Electronic Patient Registries Improve Diabetes Care and Clinical Outcomes in Rural Community Health Centers

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ABSTRACT: ***Context:*** *Diabetes care is challenging in rural areas. Research has shown that the utilization of electronic patient registries improves care; however, improvements generally have been described in combination with other ongoing interventions. The level of basic registry utilization sufficient for positive change is unknown.* ***Purpose:*** *The goal of the current study was to examine differential effects of basic registry utilization on diabetes care processes and clinical outcomes according to level of registry use in a rural setting.* ***Methods:*** *Patients with diabetes (N = 661) from 6 Federally Qualified Health Centers in rural West Virginia were entered into an electronic patient registry. Data from pre- and post-registry were compared among 3 treatment and control groups that had different levels of registry utilization: low, medium, or high (for example, variations in the use of registry-generated progress notes examined at the point-of-care and in the accuracy of registry-generated summary reports to track patients' care). Data included care processes (annual exams, screens to promote wellness, education, and self-management goal-setting) and clinical outcomes (HbA1c, LDL, HDL, cholesterol, triglycerides, blood pressure).* ***Findings:*** *The registry assisted in significantly improving 12 of 13 care processes and 3 of 6 clinical outcomes (HbA1c, LDL, cholesterol) for patients exposed to at least medium levels of registry utilization, but not for the controls. For example, the percent of patients who had received an annual eye exam at follow-up was 11%, 34%, and 38% for the low, medium, and high utilization groups, respectively; only the latter groups improved.* ***Conclusions:*** *As an initial step to achieving control of diabetes, basic registry utilization may be sufficient to drive improvements in provider-patient care processes and in patient outcomes in rural clinics with few resources.*

Diabetes is more prevalent in West Virginia, the second most rural state in the nation,[1] than in any other state or territory.[2] In 2006, the prevalence of diabetes in West Virginia was 12.1% compared to 7.5% for the United States.[2] Diabetes is a precursor to many complications, including heart disease and stroke, and is the 6th leading cause of death in the state and country.[1] West Virginia's diabetes problem is impacted through its rural geography, which limits access to health care and produces physician shortages. Patient variables also play a role, especially those associated with self-care behaviors and glycemic control such as low income and education.[3] Improving care for vulnerable populations including those who are rural-dwelling[4] is an important endeavor.

The gap between recommended care and the care patients actually receive may be greater for diabetes than it is for any other chronic disease.[5] Between 2000 and 2003, less than 48% of patients received recommended exams: A HbA1c test, a retinal exam, and a foot exam.[6] The 2006 National Healthcare Quality Report indicated that between 1999-2002, only 46% of patients with diabetes age 40 and over had their hemoglobin under control, a percentage that was statistically unchanged from 1988-1994.[6] Overall, diabetes care processes and outcomes have improved

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somewhat over the last decade,[7] but there is still much room for improvement.

Electronic patient registries can help to reduce barriers to comprehensive care, for example, by improving record-keeping and targeted care. It has even been suggested that diabetes management programs are successful in improving diabetes outcomes only when a registry is in place.[8] Most research has been conducted in urban settings or in countries with universal health care[9-11]; however, the value of electronic patient registries for management of diabetes in rural clinics is increasingly recognized as data have shown improved care processes and clinical outcomes.[12-16] In these studies, other interventions were simultaneously implemented with the introduction to the registry.[12-15,17] Interventions included mail and telephone outreach to vulnerable patients, educational materials distributed to patients and providers, and community-based activities. It is currently unclear if improvements have been driven by basic registry functioning or other ongoing interventions. Improvement in care without the expense of additional interventions is especially valuable in settings with limited resources.

A goal of our study was to examine various levels of use of an electronic registry in contexts where other planned interventions did not simultaneously occur with the onset of the registry. The electronic registry itself provides built-in intervention capabilities, but utilization of these interventions can vary by provider. The registry yields an ability to generate reports, such as progress notes with highlighted fields used to guide decision-making at the point-of-care, reports used to identify patients in need of follow-up care, and aggregate reports used as performance indicators. The current study examined the effectiveness of different registry usage levels on both patient care and clinical outcomes in rural Federally Qualified Health Centers (FQHCs) in West Virginia.

