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Care Management Processes Important for High-Quality Diabetes Care

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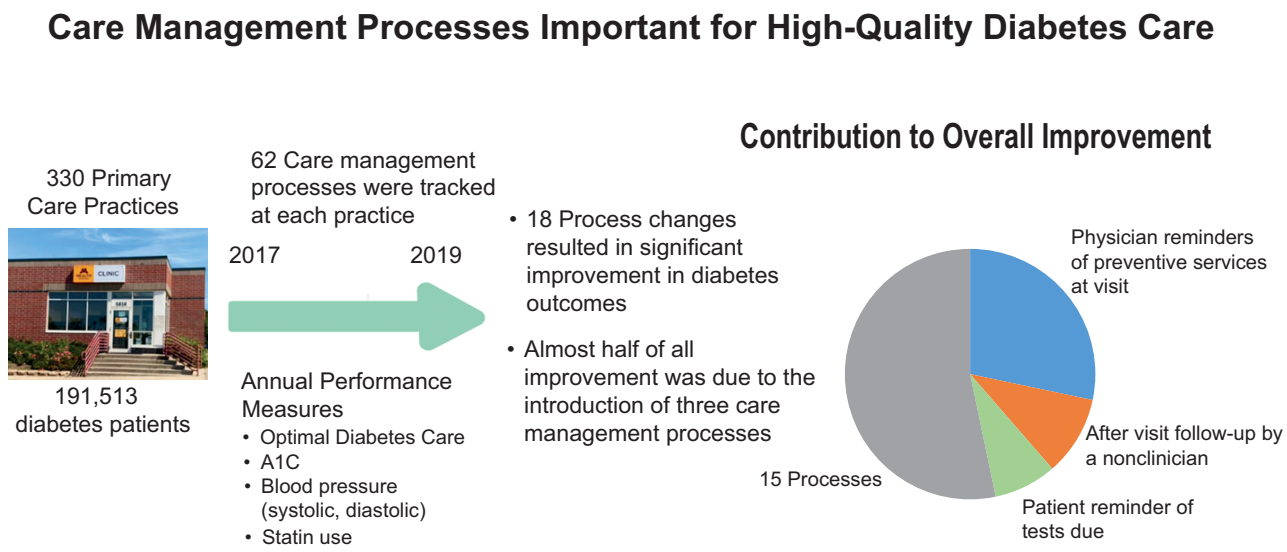

ARTICLE HIGHLIGHTS

- We undertook this study to identify how primary care practices can effectively improve diabetes outcomes.
- Our specific question we wanted to answer related to which changes in care management most improved clinical outcomes.
- We found that, although several care management processes improve discrete components of diabetes care, introducing targeted processes maximizes improvement while limiting disruption.
- Primary care practices can significantly improve outcomes by reminding patients they are due for testing, providing clinician reminders during visits, and having a nonclinician provide follow-up after visits.

Care Management Processes Important for High-Quality Diabetes Care

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ORIGINAL ARTICLE

OBJECTIVE

Identify the improvement in diabetes performance measures and population-based clinical outcomes resulting from changes in care management processes (CMP) in primary care practices over 3 years.

RESEARCH DESIGN AND METHODS

This repeated cross-sectional study tracked clinical performance measures for all diabetes patients seen in a cohort of 330 primary care practices in 2017 and 2019. Unit of analysis was patient-year with practice-level CMP exposures. Causal inference is based on dynamic changes in individual CMPs between years by practice. We used the Bayesian method to simultaneously estimate a five-outcome model: A1c, systolic and diastolic blood pressure, guideline-based statin use, and Optimal Diabetes Care (ODC). We control for unobserved time-invariant practice characteristics and secular change. We modeled correlation of errors across outcomes. Statistical significance was identified using 99% Bayesian credible intervals (analogous to $P < 0.01$).

