

Use of Chronic Care Model Elements Is Associated With Higher-Quality Care for Diabetes

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ABSTRACT

PURPOSE In 30 small, independent primary care practices, we examined the association between clinician-reported use of elements of the Chronic Care Model (CCM) and diabetic patients' hemoglobin A_{1c} (HbA_{1c}) and lipid levels and self-reported receipt of care.

METHODS Ninety clinicians (60 physicians, 17 nurse-practitioners, and 13 physician's assistants) completed a questionnaire assessing their use of elements of the CCM on a 5-point scale (never, rarely, occasionally, usually, and always). A total of 886 diabetic patients reported their receipt of various diabetes care services. We computed a clinical care composite score that included patient-reported assessments of blood pressure, lipids, microalbumin, and HbA_{1c}; foot examinations; and dilated retinal examinations. We computed a behavioral care composite score from patient-reported support from their clinician in setting self-management goals, obtaining nutrition education or therapy, and receiving encouragement to self-monitor their glucose. HbA_{1c} values and lipid profiles were obtained by independent laboratory assay. We used multilevel regression models for analyses to account for the hierarchical nature of the data.

RESULTS Clinician-reported use of elements of CCM was significantly associated with lower HbA_{1c} values ($P = .002$) and ratios of total cholesterol to high-density lipoprotein cholesterol ($P = .02$). For every unit increase in clinician-reported CCM use (eg, from "rarely" to "occasionally"), there was an associated 0.30% reduction in HbA_{1c} value and 0.17 reduction in the lipid ratio. Clinician use of the CCM elements was also significantly associated with the behavioral composite score ($P = .001$) and was marginally associated with the clinical care composite score ($P = .07$).

CONCLUSIONS Clinicians in small independent primary care practices are able to incorporate elements of the CCM into their practice style, often without major structural change in the practice, and this incorporation is associated with higher levels of recommended processes and better intermediate outcomes of diabetes care.

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INTRODUCTION

Compelling clinical trials have established clear relationships among control of blood glucose, blood pressure, and lipids and decreases in microvascular and macrovascular morbidity and mortality associated with type 2 diabetes mellitus.¹⁻⁶ Despite the clear evidence for efficacy of management of type 2 diabetes, a gap⁷ remains between what is possible and what is achieved in practice. Evidence-based guidelines from the American Diabetes Association (ADA) describe a care pattern that, if followed, would greatly reduce the impact of diabetes and its complications,⁸ yet repeated studies in a variety of settings continue to show suboptimal processes or outcomes of care.⁹⁻¹⁹ The Chronic Care Model (CCM), developed from a systematic program of research by Wagner and colleagues at Group Health Cooperative of Puget

Sound, provides a blueprint for changing office systems to improve chronic care.²⁰⁻²³ Most primary care practice is based on the traditional model of acute, episodic care delivered by an individual physician. The CCM directs improvement efforts to a population-based, proactive, and planned approach to chronic care delivery. Various trials provide substantial evidence that application of elements of the CCM—particularly expanding the care team to include an important role for office nurses,²⁴⁻²⁹ care management activities for tracking core components of care,²⁸⁻³⁴ with telephone follow-up,^{25,32,35,36} and substantial support for patient self-management activities^{35,37-39}—will improve care for individuals with diabetes. Interventions based on the CCM have not been widely or systematically adopted in primary care practices, however, and few data exist to demonstrate that the incremental incorporation of CCM elements in small, independent primary care practices is associated with better clinical outcomes.

We have previously reported a clinical trial to improve diabetes care conducted in 30 small, independent, mixed-payer primary care practices.^{40,41} The project was designed to investigate the effectiveness of a computer-assisted interactive program to support patient self-management and its impact on the guidelines-based process of care of patients with diabetes. This report describes an analysis of the association at baseline of clinician-reported use of selected elements of the CCM and measures of process and intermediate outcomes of diabetes care.