Methods

The sample of patients was from a network of 6 FQHCs in rural West Virginia that implemented an electronic patient registry to track diabetes care practices and clinical outcomes over time. Five of the 6 FQHCs were in non-metropolitan counties with Rural-Urban Continuum Codes (RUCC) greater than 3 on the 1-to-9 RUCC scale.[18] The one clinic in a metropolitan county was approximately 30 minutes outside the county's urban area, in a town with fewer than 200 people. FQHCs are nonprofit organizations, and are funded through enhanced Medicaid and Medicare payments and state subsidies.

Many FQHCs in West Virginia participated in the Health Resources and Services Administration's Health Disparities Collaborative (HDC). HDC members were introduced to and assisted with the implementation of programmatic changes in health care delivery that had been shown to be effective in improving care and patient outcomes at the national level.[19] The sample in the current study includes patients having had care influenced by the HDC (31% of sample). Membership in the HDC began during the follow-up period in this study for a few providers from 2 of the 6 health centers. In order to control for the potential confound of co-occurring interventions beyond basic registry utilization associated with HDC membership, analyses were replicated with the sample of patients who were not affiliated with the HDC sites.

The electronic patient registry implemented in these 6 FQHCs was the Chronic Disease Electronic Management System (CDEMS), developed by the Washington State Diabetes Prevention and Control Program.[20] CDEMS contains 3 main components: (1) an application used for registry maintenance and progress note generation, (2) a reporting tool used for population and patient-level data tracking and targeting of care, and (3) laboratory interfaces to eliminate the need for hand-entry of laboratory results. Training and technical support for registry users and advice in incorporating the registry into the office-flow was provided to the FQHCs by the Office of Health Services Research (OHSR), West Virginia University.

Registry construction began by importing data from health center billing or practice management systems by highlighting patients with diabetes, based on ICD-9-CM codes. These data include patient names, chart numbers, dates of birth, contact information, sex, ethnicity, insurance categories, and office visit dates. When possible, historic laboratory results for identified labs were supplied by the laboratory company that provided all lab services for these health centers. Any information that was not available for direct import (for example, services offered by providers) was manually entered into the registry following chart audits. Once registry construction was in place, these data served as baseline data for the current study.

Each FQHC maintained its own registry with updated patient information. Maintenance occurred in the following ways. First, laboratory results were downloaded daily into the registry via an interface with the laboratory company used by the FQHC and the computer server at which the registry data file is stored. Second, the progress note was reviewed and updated by the provider during the office visit. This note highlighted each patient's health profile, current medication classes, overdue services, laboratory results

that were overdue and/or outside of recommended care guidelines, as well as a graphed 24-month history of weight, blood pressure, HbA1c and lipid panel results. After the office visit, the updated progress note was forwarded to the health center personnel responsible for data entry. New information was entered into the registry, and an updated progress note was then printed and filed with the patient's chart for the provider's subsequent use.

Data for analyses were gathered by OHSR by generating a de-identified version of each health center's CDEMS data file. OHSR has agreements with each health center to obtain this data for research and quality improvement purposes. Prior to analysis, data were cleaned and reviewed for accuracy and out-of-range values. When necessary, health centers were contacted to verify specific data points and corrections were made.

Patients were included in the study if they had 2 years of continuous care, including an office visit during the year prior to registry implementation (baseline) and during the year following implementation (follow-up). No patient was included in the analyses if he or she only had baseline (N = 305) or follow-up (N = 216) data. The 2 years of continuous care during which data were collected (that is, 1 year of data from visits during baseline and 1 year of data from visits during follow-up) began at different time periods for each FQHC. Baseline data collection began on a specific date for each FQHC between August 2003 and September 2004 and continued for 1 year. Follow-up data collection began on a specific date between August 2004 and September 2005, which were dates of CDEMS implementation, and continued for 1 year. Overall, data collection lasted for 2 years for each FQHC and occurred sometime between August 2003 and September 2006.