RESULTS

Implementation of 18 of 62 CMPs was associated with statistically significant improvements in patient outcomes. Together, these resulted in 12.1% more patients meeting ODC performance measures. Different CMPs affected different outcomes. Three CMPs accounted for 47% of the total ODC improvement, 68% of A1c decrease, 21% of SBP reduction, and 55% of statin use increase: *1*) systems for identifying and reminding patients due for testing, *2*) after-visit follow-up by a nonclinician, and *3*) guideline-based clinician reminders for preventive services during a clinic visit.

CONCLUSIONS

Effective quality improvement in primary care focuses on practice redesign that clearly improves diabetes outcomes. Tailoring CMP adoption in primary care provides effective improvement in ODC performance through focused changes in diabetes outcomes.

Since diabetes care is often provided in primary care settings, the processes of care delivery in primary care practices provide an important focus for improving the quality of diabetes care throughout the U.S. Although national measures of the quality of diabetes care have demonstrated some improvement prior to the coronavirus disease 2019 pandemic, progress has been mixed and slow (1–3). Leaders in quality improvement have

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noted that improving the management of diabetes in primary care settings requires redesign of care delivery models in order to increase coordination, emphasize prevention, promote proactive patient outreach, and enhance collaboration between multidisciplinary teams (4–7).

Despite international agreement on the fundamental concepts of primary care, the specific care delivery activities implemented by primary care practices can vary widely. Evidence for clinical outcome improvement resulting from many quality improvement efforts is inconsistent (8–13). A care management process (CMP) is a specific activity performed in a clinical practice with the goal of improving or facilitating coordinated, effective clinical care. CMPs include specific activities such as the use of checklists, targeted reminders, or after-visit follow-up by a nonclinician. The process of adopting new CMPs can disrupt productivity in a busy clinical environment. During quality improvement efforts, practices ideally focus on introducing a few CMPs with the greatest likelihood of improving clinical outcomes. Understanding expected performance improvement following adoption of a CMP provides valuable information for planning effective practice redesign.

Previously, little has been published about the change in clinical outcomes expected from the implementation of specific CMPs (7). Quality improvement literature often combines multifaceted or heterogeneous interventions that offer little insight into the specific processes successfully implemented, or it focuses on pilot projects and single health care systems not generalizable to other settings (14–19). Internationally, improving care delivery in large systems often emphasizes reallocation of patients to hospital, specialist, general practice, or community settings (20). Comparison between clinical settings offers limited understanding of the effectiveness of specific activities.

The goal of the Understanding Infrastructure Transformation Effects on Diabetes (UNITED) study was to identify the specific CMPs in primary care associated with improvement in diabetes care delivery. This repeated cross-sectional study tracked changes in the presence of 62 CMPs in a cohort of 330 primary care practices in Minnesota and surrounding communities from 2017 to 2019. We evaluated change in diabetes performance associated with changes in CMPs using longitudinal data and a large and diverse set of clinical practices (21–23).

RESEARCH DESIGN AND METHODS

Study Setting and Research Design

In 2008, the Minnesota legislature required the adoption of electronic health records (EHRs) in all primary care practices by 2015 (24). Concomitantly, the legislation established the Statewide Quality Reporting and Measurement System (SQRMS) that mandated annual reporting of diabetes performance measures in any primary care practice with at least one physician (MD or DO) providing patient services. The state contracted with MN Community Measurement, a nonprofit organization (https://MNCM.org), to collect and manage quality measurement on behalf of the Department of Health. SQRMS captured a near-complete census of EHR-based outcomes for primary care patients aged18–75 years with type 1 or type 2 diabetes seen in Minnesota from 2017 to 2019. UNITED used these data to evaluate performance. The data include all practices regardless of participation in any specific quality improvement initiative.

Our data identified the presence of 62 CMPs self-reported by practices in 2017 and 2019, matched with 2017 and 2019 SQRMS data. Our research design leverages changes in the presence of individual CMPs between 2017 and 2019 to identify which CMPs were associated with the greatest improvements in care for patients with diabetes.