METHODS

Practices and Clinicians

The Diabetes Priority Program was a collaboration between our research team and the Copic Insurance Company, which provides malpractice insurance to more than 95% of the independent primary care physicians in Colorado. An initial survey questionnaire was sent to all family physicians and general internists insured by Copic in Colorado. Those returning a useable questionnaire received a project fact sheet and follow-up letter inviting them to participate.

The clinical staff in 30 practices throughout Colorado agreed to participate in the effectiveness study, to be implemented by their regular practice staff. Based on the initial survey response, participating physicians did not differ from the total sample of 1,059 primary care physicians on age or sex of physician, years in practice, size of practice, number of patients with diabetes among their patients, or use of any of a series of several quality improvement processes for diabetes, including use of guidelines, registries, tracking systems, flow sheets, or written "prescriptions" for self-care. One fourth of the physicians were in solo practice, two thirds worked in rural locations, and one fourth were female. Among the

30 participating practices, 70 physicians, 19 nurse-practitioners, and 16 physician's assistants contributed patients to the study. Of these, 60 physicians (86%), 17 nurse-practitioners (90%), and 13 physician's assistants (81%) provided information on their diabetes care practices.

Patient Participants

Once a practice agreed to participate, they were given a uniform set of instructions to generate lists of patients with diabetes. The instructions explicitly stated how to review billing data for the previous 12 months, the specific diagnostic codes to use, and the need to search all diagnoses listed for each visit. The instructions were designed to identify all patients with diabetes, even though the group identified might include some individuals without confirmed diabetes. Adults identified as having diabetes were sent a letter signed by their primary care clinician inviting them to participate, a brochure describing the project, and a postcard to return if they did not want to participate. If we did not receive a reply card, patients were called in approximately 2 weeks, screened for eligibility, invited to participate, and mailed an informed consent form. Eligibility criteria included age older than 25 years, ability to speak English, and a diagnosis of type 2 diabetes mellitus (confirmed using the criteria of Welborn et al).⁴² All procedures were approved by relevant institutional review boards, and patients were recruited during 2001-2002.

Of 1,187 eligible patients, 886 (74.6%) agreed to participate and completed baseline data and laboratory testing. Nonparticipants were slightly older, more likely to be nonwhite, and more likely to report lower family income and educational level.^{40,41} Participating patients ranged in age from 25 to 97 years (mean = 63.0, SD = 12.6) and reported an average of 2.1 (SD = 1.5) comorbid illnesses; 51.8% were female, and 13.0% were Hispanic.

The mean number of participating patients per practice was 29.5 and ranged from 13 in a solo practice to 61 in a practice with 6 physicians. For most of the practices, all eligible patients were recruited. The 886 participating patients were similar in demographic characteristics to a contemporaneous independent sample of patients with diabetes in Colorado.⁴¹

Measures

Use of CCM Elements

We developed and tested the Use of Chronic Care Model Elements Survey to assess the extent to which selected elements of the CCM are used in the routine care of patients with diabetes. We focused on items that (1) reflected changes in primary care practice that appeared to be emerging in small practices, (2) were comprehensible and unambiguous to clinicians based on our pilot tests of the instrument, and (3) emphasized

activities generally considered to be part of the delivery system design component of the CCM, which has been shown in a recent study to be associated with diabetes processes and outcomes in a large health care system.⁴³

We sent the survey questionnaire to all physicians, nurse-practitioners, and physician's assistants in each practice before enrolling patients in the study. The stem question asked, "How often do you currently use the following approaches to improving care for patients with diabetes?" The 9 individual approaches (items) were (a) use a registry to identify and/or track care of your patients, (b) use a tracking system to remind patients about needed visits or services, (c) follow up patients between visits by telephone (you or staff), (d) use published practice guidelines as the basis for your management, (e) involve office staff in identifying and reminding patients in need of follow-up or other services, (f) assist patients in setting and attaining self-management goals, (g) refer patients to someone within your practice for education about their diabetes, (h) refer patients to someone outside your practice for education about their diabetes, and (i) use flow sheets to track critical elements of care. Each item had 5 response options: never, rarely, occasionally, usually, and always.