The FQHCs were separated into 3 treatment groups based on the extent to which they had utilized CDEMS. Reviewers who were blind to the data were asked to answer the following question for each FQHC: "How well did each FQHC utilize the registry during the first year after CDEMS implementation?" on a 1-4 scale where 1 = minimal use, 2 = minimal to moderate use, 3 = moderate to maximum use, and 4 = maximum use. Ratings of 2 or 3 were collapsed into the medium registry utilization group. Reviewers reached 100% agreement of the ratings associated with the 3 treatment groups. Assigning FQHCs to low, medium, and high registry use resulted in the following: 1 low use FQHC with 70 patients, 4 medium use FQHCs with 517 patients and 1 high use FQHC with 74 patients. When FQHCs were categorized according to 2 levels (low, high) with 3 FQHCs in each level, agreement of group assignment by raters was only 67%; therefore, analyses were completed with 3 treatment groups in order to reflect the most reliable ratings of registry utilization for each FQHC.

Reviewers based their ratings of registry utilization on their own observations of staff interest and provider use of CDEMS within each FQHC. Every FQHC in this study generated progress notes from the registry in an attempt to guide patient care; however, providers were not bound to use the information from the progress note. In other words, care processes such as patient education and self-management goal setting may have resulted from information on the progress note, such as highlighted elevated laboratory values, but such care was initiated by individual providers and varied among them. In some cases, for example, personnel responsible for entering data from progress notes, which were always available in patient charts, found progress notes to be blank because providers chose to instead write patient notes in charts. In other cases, providers displayed enthusiasm about utilizing the information on the progress notes to guide patient care at the point-of-care. Providers and medical staff were also not bound to use the registry reporting tool in its fullest sense. The reporting tool offers a wide-range of special reports, such as population-level reports which detail health center-wide statistics, as well as patient-level reports used to highlight specific patients in need of care. All FQHCs submitted quarterly aggregate reports to OHSR, but accuracy in reporting and utilization of the reports varied. In the best cases, FQHCs assigned a champion of the clinic to facilitate the use of CDEMS, included CDEMS in regular office flow, held regular meetings among staff and OHSR to understand summary reports, questioned and verified statistics from reports, generated and compared individual provider reports across providers, and then, presumably adjusted care. After ongoing interaction with the staff of the FQHCs, reviewers from OHSR observed the extent to which providers displayed such behaviors and rated each FQHC accordingly.

Data analysis was conducted using SPSS for Windows, Version 15.0. For some analyses of baseline data, a mean value (eg, HbA1c) was calculated for each patient; patients may have had 1 or more data points included in this calculation and the baseline HbA1c was the mean of these patient data points. For most analyses, a 3 × 3 repeated measures ANOVA with a between-subjects factor of treatment group (low, medium, high registry utilization) and a within-subjects factor of time (the first clinical value assessed at baseline, the last or most recent clinical value assessed at baseline, and the last or most recent clinical value assessed at follow-up) was performed on clinical

Table 1. Frequency of Care Processes Provided to Patients with Diabetes (N = 661) at Follow-up (1 Year with Registry) Compared to Baseline (1 Year Prior to Registry Implementation) According to Level of Registry Utilization Observed at Follow-up

	Baseline n (%)			Follow-up n (%)		
	Low Registry Utilization (n = 70)	Medium Registry Utilization (n = 517)	High Registry Utilization (n = 74)	Low Registry Utilization (n = 70)	Medium Registry Utilization (n = 517)	High Registry Utilization (n = 74)
Completed*Annual Exams						
Foot Exam	22 (31)	180 (35)	47 (64)	5 (7)‡	286 (55)§	61 (82)
Eye Exam	22 (31)	116 (22)	14 (19)	8 (11)‡	177 (34)§	28 (38)
Dental Exam	2 (3)	19 (4)	0	0	44 (9)§	1 (1)
Screens† to Promote Wellness						
Depression	1 (1)	6 (1)	2 (3)	0	71 (14)§	6 (8)
Smoking	1 (1)	3 (1)	4 (5)	3 (4)	57 (11)§	53 (72)§
Substance abuse	0	10 (2)	0	0	41 (8)§	1 (1)
Exercise 3x per week	0	5 (1)	0	0	53 (10)§	7 (10)
Influenza immunization	18 (26)	116 (22)	28 (38)	5 (7)‡	226 (44)§	15 (20)
Pneumococcal immunization	2 (3)	29 (6)	19 (26)	1 (1)	63 (12)§	7 (23)
Education†						
Cardiovascular	0	0	0	1 (1.4)	43 (8)§	39 (53)§
Diabetes management	0	7 (1)	3 (4)	1 (1.4)	67 (13)§	60 (81)§
Nutrition	0	11 (2)	23 (31)	0	73 (14)§	41 (55)§
Self-management goal setting†	3 (4)	147 (28)	0	3 (4)	163 (32)	33 (45)