Performance Measures

We used the Optimal Diabetes Care (ODC) measure, developed using a collaborative process including providers, payers, and other stakeholders and endorsed by the National Quality Forum as NQF 0729 (25). The ODC measure includes concurrent achievement of *1*) hemoglobin A1c $<$ 8.0%; *2*) blood pressure $<$ 140/90 mmHg; *3*) use of a statin within guideline-based parameters, unless contraindicated; *4*) nonsmoker status documented in the past 2 years; and *5*) use of an antiplatelet medication for patients with ischemic vascular disease, unless contraindicated. Although these criteria do not include all elements necessary for "optimal" care, meeting the ODC target does provide documentation that a patient has achieved five important diabetes care targets.

Patient-level data for all ODC criteria were collected from all primary care encounters in 2017 and 2019. The data had identifiable practice names but anonymized patient identities. We modeled five patient outcomes: *1*) achievement of overall ODC criteria, *2*) A1c level, *3*) systolic blood pressure (SBP), *4*) diastolic blood pressure (DBP), and *5*) adherence to statin guidelines. We did not model antiplatelet use, since 99.5% of the population met this performance measure. We also did not include smoking status, because preliminary testing indicated smoking status was much less responsive to the presence of practice CMPs than other clinical variables. Practices were required to submit the last observed measurement within the calendar year. Multiple observations per year were not collected.

Practice CMPs

We solicited practice participation in the Physician Practice Connections Research Survey (PPCRS) to determine the presence of CMPs from all 585 primary care practices reporting to SQRMS in 2017 and the 626 practices reporting in 2019. Response rates were 71% in 2017 and 72% in 2019. Respondents and nonrespondents were comparable in rurality and health system size. Details about our survey process can be found elsewhere (23,26).

The PPCRS evaluates the presence or absence of 62 general and diabetes-specific CMPs in the responding practice. CMPs are grouped in the survey as Information and Tracking (6 items), Chronic Disease Management (26 items), Patient Self-Management (22 items), Care Plans/Shared Decision-Making (3 items), Performance Measurement (3 items), and High-Risk Patients (2 items). Previous validation of the survey has demonstrated that respondents report CMPs accurately, tending, if anything, to underreport CMPs' presence (27). The PPCRS is a slight modification of the survey that was developed and tested for reliability by the National Committee for Quality Assurance as a tool for Patient Centered Medical Home certification (27,28).

The study and all data handling procedures were reviewed and approved by the University of Minnesota Institutional Review Board, Minneapolis, MN.

Control Variables

Multiple practice-level control variables were included to capture characteristics of the practice environment. These include practice rurality, size of the parent health care system, and whether the practice was a Federally Qualified Health Center. We determined rurality using Rural-Urban Commuting Area Codes (29), based on ZIP code, mapped to a four-category variable: urban, large rural town, small rural town, or isolated rural town. The size of the parent system was based on the number of primary care locations in the system. This was mapped to a three-category variable: solo site, 2–11 primary care locations, or 12 or more primary care locations.

Patient-level control variables included patient age (as a categorical variable in 5-year age groups), sex, health status, and type of insurance. Controls for patient health status included indicators of depression, ischemic vascular disease, and type 1 diabetes diagnoses. Insurance coverage included commercial, Medicare, Medicaid, self-pay, and unknown status.

Patient ZIP codes allowed us to describe patient neighborhoods. While neighborhood descriptors have been shown to have poor correlation with individual patient socioeconomic status (30), neighborhood characteristics have robust correlation with diabetes incidence and control (31). We used the 5-year American Community Survey data released in the observation year to describe the patient's ZIP code. We measured race and ethnicity using percentage of residents who were non-Hispanic White; education using percentage of residents aged ≥25 years with a high school degree and/or 4-year college degree; and income and wealth using percentage of households under the Federal Poverty Limit and percentage of housing units that are owner occupied.