We pilot-tested the survey items with 4 clinicians in 2 separate practices using a "respond and think aloud" strategy for understanding the perceived meaning of the items. This testing led to modification in the items that generally reduced CCM jargon and ambiguity. From this process, we learned, for example, that although very few practices have formal diabetes registries which include all patients with diabetes, many clinicians keep a list of selected patients who might require more careful follow-up.

We computed a composite Clinician Use of Chronic Care Model score as the mean of the 9 items. The mean score for clinicians overall was 3.24 (SD = 0.70) with a range of 1.8 to 4.8. The means for the individual items are shown in Table 1.

We closely monitored completion of questionnaires and sent non-respondents reminders by mail or telephone. Sixty of the 70 physicians (86%) and 30 of the 35 nurse-practitioners and physician's assistants (86%) responded with a useable questionnaire. Response patterns for each item showed sufficient variability, and the items had reasonably high internal consistency, with a Cronbach α of 0.76.

Process of Care

The 30 practices had different medical record formats, few had a diabetes registry that reliably included all patients with diabetes, and many of the standard diabetes care items are notoriously underdocumented in the medical record. We therefore used patient reports of having received these services as our measure of process of care. The full scales described below were used in 2 previous studies with very similar patients^{44,45} and found to be reliable and to agree well with medical records in a health care system that had an electronic diabetes registry.

At baseline, all patients regardless of treatment group assignment were asked to recall when they had last received each of 10 items selected from the Diabetes Physician Recognition Program (PRP) measures of the National Committee for Quality Assurance and the American Diabetes Association⁴⁶ (<http://www.ncqa.org>). Responses for all items were multiple choice, using 6-month intervals (eg, within last 6 months, 7-12 months ago, 13-18 months ago). We summarized 6 clinical measures performed or ordered by the physician—measurement of blood pressure, lipids, microalbumin, and hemoglobin A_{1c} (HbA_{1c}); foot examination; and dilated eye examination—into a clinical care composite score. We computed a second score, the behavioral care composite score, based on responses from patients when asked about support from their primary care practice staff in setting a self-management goal, receiving nutrition education or therapy, and receiving encouragement

Table 1. Clinician Scores on the Use of Chronic Care Model Elements Survey

Survey Item	Chronic Care Model Element Addressed	Score Mean (SD)
a. Use a registry to identify and/or track care of your patients	Clinical information systems	2.53 (1.33)
b. Use a tracking system to remind patients about needed visits or services	Clinical information systems	3.60 (0.93)
c. Follow up patients between visits by telephone (you or staff)	Practice design	3.11 (0.74)
d. Use published practice guidelines as the basis for your management	Decision support	4.02 (0.80)
e. Involve office staff in identifying and reminding patients in need of follow-up or other services	Practice design	3.65 (0.99)
f. Assist patients in setting and attaining self-management goals	Self-management support	3.74 (0.87)
g. Refer patients to someone within your practice for education about their diabetes	Self-management support	2.85 (1.41)
h. Refer patients to someone outside your practice for education about their diabetes	Decision support	3.15 (1.02)
i. Use flow sheets to track critical elements of care	Decision support	3.51 (1.25)

Note: Ninety primary care clinicians provided self-reported information for 9 survey items inquiring about use of selected Chronic Care Model elements. The stem question asked, "How often do you currently use the following approaches to improving care for patients with diabetes?" Response options were never = 1, rarely = 2, occasionally = 3, usually = 4, and always = 5.

to self-monitor blood glucose. Both composite scores were computed as the sum of the individual items and have been reported as outcomes for the trial.^{40,41}