*Completed indicates completed, referred, or denied; data represent providers' objectives to offer exam to patients to the best of their ability within the setting.

†Data represent providers checking box on progress note indicating "yes" during office visit with patient. A check may indicate, for example, "Do you smoke?"

‡Frequency of follow-up care is significantly lower than at baseline, $P < .05$, with Bonferroni corrections.

§Frequency of follow-up care is significantly higher than at baseline, $P < .05$, with Bonferroni corrections.

outcomes. For follow-up data, each patient's data point was the most recent assessment recorded for that particular year because effects of registry utilization require time to occur. The time period between the first 2 time points was within a year and the time period between the last 2 time points was within the next year for each patient. Two time points at baseline separated by a period of time similar to the follow-up period allowed for control of time. Changes in clinical outcomes were not expected during the baseline period, but were hypothesized to occur during the follow-up period. McNemar's test was also used in this study. The family-wise significance level for each set of analyses was set at $P < .05$. Bonferroni corrections were made.

Results

The total number of patients meeting inclusion criteria for this study was 661. Most of the patients (95.3%) had type 2 diabetes. Patients ranged in age from 18 to 95 years old; the mean age was 60.2 years old. The majority of the cohort was female (61.9%).

Table 1 shows process outcomes. Robust improvements were detected in a number of care processes when patients were from clinics with at least medium utilization of the registry. Improvements in services offered do not simply reflect more opportunities to offer services because the total number of office visits did not increase over time.

There were significant improvements in some clinical outcomes. Table 2 shows that significantly more patients in the high utilization group had completed laboratory assessments, HbA1c and low-density lipoproteins (LDL), at follow-up than at baseline. Table 3 shows that the percentage of patients meeting American Diabetes Association (ADA) recommendations for LDL significantly increased among groups who utilized the registry at a medium or high level.

Figure 1 shows HbA1c levels worsening at follow-up for the group of patients who were affected least by the registry ($F[1, 56] = 6.63$, $P = .013$), while there were no significant changes for the medium or high treatment groups during follow-up. Analyses

Table 2. Number of Patients with Diabetes (N = 661) who Received Laboratory Assessments at Follow-up (1 Year with Registry) Compared to Baseline (1 Year Prior to Registry Implementation) According to Level of Registry Utilization Observed at Follow-up

	Baseline n (%)			Follow-up n (%)		
	Low Registry Utilization (n = 70)	Medium Registry Utilization (n = 517)	High Registry Utilization (n = 74)	Low Registry Utilization (n = 70)	Medium Registry Utilization (n = 517)	High Registry Utilization (n = 74)
Number of patients with completed laboratory						
HbA1c	65 (93)	470 (91)	52 (70)	59 (84)	459 (89)	71 (96)*
LDL	58 (83)	416 (81)	54 (73)	52 (74)	414 (80)	68 (92)*
HDL	62 (89)	414 (80)	56 (76)	55 (79)	393 (76)	68 (92)
Cholesterol	63 (90)	424 (82)	63 (84)	57 (81)	398 (77)	68 (92)
Triglycerides	62 (89)	443 (86)	61 (82)	55 (79)	418 (81)	68 (92)

*Significantly higher than baseline, $P < .05$, with Bonferroni corrections.