Statistical Analysis

We used the Bayesian method to estimate our model (32,33); details of this technique can be found in the Supplementary Material. Our unit of analysis is the individual patient, with the impact of CMPs measured at the practice level. In general, for person *i*, receiving care at practice *j*, in year *t*, for the *d*th outcome, we modeled $Y_{ijt}^{*(d)}$ as

$$Y_{ijt}^{*(d)} = \beta^{(d)\prime} X_{ijt} + \nu_t^{(d)} + \delta_j^{(d)} + \varepsilon_{ijt}^{(d)}$$

X_{ijt} is a vector containing the CMP indicators and practice- and patient-level control variables, and $\beta^{(d)}$ is a vector of coefficients to be estimated. We estimated a time effect, $\nu_t^{(d)}$, to capture trends in care delivery and practice effects, $\delta_j^{(d)}$, to capture unobserved characteristics of the practice and their average patient that do not vary over time. The remaining factors affecting these patient outcomes were captured by the general error term, $\varepsilon_{ijt}^{(d)}$. We assumed that the five error terms $\varepsilon_{ijt} = \left[\varepsilon_{ijt}^{(1)} \quad \ldots \varepsilon_{ijt}^{(5)}\right]'$ follow a multivariate normal distribution with means zero and a variance-covariance matrix to be estimated, constraining the variances associated with the binary outcomes (statin use, ODC status) to one, as is customary.

Our observed value for the *d*th outcome is $Y_{ijt}^{(d)}$. For the three continuous variables (A1c, SBP, DBP), we modeled $Y_{ijt}^{*(d)} = \ln\left(Y_{ijt}^{d}\right)$. Our use of a log transform was motivated by the skewed distributions of A1c and SBP.

We modeled the two binary variables, statin use and ODC status, using probit equations. $Y_{ijt}^{*(d)}$ is the probit latent variable, making the standard assumption that the observed indicators $Y_{ijt}^{(d)}$ are equal to one when $Y_{ijt}^{*(d)} \geq 0$ and zero when $Y_{ijt}^{*(d)} < 0$ (34).

The longitudinal framework is an important feature of our model, allowing us to leverage the substantial change in CMPs at the practice level to maximize the probability that we are identifying a causal relationship between specific CMPs and patient outcomes, rather than associations. The analysis is more complex than intervention studies in which there is a clear distinction between treatment and control groups, with observations made pre- and post-treatment. In our study, we have 62 treatments. Within a practice, an individual CMP may be added or removed between 2017 and 2019. The practices without a change in status effectively serve as controls for that CMP's effect.

The repeated observations within a practice and across time allow us to estimate practice effects to control for unobserved characteristics of the practices that might otherwise bias our estimation of the CMP effects. An important assumption for unbiased estimation is that these unobserved practice characteristics do not change over time. The patient anonymization did not allow us to link patients over time, so we did not include patient effects. If unobserved patient characteristics are also time invariant, and the patient mix within practices is stable over time, then the average effect of unobserved patient characteristics within a practice will be captured by the practice effects. If these assumptions hold, an unbiased estimation of the CMP effects will result. The stability of average observed patient characteristics seen in Table 3 implies that it is reasonable to assume the average unobserved patient characteristics are also stable over time.

The data quality is high, with only 5% of observations having any missing values; however, we have excluded these observations. Since almost all of these observations are excluded because of absent A1c value, the missingness is not random, introducing a slight risk of potential bias. Patients that are not adherent with regular A1c measurement may not be adherent with other disease management activities. However, the low frequency of missingness means that any resulting bias is minimal.

In Bayesian estimation, a 95% credible interval for a coefficient contains the coefficient's true value with a probability of 0.95, a measure analogous to a P value < 0.05. Because we were modeling statistical significance in five outcomes, we used a stricter decision rule to reduce the risk of type 1 error. We required the wider 99% Bayesian credible interval to exclude zero (analogous to a P value < 0.01), to identify which CMPs had a statistically significant impact on patient outcomes.