Intermediate Outcomes of Care

Blood for HbA_{1c} levels and lipid profiles was drawn locally, either in the practice or at a local commercial site convenient for the patient. HbA_{1c} assays were conducted at the University of Colorado Health Sciences Center using a National Glycohemoglobin Standardization Program (NGSP)-certified Bio-Rad Variant 2 analyzer (Bio-Rad, Hercules, Calif), correlated to an index of glycemic control established during the Diabetes Control and Complications Trial. The assay's reference range was 4.1% to 6.5%. Total cholesterol level was assayed using an enzymatic test with high-performance liquid chromatography methods, achieved by using microbial esterase, to ensure virtually complete hydrolysis (>99.5%) of all cholesterol esters. This process allows for direct comparability to reference procedures of the Centers for Disease Control and Prevention. High-density lipoprotein (HDL)-cholesterol was assayed using the Roche direct HDL-cholesterol automated method, which meets the goals of the National Institutes of Health and National Cholesterol Education Program for acceptable performance. To avoid colinearity and to reduce the number of dependent variables, we used the ratio of total cholesterol to HDL-cholesterol as our lipid outcome.

Covariates

Social and demographic covariates considered in every analysis included patient age, sex, race/ethnicity (white or nonwhite), educational level (completed high school or not), annual income (<\$10,000, \$10,000-\$29,999, \$30,000-\$49,999, and ≥\$50,000), insurance status (any or none), and marital status (currently married or not). Other covariates included number of comorbid illnesses, level of depressive symptoms, and clinician sex and specialty. Depressive symptoms were assessed with the 9-item Patient Health Questionnaire (PHQ-9), a self-administered instrument that has been validated as a diagnostic and depression severity measure.⁴⁷ A score of 10 has been documented to have a sensitivity of 88% and a specificity of 88% for major depression.⁴⁷ In the present study, the scale showed good internal consistency (Cronbach α = 0.86).

Physician characteristics obtained from the practice survey included age, sex, specialty, board certification, years since training had been completed, years in current practice, and patient care hours in the practice per week. Practice characteristics included size (number of physicians), location in rural or metropolitan area, and presence of an electronic medical record (EMR).

Statistical Analyses

We performed statistical analysis using SAS version 8 (SAS Institute, Cary, NC). Descriptive statistics (means, rates) were generated for patient, physician, and practice characteristics. The structure of the data was hierarchical, with patients nested within clinicians and clinicians nested within practices. Multilevel models (general linear mixed models) were used to examine the association between practice characteristics and patient outcomes, adjusting for individual patient and clinician characteristics. We examined the components of variance to determine the amount of the total variation in outcomes that was due to variation among practices, clinicians within practices, and patients within clinicians. Because practices tended to be small (many practices had only 1 or 2 physicians), however, we used 2-level models (patient within clinician). For each analysis, we computed the intraclass correlation coefficient (ICC) in an unconditional model with clinician as a random effect to determine the extent to which variability in the outcome was due to differences among patients within clinician or between clinicians. Next, we tested patient-level covariates in mixed models, adjusted for clustering of patients within clinician, and retained them if *P* was less than .15. Finally, we added clinician and practice characteristics to models that were adjusted for covariates and for clustering of patients within clinicians.

RESULTS

Of the 1,258 primary care clinicians in Colorado insured by Copic Insurance Company who were sent the initial questionnaire, 1,059 (84%) returned a useable questionnaire. The clinicians who subsequently agreed to participate did not differ from the total sample of clinicians returning useable questionnaires on age, sex, years in practice, size of practice, or use of any of a series of quality improvement processes for diabetes (eg, registries, reminder systems, follow-up calls, written behavioral goals for patients).

We carried out initial univariate analyses for each of the 2 measures of process of care (behavioral care composite score and clinical care composite score) and the 2 intermediate outcomes of care (HbA_{1c} value and lipid ratio), examining their association with patient, clinician, and practice characteristics. Those characteristics with *P* values less than .15 were included in a subsequent multivariate, multilevel model, which adjusted for clustering of patients within clinician for behavioral care composite score (ICC = .0430) and clinical care composite score (ICC = .0344), as well as for HbA_{1c} value (ICC = .0545) and lipid ratio (ICC = .0276).

