An Endocrinologist-Supported Intervention Aimed at Providers Improves Diabetes Management in a Primary Care Site

Improving Primary Care of African Americans with Diabetes (IPCAAD) 7

LAWRENCE S. PHILLIPS, MD[1]
DAVID C. ZIEMER, MD[1]
JOYCE P. DOYLE, MD[2]
CATHERINE S. BARNES, PHD[1]
PAUL KOLM, PHD[3]
WILLIAM T. BRANCH, MD[2]
JANE M. CAUDLE, MLN[1]
CURTISS B. COOK, MD[4]
VIRGINIA G. DUNBAR, BS[1]
IMAD M. EL-KEBBI, MD[1]
DANIEL L. GALLINA, MD[1]
RISA P. HAYES, PHD[5]
CHRISTOPHER D. MILLER, MD[1]
MARY K. RHEE, MD[1]
DENNIS M. THOMPSON, PHD[6]
CLYDE WATKINS, MD[2]

OBJECTIVE — Management of diabetes is frequently suboptimal in primary care settings, where providers often fail to intensify therapy when glucose levels are high, a problem known as clinical inertia. We asked whether interventions targeting clinical inertia can improve outcomes.

RESEARCH DESIGN AND METHODS — A controlled trial over a 3-year period was conducted in a municipal hospital primary care clinic in a large academic medical center. We studied all patients (4,138) with type 2 diabetes who were seen in continuity clinics by 345 internal medicine residents and were randomized to be control subjects or to receive one of three interventions. Instead of consultative advice, the interventions were hard copy computerized reminders that provided patient-specific recommendations for management at the time of each patient's visit, individual face-to-face feedback on performance for 5 min every 2 weeks, or both.

RESULTS — Over an average patient follow-up of 15 months within the intervention site, improvements in and final HbA_{1c} (A1C) with feedback + reminders (ΔA1C 0.6%, final A1C 7.46%) were significantly better than control (ΔA1C 0.2%, final A1C 7.84%, $P < 0.02$); changes were smaller with feedback only and reminders only (P = NS vs. control). Trends were similar but not significant with systolic blood pressure (sBP) and LDL cholesterol. Multivariable analysis showed that the feedback intervention independently facilitated attainment of American Diabetes Association goals for both A1C and sBP. Over a 2-year period, overall glycemic control improved in the intervention site but did not change in other primary care sites (final A1C 7.5 vs. 8.2%, $P < 0.001$).

CONCLUSIONS — Feedback on performance aimed at overcoming clinical inertia and given to internal medicine resident primary care providers improves glycemic control. Partnering generalists with diabetes specialists may be important to enhance diabetes management in other primary care settings.

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Type 2 diabetes is a public health pandemic with devastating impact on morbidity, mortality, and cost. In the U.S., the prevalence of diabetes increased from 4.9% of the population in 1990 to 7.9% in 2001 (1–4), and prevalence is projected to rise to 30 million Americans in 2030 (5). The lifetime risk of diabetes is currently projected at 33 and 38% for American men and women, respectively, born in 2000 (6), with accompanying decrease in life expectancy (6–8). Diabetes increases the risk of both microvascular (9,10) and macrovascular disease (11), and diabetes is now the sixth leading cause of death in the U.S (12). Diabetes accounted for ~11% of total U.S. health care expenditures in 2002 ($92 billion) (13), but better metabolic control can reduce costs (14).

Most diabetes management in the U.S. takes place in primary care settings, where measures of both process and outcome indicate that care is often suboptimal. Surveys in the early 1990s revealed that many Medicare beneficiaries had limited evaluation of levels of HbA_{1c} (A1C), cholesterol, or urine protein, and both dilated eye and foot examinations were infrequent (15). Although more recent studies indicate that performance measures have improved (15,16), A1C levels remain high. In the National Health and Nutrition Examination Surveys, the average A1C in patients with diagnosed diabetes rose from 7.8% in 1988–1994 to 8.1% in 1999–2000 (17).