Once the model was estimated, we used the parameter estimates to simulate the marginal effect of each statistically significant CMP on patient outcomes. We did this by predicting the change in each of the five outcomes for each of the patients, as if an individual CMP changed from "not present at the practice" to "present at the practice," holding all other patient and practice characteristics (including the status of the other 61 CMPs) constant. The unit change in A1c, SBP, or DBP, or percentage point change in the probability of statin use or ODC, represents the patient's marginal effect of the CMP, controlling for all other factors. We averaged the marginal effects across the population to determine the average marginal effect of that CMP. The "maximum effect" of the CMPs found to be statistically significant on patient outcomes assumed that all

significant CMPs changed from "not present" to "present" simultaneously, and their average combined effect was computed. These marginal effects are hypothetical changes in patient outcomes when individual CMPs are implemented or when all 18 significant CMPs are implemented.

The data sets analyzed during the study are not publicly available, because of patient privacy concerns and restrictions imposed by our data use agreements.

RESULTS

Description of Practices

A total of 477 practices completed the PPCRS survey in either 2017 or 2019. We restricted our analysis to the 330 practices participating in both years. The characteristics of these practices are described in Table 1. Thirty-four percent of practices were in rural markets, and 81% were owned by large health care systems. Only 3.6% were Federally Qualified Health Centers.

On average, practices reported the presence of 80.6% and 81.5% of the total 62 CMPs in 2017 and 2019, respectively, with details by survey section shown in Table 2. However, these summary statistics mask significant change in individual CMPs within practices. On average, each CMP was changed (added or subtracted) by 21% of the practices between 2017 and 2019. The greatest amount of movement was in Care Plans/Shared Decision-Making CMPs, which changed, on average, in 34% of practices. The least movement was in Quality Measurement CMPs, which changed on average in 10% of practices. This variation over years provides an opportunity to statistically identify the association of CMPs with patient outcomes.

Table 2—Fraction of CMPs in place by practice

	Summary of exposures: fraction of CMPs in place, mean (SD)	
	2017	2019
Information and tracking (6 items)	0.807 (0.236)	0.824 (0.210)
Chronic disease management (26 items)	0.796 (0.161)	0.804 (0.155)
Patient self-management (22 items)	0.816 (0.173)	0.816 (0.160)
Care plans/shared decision-making (3 items)	0.684 (0.327)	0.718 (0.324)
Performance measurement (3 items)	0.929 (0.175)	0.944 (0.158)
High-risk patients (2 items)	0.826 (0.320)	0.861 (0.265)
Total survey (62 items)	0.806 (0.145)	0.815 (0.133)

Description of Patients

The patient sample is summarized in Table 3. Stability of patient outcomes at the population level masks considerable movement at the practice level. Although the overall ODC rate varied by less than 1% from 2017 to 2019, the change in ODC rates at the practice level varied from a 13.6 percentage point decline to a 14.7 percentage point increase.

More than 80% of patients were aged ≥50 years. The prevalence of ischemic vascular disease was 16%, and depression was 21%. The majority had commercial, Medicare, or Medicaid coverage, and a small fraction were self-pay or coverage was unknown. The average demographics of patient ZIP codes were 79% White, non-Hispanic, 34% college-educated, and 8% living under the Federal Poverty Limit with 72% of housing units being owner occupied. The only meaningful shift in patient demographics over time was a lower prevalence of depression (23.7% to 19.6%), and a small shift from commercial, Medicare, and unknown coverage to Medicaid and self-pay categories.

The restriction to 330 continuously participating practices had little impact on the average descriptors of the sample. When compared with all 477 practices, average ODC performance rates were identical in 2017 and 2019, and patient characteristics were nearly identical. Practice characteristics of our final sample of 330 practices were very similar to all 477 practices. A slight increase appeared in the share of practices in isolated rural locations in 2019, and, in both years, the population in ZIP codes served by the practices had a slight increase in the proportion that were White, non-Hispanic. Details on the broader sample are available in Supplementary Tables 1 and 2.