Process of Care

Overall, patients reported receiving (according to guidelines) an average of 2.1 (SD = 0.95) of 3 ele-

ments of the behavioral care composite and 3.0 (SD = 0.95) of 7 elements of the clinical care composite. As shown in Table 2, greater clinician use of the CCM

was associated with higher behavioral and clinical care composite scores, reaching statistical significance for the behavioral care composite score ($P = .001$) but just failing significance for the clinical care composite score ($P = .07$). The behavioral care composite score, was not significantly associated with patient age, race/ethnicity, or severity of depressive symptoms. The clinical care composite score was associated with patient age ($P = .03$), but not with any of the clinician characteristics.

Table 2. Multivariate, Multilevel Regression Model Showing Association of Clinician Use of Chronic Care Model Elements and 2 Measures of Process of Diabetes Care

Parameter	Parameter Estimate*	SE	P Value
Behavioral care composite score†			
Intercept	1.7038	0.2891	<.001
Patient age	-0.0054	0.0029	.07
Patient race/ethnicity: white (vs nonwhite)	0.1483	0.0927	.11
Patient PHQ-9 (depression) score	-0.0130	0.0074	.08
Clinician score for use of CCM	0.2105	0.0595	.001
Clinical care composite score‡			
Intercept	2.8214	0.3672	<.001
Patient age	0.0066	0.0031	.03
Patient race/ethnicity: white (vs nonwhite)	0.1418	0.0958	.14
Clinician score for use of CCM	0.1592	0.0868	.07

PHQ-9 = 9-item Patient Health Questionnaire; CCM = Chronic Care Model.

* The parameter estimates indicate the strength of the association in each model. Each unit difference in clinician-reported frequency of CCM use (eg, from "rarely" to "occasionally") is associated with a change in the dependent variable (behavioral care composite score or clinical care composite score) equal to the parameter estimate.

† Covariates included patient age, race/ethnicity, and severity of depressive symptoms (PHQ-9 score).

‡ Covariates included patient age and race/ethnicity.

Intermediate Outcomes of Care

Patients' HbA_{1c} values averaged 7.3% (SD = 1.3%) and lipid ratios averaged 4.38 (SD = 1.29). As shown in Table 3, greater clinician use of the CCM elements was associated with lower values for both HbA_{1c} and lipid ratio after adjusting for covariates. Older patient age was also associated with lower values for both outcomes, and white race/ethnicity, female clinician sex, and nurse-practitioner clinician specialty were associated with lower HbA_{1c} values.

The strength of the association between use of CCM elements and intermediate outcomes can be estimated from the parameter estimates in Table 3. To illustrate, the parameter estimate for the association of clinician use of CCM and HbA_{1c} values is -0.3013 (Table 3); thus, for every unit increase in clinician-reported use of CCM elements (eg, from "rarely" to "occasionally"), there would be an associated decrease in HbA_{1c} value of 0.30%. Similarly, for the same unit increase in clinician use of CCM elements, we would expect a decrease in the lipid ratio of 0.17.

It is notable that none of the practice characteristics of size, urban/rural location, or presence of an EMR was associated with the process of care or intermediate outcome measures. Among patient characteristics, white race was not significantly associated with either process measure or with lipid ratio, but was associated with lower HbA_{1c} level. In our sample, patient insurance status was not associated with any process or intermediate outcomes.