Inadequate glycemic control and related diabetes complications are due both to patient nonadherence (18,19) and to the failure of providers to initiate or intensify therapy appropriately. We have designated the latter problem as clinical inertia (20), which may limit control of hypertension (21) and dyslipidemia (22)

From the [1]Division of Endocrinology and Metabolism, Department of Medicine, Emory University School of Medicine, Atlanta, Georgia; the [2]Division of General Medicine, Department of Medicine, Emory University School of Medicine, Atlanta, Georgia; the [3]Division of Cardiology, Department of Medicine, Emory University School of Medicine, Atlanta, Georgia; the [4]Department of Medicine, Mayo Clinic, Scottsdale, Arizona; [5]Eli Lilly, Indianapolis, Indiana; and the [6]Department of Educational Psychology and Special Education, Georgia State University, Atlanta, Georgia.

Address correspondence and reprint requests to Lawrence S. Phillips, MD, General Clinical Research Center, Emory University Hospital, Room GG-23, 1364 Clifton Rd., Atlanta, GA 30322. E-mail: medlsp@emory.edu.

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Abbreviations: ADA, American Diabetes Association; GEE, generalized estimating equation; IPCAAD, Improving Primary Care of African Americans with Diabetes; sBP, systolic blood pressure.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

as well as diabetes (23–27). At Grady Memorial Hospital in Atlanta, there was more clinical inertia and A1C levels were higher in the general medicine primary care clinic as compared with the diabetes specialty clinic (28). Differences in apparent clinical inertia might be due to the reluctance of primary care providers to intensify therapy for patients who seem unmotivated, but we believe the differences also reflect prior quality improvement efforts in the specialty clinic that reduced clinical inertia and lowered A1C levels (29). Consistent with a role for clinical inertia, those providers in the primary care clinic who had less clinical inertia also had patient populations with lower A1C levels (30). These findings in combination suggested that diabetes management in primary care settings might be improved by targeting clinical inertia and translating diabetes specialist strategies to allow implementation by generalists.

We have tested these hypotheses in the Improving Primary Care of African Americans with Diabetes (IPCAAD) study, a controlled trial based on a novel partnership of generalists with specialists (31). Internal medicine residents (generalist physicians in training) were randomized with a 2 × 2 factorial design to the control or to one or both of the two endocrinologist-supported interventions. The interventions utilized strategies proven capable of changing physician behavior (32–40) and involved *1)* computerized decision support reminders that provided individualized recommendations for management at the time of patient visits and/or *2)* face-to-face, individualized feedback on performance in 5-min sessions every 2 weeks. The impact of these interventions on outcomes of major clinical importance, such as primarily levels of A1C, was assessed prospectively over a period of 3 years.

RESEARCH DESIGN AND METHODS

The IPCAAD study was approved by the Emory University Institutional Review Board for conduct without informed consent of patients or written consent from physicians. The study was based in the Grady Medical Clinic, the largest site of primary care in the Grady Health System, which serves an economically disadvantaged municipal population (41). The Medical Clinic has roughly 60,000 patient visits per year and is staffed by internal medicine residents, nurse practitioners, physician assistants, attending physicians, pharmacists, nutritionists, health educators, and social workers. About two-thirds of the patients are cared for by residents who attend their continuity clinic one-half day per week throughout postgraduate training. During each visit, such patients are seen first by the resident and then by a faculty member who finalizes the plan for management. The IPCAAD study focused on type 2 diabetic patients of residents supervised by Emory Division of General Medicine faculty members.

Beginning in July 1999 and continuing through December 2002, all Medical Clinic patients who self-identified as having diabetes were directed to a research assistant who assigned a diagnosis of type 2 diabetes on the basis of prespecified clinical criteria. At each visit, the research assistants measured weight, blood pressure, and capillary glucose levels and entered information into a database. Appropriate orders for laboratory measurements according to American Diabetes Association (ADA) guidelines (A1C and fasting lipid profiles) were placed in all charts to limit the possibility of confounding by differences in process. At the end of the visit, additional information included the recorded incoming and outgoing medications and the blood pressure if repeated by the resident. If the patient presented to a clinic unit where the reminders intervention was conducted, the research assistant printed out an updated computerized reminder and placed it on the top of the chart at the beginning of the visit.

Interventions

From 1999 through 2002, all residents (including all intervention arms) and faculty members were given yearly orientations about the trial and yearly lectures about management of type 2 diabetes; the importance of early provider action was emphasized. Each year, all residents were also given pocket cards that reiterated treatment goals and therapeutic thresholds and sent letters that provided feedback about the completeness of their visit notes.