Table 3. Patients with Diabetes Meeting ADA* Recommendations at Follow-up (1 Year with Registry) Compared to Baseline (1 Year Prior to Registry Implementation) According to Level of Registry Utilization Observed at Follow-up

	Baseline n (%)†			Follow-up n (%)		
	Low Registry Utilization (n = 70)	Medium Registry Utilization (n = 517)	High Registry Utilization (n = 74)	Low Registry Utilization (n = 70)	Medium Registry Utilization (n = 517)	High Registry Utilization (n = 74)
ADA recommendations						
HbA1c < 7	24 (42)	217 (51)	25 (49)	21 (37)	229 (54)	26 (51)
LDL < 100	35 (80)	203 (59)	20 (41)	35 (80)	231 (67)‡	37 (76)‡
HDL						
>40 for males	7 (32)	70 (59)	3 (16)	9 (41)	69 (58)	7 (37)
>50 for females	10 (37)	86 (41)	6 (19)	9 (33)	79 (37)	8 (25)
Triglycerides < 150	18 (37)	148 (40)	24 (43)	18 (37)	172 (46)	28 (50)

*ADA indicates American Diabetes Association.
†n varies with each laboratory; percentage is calculated with the number of patients with both baseline and follow-up laboratory value.
‡Significantly higher than baseline, $P < .05$, with Bonferroni corrections.

performed included a significant simple effect test following an ANOVA with a significant interaction effect ($F[4, 1,058] = 2.48$, $P = .043$) and planned contrasts that showed the interaction occurred at follow-up versus baseline, $F(2, 529) = 4.85$, $P = .008$. Among patients with baseline HbA1c greater than 8.0%, patients who were affected by medium or high use of the registry significantly decreased their HbA1c levels, ($F[1, 87] = 5.49$, $P = .021$, $F[1, 9] = 7.69$, $P = .026$, respectively). Again, significant simple effect tests followed an ANOVA with a significant interaction effect ($F[4, 220] = 2.48$, $P = .045$) and planned contrasts that showed the interaction occurred at follow-up versus baseline, $F(2, 110) = 4.39$, $P = .015$.

Similarly, patients who were affected by medium or high use of the registry significantly decreased their LDL ($F[1, 343] = 9.43$, $P = .002$, $F[1, 48] = 16.0$, $P < .001$, respectively) and cholesterol ($F[1,343] = 6.64$, $P = .01$, $F[1,55] = 12.63$, $P = .001$, respectively) levels. LDL changes are shown in Figure 2; cholesterol followed a similar trend. Again, significant simple effect tests followed ANOVAs with significant interaction effects (LDL: $F [4, 866] = 5.07$, $P < .001$), cholesterol: ($F[4, 894] = 3.15$, $P = .014$) and planned contrasts that showed the interaction occurred at follow-up versus baseline, ($F[2, 433] = 7.19$, $P = .001$, $F[2, 447] = 4.96$, $P = .007$, respectively).

Blood pressure showed a slightly different pattern of results. Patients from the low use group ($F[1, 69] =$

Figure 1. HbA1c Significantly Increased During the Follow-Up Year for Patients Exposed to Low Registry Use, $P = .013$, but was Maintained for Patients from Federally Qualified Health Centers with Medium or High Utilization of the Registry.