Table 1—Primary care practice characteristics (*N* = 330)

	N	%
Rurality		
Isolated rural town	60	18.2
Small rural town	21	6.4
Large rural town	31	9.4
Urban	218	66.1
Health system size		
Single site	4	1.2
2–11 primary care sites	59	17.9
12 or more primary care sites	267	80.9
Federally Qualified Health Center	12	3.6

CMPs' Impact on Clinical Outcomes

Our analysis found 18 of 62 CMPs had a statistically significant association with decreased A1c, reduced SBP or DBP, increased statin use, or increased rates of overall ODC. Table 4 summarizes the marginal effect of these 18 CMPs on patient outcomes. All model coefficients are provided in Supplementary Tables 3 and 4. Two stars indicate the CMP met our inclusion criterion based on a 99% credible interval for that outcome; one star indicates the CMP was marginally significant for a second outcome based on a 95% credible interval. The relative contribution of statistically significant CMPs to total ODC improvement is shown graphically in Figure 1.

The maximum effect of the combined 18 CMPs predicted by our model was a decrease in the population-average A1c score by 0.15; a decrease in average SBP and DBP by 6.3 and 3.9 mmHg, respectively; an increase in the number of patients using statins by 3.9 percentage points; and a 12.1 percentage point increase in the number of patients meeting the ODC requirements. This is equivalent to a 1.4 SD increase and represents a 25%

Table 3—Summary of patient characteristics

	2017	2019
Number of patients	177,104	191,513
Patient outcomes		
HbA_{1c} value, mean (SD)	7.40 (1.59)	7.39 (1.59)
SBP, mean (SD)	127.1 (14.6)	127.5 (14.9)
DBP, mean (SD)	75.0 (14.6)	75.3 (14.9)
Percent meeting statin requirement, %	88.6	88.7
Percent meeting ODC standard, %	48.6	48.4
Patient characteristics, %		
Age distribution		
Under 40 years	7.1	7.1
40–44 years	4.9	5.0
45–49 years	7.9	7.6
50–54 years	11.1	10.6
55–59 years	15.6	15.1
60–64 years	17.5	17.7
65–69 years	17.7	18.2
70 years or older	18.1	18.6
Female	46.3	46.3
Health status		
Type 1 diabetes	5.9	5.9
Has ischemic vascular disease	15.9	15.6
Has depression	23.7	19.6
Type of insurance		
Commercial	42.3	41.8
Medicare	37.5	35.9
Medicaid	13.6	14.3
Self-pay	2.6	4.7
Unknown	4.0	3.3
Characteristics of patient ZIP codes, %		
Mean percent White, non-Hispanic	79.5	79.2
Mean educational distribution		
No high school	7.7	7.5
High school/GED	59.0	58.6
4-year college degree	33.3	33.9
Mean percent households under Federal Poverty Limit	8.6	8.2
Mean percent housing units that are owner occupied	71.7	71.8

increase in average ODC score. For our average patient population of approximately 185,000 patients, this "maximum effect" represents more than 7,700 additional patients achieving an A1c $<$ 8%, 24,100 additional patients achieving blood pressure $<$ 140/90 mmHg, 7,300 additional patients using statins, and 22,400 additional patients achieving the overall ODC target.

Blood pressure was most responsive, with 13 CMPs significantly increasing the probability of lower SBP and/or DBP. Improvement of statin use was limited to the use of clinician reminders for age-appropriate preventive services (C32) and screening for alcohol/substance abuse (D3; a correlation with liver damage as an exclusion for statin use). Only two CMPs were found to significantly reduce A1c levels: a systematic approach to identify and remind patients they are due for preventive services (C24) and referral to formal programs that assist in self-management (D13). In addition, having a care team member provide after-visit follow-up (C28) lowered A1c (marginally significant), with that CMP's primary impact being a reduction in SBP and an increase in the probability of ODC.