Computerized reminders. Decision support included both a flowsheet to show sequential laboratory values, weight, blood pressure, and use of medications and recommendations for treatment and was provided for 85% of visits of patients in the Reminders groups; residents in this group acknowledged in anonymous questionnaires that they had received the reminders. The recommendations for management of hyperglycemia, hypertension, and dyslipidemia were based on IPCAAD algorithms developed by the endocrinologist and generalist leaders of the study and confirmed for clinical acceptability; use of the hyperglycemia algorithm in the diabetes clinic improved attainment of A1C goals (A1C <7%) (42). The algorithms took into account each patient's medications (as prescribed at the previous visit) and recent laboratory/clinical values (≥1 week before the visit) and recommended changes in dosage of current medications and/or new medications. Such individualized features are thought to make it most likely that providers will respond appropriately (32–40,43).

Feedback on performance. Feedback sessions between one of the endocrinologists and a resident were ~5 min in duration and scheduled every 2 weeks; missed sessions were made up later, and feedback was provided overall for 97% of scheduled sessions. The sessions specifically avoided consultative advice on management. Instead, feedback was based on IPCAAD report cards that showed individual provider actions or outcomes of the patients seen by that provider but did not identify specific patients. Emphasis was placed on achieving ADA goals (44) and on acting when values were abnormal during visits, i.e., random capillary glucose >150 mg/dl or systolic blood pressure (sBP) >130 mmHg. We have found such glucose values to be highly predictive of A1C >7% (45) and intensification of therapy based on such values to be associated with very little risk of severe hypoglycemia (46). (Home glucose monitoring data are frequently not available; only 24% of visits in one Grady primary care site had data brought in [47].) The sessions were designed to be interactive and were scripted to elicit responses from the residents. Such "active" features are thought to be important in adult learning and should help change provider behavior (48,49).

Design

Patients were accrued from 19 July 1999 to 31 December 2002, the intervention was conducted from 1 January 2000 to 31 December 2002, and outcomes were examined for all visits throughout the study period. In a 2 × 2 factorial design, the unit of randomization was the resident; residents were either control subjects or received computerized reminders, feedback on performance, or both interven-

tions. When residents completed their postgraduate year 3, their patients were reassigned to a resident receiving the same intervention. Logistics demanded that a given intervention arm be conducted in only one half-day clinic at a time and in either clinic module I or II, adjacent clinic units each with its own waiting area, check-in desk, offices, exam rooms, etc.; module III involves faculty and residents from another medical school. Accordingly, the 20 module/half-days were divided by five for each intervention arm and assigned randomly but constrained according to stratification rules: feedback in only one site at a time, reminders in only one site at a time, and balanced distribution morning/afternoon.

We also anticipated that there would be contamination among intervention arms (discussions among residents and faculty regarding reminder recommendations and feedback content). Accordingly, to determine whether the intervention(s) were robust, we also compared outcomes within the intervention sites to those in nonintervention primary care sites within the same health system; there was no rotation of attendings or residents between the two groups of sites. Using uniform ascertainment algorithms based on current procedural terminology codes (to assure comparable accuracy and completeness of data), A1C values for patients in Medical Clinic modules I and II (intervention sites) were compared with values from Medical Clinic module III and two faculty-staffed sites, the Dekalb-Grady Neighborhood Heath Center and the Northwest Grady Neighborhood Heath Center. These analyses included all patients (those seen by residents, nurse practitioners, faculty members, etc.); data from the other primary care sites were only available from the hospital database for 2001–2002. We assigned a specific clinic to a patient if at least 80% of that patient's visits were in that particular clinic.

Analysis

Clinical and laboratory data from all visits were maintained in a relational database (Oracle, Redwood City, CA). Blood pressure was measured with Dinamap instruments (Critikon, Tampa, FL), and A1C and lipids were measured with the Hitachi 717 (Boehringer Mannheim, Indianapolis, IN). Capillary glucose was measured with the MediSense Precision PCx Point-of-Care System (Abbott Laboratories, Bedford, MA). Glucose was defined as random if determinations were <5 h since the previous meal and fasting otherwise. In the resident report cards, 25 mg/dl was added to fasting glucose levels to render them comparable to random glucose; the relationship between A1C and random glucose is similar to that between A1C and (fasting glucose + 25 mg/dl) (50).

