabetes Summary Quality Index (Diabetes-SQUID), reflected the average percentage of the 13 targets met by patients in that practice.

Statistical Analyses

Statistical analyses were performed using SAS version 9.0 (SAS Institute, Inc, Cary, NC). For the primary analyses, we calculated practice-level performance for each measure and Diabetes-SQUID at baseline and follow-up and compared changes by paired t tests. For the secondary analysis, monthly Diabetes-SQUID measures were calculated for each practice. A general linear mixed regression model was used to assess the relationship between the Diabetes-SQUID and a number of practice-related demographic variables (ie, average age of patients with diabetes, percentage of patients with diabetes who were male, percentage of patient population with diagnosis of diabetes) and the extent of participation in the A-TRIP project (ie, indicators for the receipt of a 2004 practice report, a site visit prior to 2004, a site visit in 2004, and network meeting participation in 2004). The model incorporated random practice effects with an autoregressive (type I) error structure to adjust for practices' measures that were correlated over time. The significance of 2-way interaction effects (between the variables of interest and time) were of primary focus and determined whether certain practice characteristics were significantly associated with improvements in the Diabetes-SQUID over time.

RESULTS

Participating Practices and Patients

Sixty-six practices from 33 states were included in the analyses. As of July 1, 2005, these practices included 372 clinicians (ie, 290 physicians, 38 physician assistants, 44 nurse practitioners). Forty-nine were family medicine practices, and 17 were internal medicine practices. Thirteen (20%) of the practices were from the Northeast (Connecticut, Maryland, New Jersey, New York, Pennsylvania, Rhode Island, Vermont), 19 (29%) from the South (Alabama, Arkansas, Florida, Kentucky, North Carolina, South Carolina, Tennessee, Texas, Virginia), 14 (21%) from the Midwest (Iowa, Illinois, Indiana, Michigan, Missouri, Nebraska, Ohio, Wisconsin), and 20 (30%) from the West (Alaska, Arizona, California, Colorado, New Mexico, Nevada, Oregon, Idaho, Washington). Eighteen (27%) of the practices had 1 or 2 clinicians, 19 (29%) had 3 or 4 clinicians, 22 (33%) had 5 to 9 clinicians, and 7 (11%) had 10 or more clinicians. These practices had 299 343 active patients at least 18 years of age on January 1, 2004, 20 869 (7.0%) of whom had a diagnosis of diabetes mellitus. On July 1, 2005, they had 312 104 active patients at least 18 years of age, 24 250 (7.8%) of whom had a diagnosis of diabetes mellitus. The average age of the diabetes patients was 60.3 years (SD = 14.8), and 47.6% of were male.

Participation in Project Activities

Sixty of the 66 practices (91%) received practice reports in both 2004 and 2005; the remaining 6 joined PPRNet and received their first report after January 1, 2005. Thirty-six of the practices (55%) hosted 1 or more site visits in 2004, and 24 of the practices (36%) participated in the 2004 network meeting.

Changes in Performance for Study Indicators

The average Diabetes-SQUID was 50.6% on January 1, 2004 (10th percentile 36.5%, 90th percentile 63.0%). On July 1, 2005, the average

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Table 2

Performance for Study Indicators at Baseline (January 1, 2004) and Follow-up (July 1, 2005) Among 66 Practices

	% of Patients at Targets Among Practices						Absolute Change in % of Patients at Target Between Jan 1, 2004, and Jul 1, 2005			
	Jan 1, 2004 (n = 20 869)			Jul 1, 2005 (n = 24 250)						
	Mean	10th Percentile	90th Percentile	Mean	10th Percentile	90th Percentile	Mean Change	SD	95% Confidence Interval	*P* Value*
Process measures										
Glycosylated hemoglobin in prior 6 mo	56.1	20.1	74.8	62.2	45.5	78.2	6.0	14.5	0.3, 9.6	<.0001
Blood pressure in prior 6 mo	80.0	72.6	90.5	83.5	75.5	90.9	3.5	12.2	0.5, 6.5	.023
LDL cholesterol in prior 12 mo	64.9	42.8	83.7	74.9	56.9	90.2	10.0	16.2	6.0, 14.0	<.0001
HDL cholesterol in prior 12 mo	66.1	44.2	83.8	75.1	57.5	90.5	9.1	16.0	5.1, 13.0	<.0001
Triglycerides in prior 12 mo	66.2	44.6	83.7	75.2	57.6	90.7	9.0	16.4	5.0, 13.1	<.0001
Urinary microalbumin in prior 12 mo	21.8	0.0	51.4	29.5	0.0	64.5	7.7	14.3	4.2, 11.2	<.0001
Prescription of antiplatelet therapy in patients >40 y	30.6	11.6	51.0	44.8	16.4	72.4	14.1	16.1	10.2, 18.1	<.0001
Prescription of ACE inhibitor or ARB in patients with hypertension	71.2	57.5	82.1	72.9	63.3	81.9	1.7	7.9	−0.2, 3.6	.085
Outcome measures										
Most recent glycosylated hemoglobin <7%	46.8	30.3	64.2	51.0	37.1	64.4	4.3	12.1	1.3, 7.2	.006
Most recent BP measurement <130/80 mm Hg	52.5	40.7	65.9	58.8	44.9	73.2	6.3	10.4	3.8, 8.9	<.0001
Most recent LDL cholesterol <100 mg/dL	38.9	19.3	55.1	51.9	35.8	66.0	13.0	9.4	10.7, 15.3	<.0001
Most recent HDL cholesterol >45 mg/dL	34.7	19.4	50.1	40.5	24.5	53.2	5.8	12.7	2.7, 9.0	<.001
Most recent triglycerides <150 mg/dL	36.0	16.7	51.0	45.0	33.6	58.9	9.0	11.9	6.0, 11.9	<.0001
Diabetes Summary Quality Index	50.6	36.5	63.0	58.4	47.6	69.7	7.8	7.8	5.9, 9.7	<.0001