We chose to use Bayesian modeling for this analysis because it allowed us to borrow statistical power across equations and improve our ability to detect impactful CMPs. As a sensitivity check, we used frequentist methods to estimate independent linear regressions of A1c, SBP, and DBP, and independent probit regressions of statin use and ODC status. The predicted marginal effects from these independent models are strikingly similar to our Bayesian results, though they exhibit the expected loss of statistical power. This sensitivity check is summarized in Supplementary Table 5.

Three CMPs drove improvement across multiple components and provided a large improvement in overall ODC: *1*) a systematic approach to identify and remind patients with diabetes who are due for testing (C24), *2*) providing after-visit follow-up by a nonclinician (C28), and *3*) providing guideline-based clinician reminders for preventive services during a clinic visit (C32).

CONCLUSIONS

We identified 18 of 62 CMPs that were significantly associated with improved diabetes care. This study provides a strong argument that these CMPs were the cause of specific improvements across a broad range of primary care practices. Study design elements that support a causal interpretation include *1*) adjustment for potential patient and practice level confounding variables, *2*) inclusion of practice-level effects to capture unobserved practice and average patient characteristics that did not vary over time, and *3*) longitudinal data that contribute to our ability to identify the impact of CMPs on patient outcomes. Nearly all practices had adopted some combination of the CMPs evaluated. We used the change in CMPs over time to measure the impact of adopting (or dropping) individual CMPs.

These data show some important differences from our previous cross-sectional work (23). The previous study provided an estimate of association, but the study design could not imply causality. In particular, the effects of shared decision-making (E1) have now disappeared, suggesting that improvements associated with E1 may have been due to a trend among high-performing practices adopting shared decision-making models. In addition, our current longitudinal work allows the previously reported impact of "providing guideline-based reminders of age-appropriate risk assessments (C33)" to be more precisely identified as the "provision of guideline-based reminders for age-appropriate preventive services when seeing the patient (C32)."

The findings underscore that CMPs influence clinical outcomes in very different ways. Blood pressure can be lowered by 13 distinct CMPs from improved information management and tracking systems, improved clinical management tools, and/or use of resources promoting self-management of weight and physical activity. However, most of these changes have little influence on A1c or statin use. Lowering

Table 4—Marginal effect of the 18 CMPs identified as statistically significant and combined maximum effect

	Change in A1c score	Change in SBP level	Change in DBP level	Change in probability statin used	Change in probability ODC criteria met
Information and tracking					
B1. Does your clinic have a system for tracking laboratory tests until results are available to the clinician?	−0.0012	−0.5772**	−0.3404**	0.0014	0.0114**
B3. Does your clinic have a system to provide alerts about clinically important abnormal test results to the doctors at the time they are received?	0.0350	−0.7254**	−0.5967**	−0.0074	−0.0057
B5. Does your clinic have a structured protocol for following up with patients when abnormal test results are identified?	0.0000	−0.3994**	−0.3163**	0.0033	0.0038
Chronic disease management					
C13. Does your clinic use its scheduling system to encourage patients to see their personal physician?	−0.0181	0.1112	−0.3250**	−0.0012	−0.0031
C15. Does your clinic use the following tools for managing patient care: Checklists of tests or interventions that are needed for prevention or monitoring of diabetes?	−0.0077	−0.3444**	−0.1052	0.0044	0.0087*
C23. Does your clinic have a systematic approach to identify and remind patients with chronic illnesses who are due for a follow-up visit?	0.0141	−0.1015	−0.3654**	−0.0059	−0.0085
C24. Does your clinic have a systematic approach to identify and remind patients with chronic illnesses who are due for testing (e.g., LDL test or dilated eye exam)?	−0.0412**	−0.3850*	0.0558	0.0016	0.0098*
C28. What components of care management are routinely provided to your patients with diabetes by someone other than a physician, PA or NP? After-visit follow-up	−0.0226*	−0.3371**	−0.0153	0.0007	0.0125**
C32. Does your clinic have guideline-based reminders for age-appropriate preventive services (e.g., influenza) when seeing the patient?	−0.0394	−0.5889**	−0.1369	0.0193**	0.0343**
Patient self-management					
D3. Does your clinic have a systematic process to screen or assess patients for the following risk factors: Alcohol/substance abuse?	0.0044	−0.2126	−0.0701	0.0114**	0.0112**
D8. Does your clinic provide or refer patients to formal support programs to assist in weight loss or management?	−0.0062	−0.9799**	−0.5233**	−0.0008	0.0129
D10. Does your clinic provide or refer patients to formal support programs to assist in physical activity?	−0.0012	−0.5129**	−0.2359**	−0.0023	0.0042
D11. Does your clinic provide or refer patients to formal support programs to assist in self-management of asthma?	−0.0115	0.0439	0.2010	0.0099**	0.0101
D13. Does your clinic provide or refer patients to formal support programs to assist in self-management of cardiovascular disease?	−0.0412**	−0.0517	−0.1038	−0.0050	0.0036
D17. Does your clinic routinely provide written materials that explain recommended medical care guidelines for their illness, to encourage patient self-management?	0.0214	−0.2469	−0.3143**	0.0038	0.0071
D18. Does your clinic have systems to encourage patient self-management for diabetes?	−0.0023	−0.4216**	−0.3189**	−0.0014	0.0059
D22. Does your clinic routinely use and exchange data with patients who have access to their own EHR or personal health record, to support self-management for patients and their families?	−0.0167	−0.5119**	−0.2352**	−0.0017	−0.0025
Performance measurement					
F1. Does your clinic have a formal process (i.e., a written plan with a set of procedures and defined	−0.0167	0.0610	−0.0912	0.0078**	0.0091**