Statistics

The limitations associated with trials conducted in usual care settings precluded evaluation simply on the basis of intention to treat. Patients were enrolled continuously after 1 July 1999 and followed through 31 December 2002 but did not always have laboratory tests as scheduled, and some patients dropped out and/or returned on days when their assigned intervention was not being conducted. Although 95% of the study patient visits were with residents and 70% of study visits were within the assigned intervention arm, only 42% of patients saw only their assigned resident at all of their visits. Our analysis (below) was designed to accommodate such limitations.

Linear mixed model multivariable regression analyses were conducted to account for the multilevel nature of the data: patients nested within residents nested within clinic units, which adjusted for differences in the diabetes knowledge/interest of different groups of attendings. The analyses utilized all available data, and the data were structured such that patient outcomes at a given time were associated with the resident seen on the previous visit (because provider actions at a given visit could only affect outcomes following the visit). The intervention arm responsible for a given sBP for each patient was assigned as that of the resident seen at the previous visit, and baseline pressure was taken as that at each patient's first visit during the trial. A1C and LDL values were assigned as associated with a given visit if obtained >14 days but <6 months following the visit; baseline values were taken as those obtained from 6 months before 14 days following a patient's first visit. We assumed a first-order autoregressive correlation structure for the variance-covariance matrix of repeated observations over the study period and assumed that missing values were missing at random.

Patients within residents within modules was included as a random effect in the regression models to account for potential clustering effects due to exposure to different endocrinologists and Medical Clinic faculty members. The regression model was then used to calculate a predicted baseline and end-of-study mean outcome for each treatment arm adjusted for patient characteristics of age, sex, race, BMI, length of time a patient had diabetes, as well as the number of medical clinic and diabetes clinic visits and duration of exposure to the intervention. Adjusted outcome means were calculated for a typical patient, i.e., the mean of the patient characteristic and clinic visit variables. Findings from such analyses that included all patients and all available data were consistent with findings from examination of the 2,124 patients who met conservative criteria for assessment (≥3 visits, ≥6 months of follow-up, ≥50% of visits seen by residents) (data not shown).

Attainment of ADA goals was analyzed by a generalized estimating equation (GEE) approach to longitudinal binary data. This approach was used because it provides consistent and asymptotically normal estimates of regression parameters even if the covariance structure of the repeated binary observations is misspecified (51). Patients within residents within modules was included as a random effect to account for the clustered nature of the data. Odds ratios were used to express the effects of the interventions, the covariates (above), and an additional covariate, the value of A1C, sBP, and LDL associated with the patient's first Medical Clinic visit in the intervention period.

For both the linear mixed and GEE models, the intervention arms were dummy coded (1/0), and thus their coefficients in the model tested the hypothesis of a difference from the control arm. Specifically, the linear mixed model coefficients tested the hypothesis of a decrease in absolute A1C, sBP, or LDL values and the GEE models an increase in the odds of attaining goals in the intervention arms compared with the control arm.

For the comparison of intervention versus nonintervention sites, unpaired *t* tests were used to compare outcome means for patients in Medical Clinic modules I and II with those in the other clinics at 6-month intervals. Trends over time were assessed using linear mixed effects regression.

The statistical analyses were conducted using S-Plus, version 6 (Insightful, Seattle, WA) and STATA, version 7 (STATA, College Station, TX).

Table 1—*Characteristics of all randomized controlled trial study patients and intervention groups at the time of their first Medical Clinic visit with a participating resident*

	All patients	Control	Reminders	Feedback	Feedback + reminders	*P* value
n (%)	4,138	983 (24)	1,043 (25)	1,049 (25)	1,063 (26)	0.305
Age (years)	59 ± 13	59 ± 12	59 ± 12	58 ± 12	58 ± 12	0.745
Sex (% female)	67	66	68	67	68	0.890
African American (%)	94	93	94	94	93	0.939
BMI (kg/m^2)	33 ± 8	33 ± 8	33 ± 8	33 ± 8	33 ± 9	0.635
Length of disease (years)	9 ± 9	9 ± 9	9 ± 9	9 ± 9	9 ± 9	0.968
Follow-up (months)	15 ± 13	14 ± 12	15 ± 13	15 ± 13	15 ± 13	0.007*
Medical Clinic visits	6 ± 5	6 ± 5	6 ± 5	7 ± 6	6 ± 5	<0.001†
Diabetes Clinic visits	2 ± 3	2 ± 3	2 ± 3	2 ± 3	2 ± 3	0.304
A1C (%)	8.1 ± 2.2	8.2 ± 2.4	8.0 ± 2.2	8.1 ± 2.3	8.1 ± 2.4	0.833
sBP (mmHg)	140 ± 23	141 ± 23	140 ± 22	140 ± 23	141 ± 22	0.595
LDL cholesterol (mg/dl)	118 ± 40	120 ± 42	117 ± 38	116 ± 38	118 ± 43	0.246