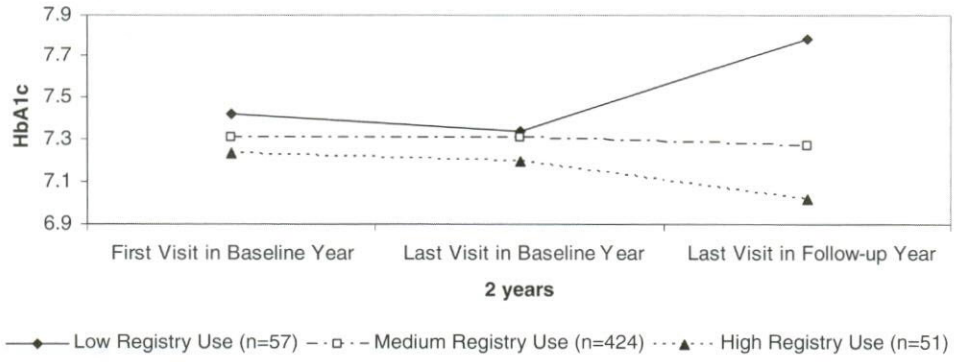
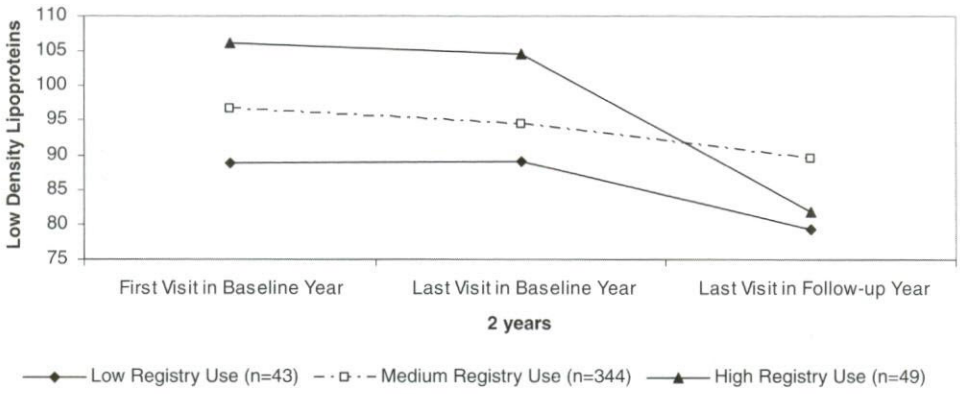


Figure 2. LDL Significantly Decreased During the Follow-Up Year for Patients from Federally Qualified Health Centers Exposed to Medium or High Registry Use, $P = .002$ and $P < .001$.



14.56, $P < .001$) and those from the high use group (F[1, 69] = 8.28, $P = .005$) improved their systolic blood pressure at follow-up. However, those from the low use group had a decrease in systolic blood pressure at follow-up that followed an increase at baseline. Simple effect tests followed a significant interaction effect, F (4; 1,294) = 4.36, $P = .002$ and planned contrasts showing that the interaction occurred at follow-up, F (2, 647) = 5.23, $P = .006$. A similar pattern of results emerged for diastolic blood pressure, but results were not statistically significant.

In an attempt to control for effects that might have been associated with parallel efforts of the HDC, analyses were repeated with a subsample of patients (N = 456) who were not in the Health Disparities Collaborative. Improvements in care processes, and all but 1 clinical outcome, HbA1c for all patients, were replicated with this smaller sample. Furthermore, a significant effect of time was found for triglycerides (F (2, 676) = 3.01, $P < .05$). Means and standard deviations were 225.26 (17.32) and 226.43 (16.71) for baseline and 200.31 (9.28) for follow-up.

Repeated measures ANOVAs with clinical outcomes were also replicated with the earliest possible data point during the follow-up period, that is, the first clinical outcome value assessed following the date of CDEMS implementation instead of the last or most recent clinical outcome value. The assumption was made that the effects of the registry would take time to occur and results from these analyses supported this

methodological assumption. Only the effect of differential registry utilization on LDL remained significant.

When analyses were replicated with 2 (low, high) versus 3 (low, medium, high) treatment groups, some statistically significant changes in clinical outcomes according to group disappeared or weakened. For example, although the low registry use group had HbA1c levels that worsened at follow-up and the high registry use group showed improvements, effects did not reach statistical significance. For LDL, the low group and the high group improved over time, but significant improvement occurred at follow-up only. For cholesterol, improvements occurred in the expected direction, but no effects over time reached significance. Results did not change substantially for care processes because improvements were nearly at the ceiling; however, the remaining care process improvement, in self-management goal setting, reached statistical significance.

In summary, evidence showed that registry utilization differentially affected outcomes according to variations in registry use. Improvements were seen in 12 of 13 care processes when the registry was used at a moderate level or higher. Monitoring of clinical outcomes improved, as evidenced by more patients with completed assessments of HbA1c and LDL following high registry utilization. There were more patients meeting ADA recommendations for LDL following medium or high registry utilization. There was evidence of HbA1c levels remaining stable, rather than getting significantly worse at follow-up, but only among those who utilized the registry at a medium or high level. There were improvements in HbA1c among patients with poor glycemic control at baseline, and cholesterol and LDL among all patients, from the medium and high utilization groups.