LDL = low-density lipoprotein; HDL = high-density lipoprotein; ACE = angiotensin-converting enzyme inhibitor; ARB = angiotensin receptor blocker; BP = blood pressure.
**P* values are based on paired *t* tests.

Diabetes-SQUID was 58.4% (10th percentile 47.6%, 90th percentile 69.7%). The 18-month improvement in the median Diabetes-SQUID was 7.8% (95% confidence interval [CI], 5.9%-9.7%).

Statistically significant improvement occurred for 7 of 8 process measures and all 5 outcome measures (Table 2). The only measure that did not improve was prescription of angiotensin-converting enzyme inhibitors or angiotensin receptor blockers in patients with coexisting hypertension. Ranked by effect size, the greatest statistically significant improvements (more than 10%) occurred in documentation of prescriptions for antiplatelet therapy and control of LDL cholesterol. The smallest statistically significant improvements (<5%) were for recent blood pressure measurement and glycosylated hemoglobin control. Improvements in other measures were between 5% and 10%.

In the general linear mixed regression model, practices that attended the 2-day 2004 PPRNet network meeting had significantly ($P = .041$) greater improvements in the Diabetes-SQUID than those that did not. Practices that attended the 2004 network meeting exhibited an average change of 9.2% (95% CI, 7.0%-11.4%) in their Diabetes-SQUID scores, compared to an average improvement of 6.3% (95% CI, 4.6%-8.0%) among practices that did not attend the network meeting. None of the other practice characteristics (ie, proportion of total adult patient population with diagnosis of diabetes, average age of

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patients with diabetes, percentage of patients with diabetes who were male, hosting practice site visits, practice specialty, and practice size) were associated with significant improvement over time.

DISCUSSION

The findings presented in this report suggest that independent primary care practices participating in a QI project involving performance reports, occasional practice site visits, and annual network meetings can improve the extent to which their patients with diabetes mellitus receive recommended monitoring and treatments and achieve clinical targets for glycosylated hemoglobin, lipid measures, and blood pressure. The improvements occurred over a relatively short period of time and across a broad spectrum of indicators. Performance improved for practices performing at a range of levels at baseline, as there were comparable increases in the mean, 10th percentile, and 90th percentile measure of the Diabetes-SQUID.

The findings further suggest that participation of these types of practices in QI research is facilitated by interventions that are relatively simple to do, provide a tangible benefit for the practice, and can be titrated in intensity based on the particular needs and interests of the practice. Unlike manual chart audits, the reports provided in this project were highly automated, involving a few minutes of practice staff time each quarter. Tangible benefits included the reports, continuing medical education credit for participating in practice site visits and network meetings, and limited financial support to attend the network meetings. Participation in practice site visits and network meetings was voluntary, enhancing the acceptability of the project to a broad spectrum of practices. Site visits provided by individuals not a part of the practice environment or community may provide a new perspective to practice staff, offering the opportunity for staff development. The inclusion of all staff at these visits may reduce barriers to adoption of the model for improvement by increasing buy in and the consideration of alternative approaches to what the practice considers routine. Finally, a QI intervention for diabetes mellitus, a condition so prevalent in primary care[16] and contributing greatly to both practice workload and patient morbidity,[17] may be a natural attractor for primary care clinicians.