Data are means ± SD. *Control group less than all other groups; †control group less than feedback only. Visit number shows the total number of visits during follow-up of each patient beginning with the date of initial accrual into the study.

RESULTS

Characteristics of residents and patients participating in the randomized controlled trial

The 345 residents averaged 27 ± 3 years of age, 35% were female, 58% were non-Hispanic White, and 8% were African American. The 4,138 patients with type 2 diabetes seen by the residents during the study period had average age 59 years, were 67% female and 94% African American, had average duration of diabetes 10 years and BMI 33 kg/m^2, and had baseline sBP 140 mmHg, A1C 8.1%, and LDL cholesterol 118 mg/dl (Table 1). At entry, there were no significant differences among patients assigned to residents in different intervention arms. The control patients had slightly shorter follow-up than the other groups and fewer Medical Clinic visits than the feedback-only group; our analysis adjusted for the impact of such differences (below). Of the 4,138 patients, all had age, sex, and race information available. Six percent were missing BMI values, and 2.7% were missing duration of disease. With respect to outcome variables, 98.5% had valid sBP values, 84.8% valid A1C values, and 70.6% had valid LDL values.

Impact of the interventions

We utilized a linear mixed models analysis to permit inclusion of all of the data. Table 2 shows model-predicted baseline and end-of-study values for patients who saw residents in the different intervention arms; the values are shown adjusted for differences in age, sex, race, BMI, known duration of diabetes, length of follow-up, clustering, and number of medical clinic and diabetes clinic visits (it was not possible to exclude the option of visits to the latter clinic). During the study, improvement of A1C with feedback + reminders (0.6%) was significantly greater than in the control group (0.2%, $P < 0.02$). A1C also improved significantly with both feedback only (−0.4%) and reminders only (−0.3%), but end-of-study values in these groups were not significantly different from the control group. sBP also improved significantly with both feedback + reminders (−3.4 mmHg) and feedback only (−3.2), but did not change significantly with either reminders only (+1.2) or in the control arm (−2.4). LDL cholesterol improved significantly with all of the intervention arms, but the change was greatest with the feedback + reminders arm (−18 mg/dl).

Multivariable analysis of the independent contribution of the interventions

In order to adjust for potential differences in group characteristics, we evaluated the independent contributions of the inter-

Table 2—*Linear mixed effects fully adjusted* model-predicted outcomes at baseline and end of study for randomized controlled trial patients with visits to residents in the different intervention arms*

	Adjusted*		*P*	
	Baseline	End of study	Within group	Control
A1C (%)				
Control	8.00	7.84	0.1991	
Reminders only	7.99	7.69	0.0134	0.3439
Feedback only	7.98	7.58	0.0002	0.1523
Feedback + reminders	8.02	7.46	<0.0001	0.0140
sBP (mmHg)				
Control	138.19	135.77	0.0554	
Reminders only	135.73	136.93	0.3477	0.0544
Feedback only	137.05	133.87	0.0084	0.5693
Feedback + reminders	138.36	134.96	0.0037	0.5872
LDL cholesterol (mm/dl)				
Control	121.94	106.49	<0.0001	
Reminders only	119.24	104.01	<0.0001	0.9413
Feedback only	119.08	104.94	<0.0001	0.8029
Feedback + reminders	121.63	103.43	<0.0001	0.6028

*Adjusted for differences in age, sex, race, BMI, known duration of diabetes, length of follow-up, clustering, and number of medical clinic and diabetes clinic visits. *P* values vs. control compare differences with changes in values in the control group.