Discussion

Results suggest that a basic electronic registry assisted in improving care practices and clinical outcomes for patients with diabetes in FQHCs, but only when the registry was utilized at a moderate level or better. Furthermore, this study showed improvements following registry implementation without other ongoing interventions. Prior studies[12-15,17] investigating the effects of registry utilization have been complicated by intentional, co-occurring interventions that require more resources than FQHCs typically possess. The registry utilization associated with positive effects in this study was very simple. It consisted of registry maintenance with enthusiasm, the use of registry-generated progress notes that included "flags" (laboratory values and services that were highlighted because they were either overdue or outside of recommended guidelines), registry utilization at the point-of-care, and the use of registry-generated summary reports to track patients' care.

It is not clear from the results of this study if the observed improvements in care that corresponded to registry utilization are improvements initiated by the registry or improved documentation. However, where clinical outcomes also improved with care practices, the results suggest that improvements were initiated by the registry and were not simply improvements in documentation.

Improvements in clinical outcomes included the following. When FQHCs chose to utilize the registry at a moderate level or better, patients had improved cholesterol and LDL. When FQHCs chose to utilize the registry minimally, HbA1c levels got worse over time. Among patients with elevated levels of HbA1c at baseline, patients from these FQHCs also had improved HbA1c levels.

Analyses with 2 versus 3 groups proved to be less informative when understanding differential registry usage effects on clinical outcomes. Effects of the registry according to treatment group were less pronounced when the moderate registry usage group was separated into low and high groups. Overall results suggest that analyses with the FQHC that minimally used the registry allowed for significant differences in registry usage to be revealed; in other words, such classification resulted in a useful control group. It may be true that diabetes management programs are successful in improving diabetes outcomes only when a registry is in place, which has been suggested,[8] but having a registry in place is not sufficient for improvements.

In this study, some patients had providers who participated in the HDC, a national effort to improve care provided to patients with chronic conditions including diabetes. However, when analyses were limited to patients who were not directly influenced by the HDC, care practices and clinical outcomes continued to show improvement, even in a smaller sample. It is possible that the substantial influences of the HDC on care practices and clinical outcomes can extend to providers beyond those directly affected by the organization, but it is unlikely that these indirect influences would be a significant influence on the results of this study.

Although results are encouraging, especially for health centers with few resources such as rural FQHCs, we do not advocate that the patient registry alone is sufficient to achieve ideal control of diabetes. For example, this study showed that fewer than 35% and 9% of patients in the health centers had recommended

annual eye and dental exams, respectively, in the year following registry implementation; the goals of the HDC are to have at least 70% of a health center's patients have these exams completed each year.[21] On the other hand, this study was able to show improvement in clinical outcomes where other studies have failed to show improvements, for example, in LDL[12] and HbA1c.[10]

Improvements in HbA1c were more pronounced among those patients with the worst initial glycemic control. This finding is consistent with those from other studies.[8,9] Documentation, prompts, and treatment guidelines may be most valuable when patients are clinically at their worst. Additionally, examining improvement in HbA1c levels with a continuous measure, rather than reporting the percentage of patients who are in control or below some other threshold, is a measure of progress that should be used more frequently.[22]

Limitations of the study included the use of a non-randomly assigned control group and the inclusion criterion that required patients to have both baseline and follow-up care. The inclusion of patients who entered care at baseline might have inflated baseline averages because patients are likely to get better with care that occurs over time, including improvements in medication, increased caregiver attention to LDLs, exposure to West Virginia's Diabetes Prevention and Control Program, or the presence of personnel such as certified diabetes educators. Additionally, improvements in LDL initiated by the registry are made cautiously because the group that utilized the registry at a low level had the least opportunity to improve LDL levels. For example, this group had the highest percentage of patients in control at baseline and follow-up.

Overall, results suggest that basic registry utilization will drive improvements in provider-patient processes and in patient outcomes. Further research should investigate the extent to which improved care and clinical outcomes associated with the registry are a result of improved care processes initiated by registry utilization.

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