The importance of feasible and customizable QI interventions cannot be overemphasized, even for prevalent and morbid conditions. In another study of QI for diabetes, O'Connor et al had difficulty recruiting practices for his trial and had minimal impact on diabetes process and outcome measures.[6] Participating practices had to take part in extensive training, previsit chart preparation, and manual development of diabetes registries but paid little attention to overcoming clinical inertia or activating patients. In our study, regular audit and feedback helped practices overcome the denial that can be a component of clinical inertia, and the diabetes registries were developed through ongoing EMR documentation of office encounters. Practices could then focus on care improvement and less on data management. The limitations of single improvement approaches, even those based on information technology, were also demonstrated in 2 other recent trials.[7,8] Although EMR-based reminders at the point of care are a component of the PPRNet-QI and are relatively easy to use, we believe providers react differently to these tools and, consequently, adoption is variable. A multicomponent model for improvement allows providers to adopt the components with which they are most comfortable.

There are several likely explanations for the improvements noted. At site visits, network meetings, and through other forms of communication, a number of practices indicated that the regular reports helped them break through the denial about the adequacy of the care they delivered and stimulated improvement efforts. Such efforts included clinician efforts to overcome clinical inertia, often cited as a cause for inadequate diabetes management in primary care settings,[18] and redesign of office practices to involve nurses and medical assistants in identifying the need for recommended services. This included increased use of nurse templates for data collection at the visit and a heightened focus on identifying all current medications the patient was prescribed and taking. Practice staff limited telephone medication refills for patients who did not meet process or outcome measures. Many practices implemented disease management protocols that required an increased frequency of visits for patients with diabetes, enabling more consistent monitoring of the applicable indicators. Some practices also adopted the use of point-of-care laboratory devices for glycosylated hemoglobin and lipid measurements. These devices increased the patient's access to these tests and allowed clinicians to act immediately on the laboratory results at the time of the patient visit,

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consistent with the most recent recommendations from the American Diabetes Association.[1] To activate patients for improved diabetes care, some practices organized group visits and/or used laboratory result letter templates within the EMR that included patient education on clinical targets. Clinical goals for treatment were reinforced to patients through the use of consistent posters and handouts that were customizable by the practice. Introduction of the patient-level reports midway through the project helped some practices focus their efforts on patients needing additional care, either in the form of more regular office visits, intensification of medical therapy in concert with recent practice guidelines, or both. Informally, investigators heard that competition with other practices played a role in a practice's improvement efforts. Although all clinicians express a desire to do what is best for their patients, the inclusion of performance targets based on ABC and provision of awards to high-performing practices at network meetings provided an additional impetus. Although a few practices participating in the study were involved in pay-for-performance programs with some of their payers, the relative rarity of these incentives mitigates against this factor as a significant contributor to the study findings.

LIMITATIONS AND CONCLUSIONS

There are 4 major important limitations of the present report. First, there was no comparison group, and it is not possible to be certain that the improvements noted among the 66 practices were due to the study interventions and not merely to secular changes occurring for other reasons. However, it is unlikely that the magnitude of the observed benefits were entirely due to secular changes. The 2004 National Healthcare Quality Report (NHQR) documented a median 1-year improvement of only 1.4% across 49 measures of ambulatory care quality, approximately one quarter of the annualized improvement in the Diabetes-SQUID.[2] Second, some of the improvement may have been due to better recording rather than improved performance. For instance, the greatest improvement occurred in documentation of antiplatelet therapy. The practice reports obtained this information from the medication section of the EMR, and some improvement in this indicator was likely due to greater clinician attention to documentation of recommended therapy in this area. However, improvement in most other areas is unlikely to have been due to better documentation. Most practices have automated laboratory interfaces that obviate the need for manual entry of laboratory results. Also, the improvements seen in actual lipid measures and glycosylated hemoglobin control could not have been due to better documentation. A third limitation is that the indicators included in this study reflect only a subset of guidelines for management of diabetes care. Other important indicators, such as provision of recommended immunizations, nutrition and physical activity counseling, and screening for diabetic neuropathy, were not assessed because of limitations in the PPRNet database. Finally, it is problematic to ascertain which components of the QI intervention were most responsible for the improvements noted. The absence of an association between hosting site visits and improvement suggests this component may not have been necessary; however, because participation in site visits was not based on random allocation, this conclusion is problematic.

Contrasts between our findings and those in other reports are problematic because of differing measurement approaches and time periods of study. However, it is likely that the performance of practices in this study is much better than national averages. The 2004 NHQR indicated that among patients with diabetes, 59% have blood pressure values less than 140/90 mm Hg.[2] In our study, the same proportion of patients had blood pressure values less than 130/80 mm Hg. Similarly, the NHQR reported LDL cholesterol control less than 130 mg/dL in 33% of patients with diabetes in contrast with the 52% less than 100 mg/dL in our study and that glycosylated hemoglobin was less than 7% in 37% of patients with diabetes, whereas our practices achieved this target in 51% of patients. These findings suggest that broader adoption of EMR and QI activities among primary care practices can improve the delivery of diabetes care.

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