Table 3—*Effects on attainment of ADA goals for A1C (<7%), sBP (<130 mm Hg), and LDL cholesterol (<100 mg/dl): logistic regression analysis (based on GEE) that considered nesting of randomized controlled trial patients at both the clinic and physician level*

Variable	Odds ratio	95% CI		*P*
A1C goal				
Age (10-year increments)	1.2068	1.1533	1.2628	<0.001
BMI (10-kg/m^2 increments)	0.8866	0.8366	0.9396	<0.001
Length of disease (10-year increments)	0.7661	0.7277	0.8066	<0.001
Female sex	0.9165	0.8222	1.0217	0.116
African American	0.9133	0.7367	1.1323	0.408
Medical clinic visits	0.9930	0.9836	1.0025	0.147
Diabetes clinic visits	1.0270	1.0140	1.0402	<0.001
Baseline A1C (1% increments)	0.4934	0.4653	0.5232	<0.001
Length of follow-up (1-year increments)	1.1571	1.1042	1.2126	<0.001
Reminders	0.9797	0.8582	1.1185	0.762
Feedback	1.1762	1.0311	1.3416	0.016
Reminders × feedback (interaction term)	0.9900	0.8225	1.1917	0.916
sBP goal				
Age (10-year increments)	0.8387	0.8101	0.8682	<0.001
BMI (10-kg/m^2 increments)	0.8368	0.7991	0.8762	<0.001
Length of disease (10-year increments)	0.9142	0.8781	0.9518	<0.001
Female sex	0.9411	0.8669	1.0217	0.148
African American	0.6585	0.5621	0.7715	<0.001
Medical clinic visits	0.9885	0.9808	0.9962	0.003
Diabetes clinic visits	1.0678	1.0580	1.0778	<0.001
Baseline sBP (10-mmHg increments)	0.7499	0.7353	0.7648	<0.001
Length of follow-up (1-year increments)	1.1119	1.0669	1.1587	<0.001
Reminders	1.0426	0.9378	1.1592	0.440
Feedback	1.1885	1.0723	1.3174	0.001
Reminders × feedback (interaction term)	0.9179	0.7946	1.0602	0.244
LDL goal				
Age (10-year increments)	1.0766	1.0223	1.1339	0.005
BMI (10-kg/m^2 increments)	0.9815	0.9152	1.0526	0.602
Length of disease (10-year increments)	1.0191	0.9562	1.0862	0.560
Female sex	0.7620	0.6716	0.8646	<0.001
African American	0.8340	0.6473	1.0746	0.160
Medical clinic visits	1.0239	1.0113	1.0366	<0.001
Diabetes clinic visits	1.0432	1.0260	1.0607	<0.001
Baseline LDL (10-mg/dl increments)	0.6924	0.6752	0.7099	<0.001
Length of follow-up (1-year increments)	1.3942	1.3168	1.4761	<0.001
Reminders	0.9209	0.7851	1.0802	0.311
Feedback	0.9578	0.8190	1.1201	0.589
Reminders × feedback (interaction term)	1.0476	0.8373	1.3107	0.684

ventions to attainment of ADA treatment goals (Table 3). Attainment of the A1C goal was impeded by higher BMI, longer duration of diabetes, and higher baseline A1C, but facilitated by greater age, more diabetes cinic visits, longer follow-up, and the feedback intervention (P = 0.016). Among 2,124 patients who would have been expected to be impacted by the study interventions (≥3 visits, ≥6 months follow-up, ≥50% of visits seen by residents), baseline values were comparable (not shown), but the A1C goal was attained by 56% of patients in the feedback + reminders group, 57% with feedback-only, 47% with reminders-only, and 49% with control subjects ($P < 0.02$ for feedback + reminders and feedback-only versus control group and reminders-only). Attainment of the sBP goal was reduced by greater age, BMI, longer duration of diabetes, African-American ethnicity, having had more medical clinic visits, and higher baseline blood pressure but was facilitated by having had more diabetes clinic visits, longer follow-up, and the feedback intervention (P = 0.001). However, the interventions had no independent effect on attaining the LDL goal.