Table 3. Multivariate, Multilevel Regression Model Showing Association of Clinician Use of Chronic Care Model Elements and 2 Measures of Diabetes Care Intermediate Outcomes

Parameter	Parameter Estimate*	SE	P Value
Hemoglobin A_{1c} value†			
Intercept	9.3118	0.5709	<.001
Patient age	-0.0082	0.0041	.049
Patient race/ethnicity: white (vs nonwhite)	-0.5990	0.1290	<.001
Clinician sex: female	-0.3371	0.1318	.01
Clinician specialty			
Physician's assistant	-0.6152	0.4299	.16
Nurse-practitioner	0.8065	0.2556	.003
General internal medicine	0.1901	0.1263	.14
Family physician (reference)	-	-	-
Clinician score for use of CCM	-0.3013	0.0879	.002
Lipid ratio (total cholesterol:HDL-cholesterol)‡			
Intercept	5.8541	0.3414	<.001
Patient age	-0.0148	0.0035	<.001
Patient marital status: married	0.1589	0.0967	.10
Clinician score for use of CCM	-0.1663	0.0690	.02

CCM = Chronic Care Model; HDL = high-density lipoprotein.

* The parameter estimates indicate the strength of the association in each model. Each unit difference in clinician-reported frequency of CCM use (eg, from "rarely" to "occasionally") is associated with a change in the dependent variable (hemoglobin A_{1c} value or lipid ratio) equal to the parameter estimate.

† Analyzed as a continuous variable. Covariates included patient age, patient race/ethnicity, clinician sex, and clinician specialty.

‡ Analyzed as a continuous variable. Covariates included patient age and marital status.

DISCUSSION

Our findings contribute to the modest body of evidence for the effectiveness of some elements of the CCM in improving the care of

patients with chronic disease in organized health care settings.^{35,43} A recent report from a large multispecialty medical group demonstrated a cross-sectional association among practice-level implementation of the delivery system design components of the CCM and selected process and outcome measures.⁴³ Our data assessed clinician-level patterns of diabetes care in small, independent, mixed-payer practices in which no previous systematic efforts to implement the CCM had been attempted. Although drawn from cross-sectional data, our results provide reason to hope for a cause-effect relationship and suggest that relatively modest clinician-level efforts to incorporate elements of the CCM into their daily practice routine might be associated with significantly improved processes and outcomes of diabetes care. If this association is verified, our data suggest an effect on process and outcomes of diabetes care even at relatively modest doses and provide encouragement for small practices to consider more ambitious efforts to reengineer processes within the practice to enhance chronic care.

Interestingly, the presence of an EMR in approximately 15% of the practices in our study was not independently associated with improved process or outcome. This finding is consistent with previous reports⁴⁸⁻⁵¹ and supports the hypothesis that the presence of an EMR alone does not appreciably improve care unless it is used to support chronic care in specific ways, such as flagging surveillance tasks that are overdue or providing clinician reminders to support patient self-management activities.

Our study is limited by the self-reported nature of both clinician use of CCM elements (by clinicians) and process of care measures (by patients). Physician report has been used extensively in previous studies, and we would argue that although self-report may lack precision, the scales we used were effective in distinguishing relative frequency of use of chronic care practice behaviors. Although patient self-report of services received has been shown to lack sensitivity depending on the type of service,⁵² previous work from our group has shown adequate concordance between medical record review and patient report of the process items used in this study.^{44,45} Also, imprecision in either patient or clinician reports should have reduced the magnitude of associations found. Gathering process and outcome information from 3 separate sources (ie, clinician report of the use of CCM, patient report of services received, and laboratory ascertainment of physiologic outcomes) lends strength to our data and reduces the likelihood of variance arising from shared methods. Our study also may have oversampled rural clinicians in our purposeful focus on small, independent primary care practices. Strengths of our study include (1) a diverse patient population, including a range of ages and races/ethnicities, (2) a diverse clinician population, including family physicians, general internists, nurse-

practitioners, and physician's assistants in small, independent practices, (3) diverse practice locations, including both rural and metropolitan areas, and (4) similarity of participating clinician's self-reported practices for diabetes care compared with practices of the larger population of primary care physicians in Colorado.

Future research is needed to replicate our findings in different settings and to experimentally test whether increases in adoption of CCM-based practices improve the process of care and outcomes of diabetes and other chronic illnesses.

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Key words: Diabetes mellitus; Chronic Care Model; primary care physicians; quality of health care; quality improvement; process assessment (health care); chronic diseases; health services research

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