A1C outcomes in the intervention site versus other primary care sites

To assess the efficacy of the intervention(s) with a paradigm free of potential contamination, we also compared clinic-wide A1C levels in intervention site patients with those of patients in three nonintervention primary care clinics (Fig. 1). All sites were within the Grady Health System, all serve patient populations that are predominantly urban and indigent, all were exposed to standard continuing medical education programs, and none received diabetes-specific quality improvement initiatives other than the IPCAAD study directed at residents within the intervention site. Although information about patients in the nonintervention sites was limited, subjects who had at least three visits over 2 years were generally similar to study-site patients in age (study site vs. other sites, 61 vs. 63 years, $P < 0.0001$), racial/ethnic distribution (study site vs. other site, 94 vs. 92% African American, $P < 0.05$), and number of diabetes clinic visits during 2001–2002 (study site vs. other site, 0.2 vs. 0.3 visits, $P < 0.0001$). In these other clinics, there was no significant change in A1C during the period of study ($P = 0.5$ for trend), which contrasted with the progressive fall in A1C in the study site ($P < 0.0001$ for trend). During 2001–2002, A1C values in the study site were significantly lower than values in the other primary care clinics, even though the study site group included both patients who saw residents in the control intervention arm and patients of faculty members and nurse practitioners who did not participate in the study.

CONCLUSIONS — Our findings demonstrate that endocrinologist-supported interventions aimed at providers to reduce clinical inertia can improve diabetes management in a large primary care site. The feedback on performance intervention was associated independently with reductions in both A1C and sBP as shown by multivariable analysis, and the feedback + reminders group exhibited improvements in A1C that were significantly greater than in the control group despite evident contamination. The A1C changes and end-of-study A1C differences between feedback + reminders and control patients were of a magnitude thought to be significant in improving clinical outcomes (52) and contrasted with other recent performance feedback studies that mainly improved process measures (53,54). The computer-

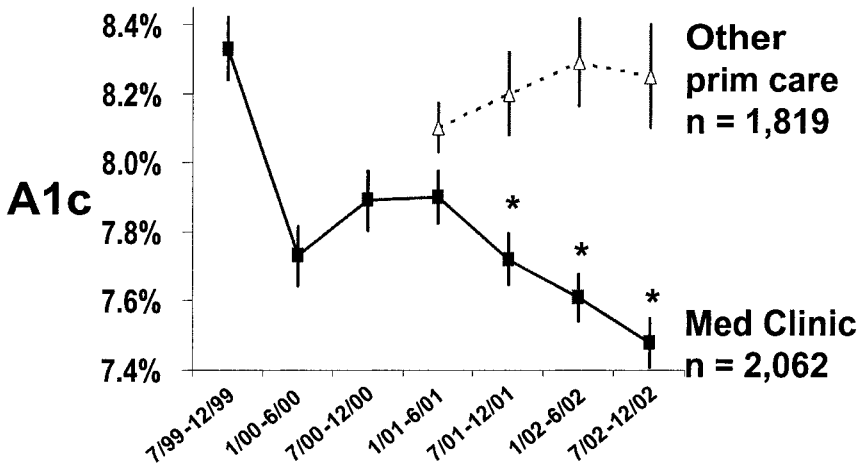

Figure 1—*Impact of the IPCAAD interventions on clinic-wide disease management. A1C (%) values are shown for patients seen in Grady Medical Clinic modules I and II (where the interventions took place), compared with values from patients seen in three other primary care sites where the interventions were not implemented (the Dekalb-Grady Neighborhood Heath Center, module III of the Grady Medical Clinic, and the Northwest Grady Neighborhood Heath Center). The interventions were initiated 1 January 2000. Data are means ± SE.* *P $<$ *0.001 by unpaired* t *test.*

ized reminders alone were associated with a within-group reduction in A1C but not in blood pressure. LDL cholesterol improved significantly in all study arms independent of the interventions. Improvement in A1C levels within the IPCAAD study site contrasts with lack of improvement in A1C in comparison with other primary care sites within the same health care system and lack of improvement across the U.S. (17). By the end of the study, A1C levels in the IPCAAD primary care site were comparable to those in a diabetes specialty care site in the same medical center (46).

It should be emphasized that our conservative, real-world design (no incentives, no limits on interactions between study groups) conferred a high likelihood of both contamination among the intervention arms and Hawthorne effects (changes in management due to recognition that behavior was being monitored [55]). Such effects would have decreased the relative impact of the active interventions. However, the feedback + reminders intervention improved A1C significantly more than the control intervention, and the independent benefit of the feedback intervention in improving A1C and blood pressure and in attaining ADA goals persisted in multivariable analyses. To the extent that better control of lipid levels via more intensive use of a single lipid-lowering medication may have been easier to implement than control of hyperglycemia and hypertension, which often requires use of multiple agents (56,57), such confounding may also have contributed to lack of impact of the interventions on LDL cholesterol.

Approaches similar to ours may also improve management for other disorders such as hypertension and dyslipidemia, where provider action is frequently inadequate and not symptom driven (21,22). In this regard, we believe that the emphasis should be on changing provider behavior (25,26,32–40,43). Our strategy was based on previous surveys that indicated that the residents were familiar with glycemic goals (58) and diabetes medications but often failed to intensify therapy when glucose levels were high (28). The IPCAAD report cards used to assess provider behavior were based mainly on indicators available at each visit (glucose and blood pressure levels), although the providers were reminded to consider the clinical context. We also emphasized that when time is short, addressing treatment targets early in the visit ensures that attention will be given to diabetes, hypertension, and dyslipidemia (59). Although reminder-based approaches have been effective in other settings (60) and can be computerized (61), our findings suggest that feedback on performance may be a more effective strategy unless the intrinsic limitations of reminders can be avoided (see below).

Other approaches to improving diabetes management include use of case managers who can address patient education, diet, exercise, and/or use of medication (62,63) and changes in the structure of care delivery (64). However, it would be impractical to have case managers for each of multiple chronic diseases, and approaches based largely on patient education (65–67) or altering the structure of care (68) may improve patient knowledge but have less impact on A1C levels. In contrast, our strategy focused only on the providers and avoided potential confounding by "gaming the system" (69); providers could not simply avoid patients with high A1C levels, since our measures emphasized what the providers did when glucose, blood pressure, and/or lipid levels were out of target range.

Our study has several limitations. First, unlike many clinical trials, there were no resources to encourage the participation of the patients (no free drugs, visits, or financial incentives), and many patients failed to keep follow-up appointments. In this regard, it is interesting that patients assigned to residents in the active intervention arms had slightly longer follow-up (Table 1), although the benefit of the interventions persisted after adjustment for duration of follow-up and number of visits. Second, since it would have been inappropriate to limit the opportunity of the patients to have visits to the diabetes clinic, the care of some of the patients may have been improved by such visits (Table 3 and [28]). However, diabetes clinic providers were not aware of either patient study status or intervention assignment, there was no difference in the frequency of diabetes clinic visits among the different intervention arms (Table 1), and the benefit of the interventions persisted after appropriate adjustment. Third, the impact of the reminders may have been hampered because we had no capability to ensure that the reminders could not be ignored (70). In contrast, the residents in the feedback intervention could not avoid discussing their own performance. Fourth, the IPCAAD study involved residents and was based in a municipal hospital and might not be generalizable. Selection of the study site was based largely on feasibility, and our approaches should be tested in other venues, such as sites with more experienced physicians whose care might improve as much or more with changes in workflow and process; as proof of concept, our findings justify such extensions. However, it should also be recognized that sites such as ours often provide care for minorities who suffer disparities in health (71,72) and it may be difficult to improve their management (73); it is particularly im-

portant to establish strategies that are effective in such settings. Fifth, we could not prevent contamination among the treatment arms. However, although contamination would have contributed to improvement in the control arm, the effects of feedback + reminders on A1C were significantly better. The improved A1C in the control arm also contrasts with the lack of improvement in primary care clinics not receiving the intervention (Fig. 1), further evidence of the (contaminating) benefit of the interventions. Sixth, our interventions focused largely on glucose control, which may have contributed to relatively reduced impact on blood pressure and LDL. And finally, it should be recognized that the IPCAAD approach requires information management and was based on specialists acting in partnership with generalists. Our use of information management is consistent with the recent recommendations of the Institute of Medicine (74). However, if our strategies were to be implemented on a broad scale, they would either require addition of a new dimension to fellowship training to prepare specialists for a role in generalist support or education as needed for senior generalist physicians to provide feedback on performance.

The IPCAAD study demonstrates that generalist-specialist partnerships can work to the advantage of patients and that giving providers feedback on their performance can improve outcomes. Our strategies need to be tested in other settings, but if they prove effective, they should constitute an approach to improving the quality of care for many chronic disorders—helping to close the "quality chasm" (74).

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