Continued on p. 1768

Table 4—Continued

	Change in A1c score	Change in SBP level	Change in DBP level	Change in probability statin used	Change in probability ODC criteria met
end points for accountability) for measuring performance for individual physicians or for the practice site?					
Combined maximum effect of all 18 CMPs	−0.1514**	−6.2905**	−3.9206**	0.0394**	0.1214**

SBP and DBP are given in mmHg. A1c score denotes percentage hemoglobin A1c; statin used denotes met criteria for guideline-based statin use including contraindications. **The 99% Bayesian credible interval does not contain zero (analogous to $P < 0.01$), the basis of statistical significance in the study. *The 95% Bayesian credible interval does not contain zero (analogous to $P < 0.05$), indicating marginal significance.

A1c requires CMPs that proactively identify and remind patients of recommended testing or promoting educational resources for self-management. Solberg et al. (7) describe three stages in the evolution of diabetes care delivery, as primary care settings advance from individual physician practices to physician group practices to practices providing proactive patient support. The findings of Solberg et al. are consistent with the positive marginal effect we demonstrate among practices using a systematic approach to proactively identify and remind patients due for diabetes testing.

This study makes an important contribution to literature that is dominated by studies of medical home certification status. Very few studies have looked at granular measures of practice configuration (24). Our evaluation of 62 CMPs provides practical guidance in redesigning primary care delivery for diabetes. The adoption of CMPs with strong evidence of improving diabetes outcomes is fundamental to the evolution of better primary care services.

The current study has significant limitations. Although the data identify the average change in clinical performance, not all practices will experience the same change. Implementation of care processes may vary in consistency or quality, and different patient population mixes may respond differently to the implementation of a new process. In addition, synergies and temporal dependencies between CMPs are not identified by our model. To conserve statistical power and avoid accumulation of type 1 error, we do not attempt to identify interactions or threshold effects between CMPs.

The results we identify may not be generalizable to patients with conditions other than diabetes. Although global similarities exist in primary care delivery, our sample was limited to a single geographic region. Mandatory diabetes performance reporting in Minnesota provided comprehensive tracking of diabetes outcomes difficult to replicate elsewhere. Performance reports evaluate the last measure taken in a calendar year and may not accurately represent average control over the entire year.

Another limitation results from potential multicollinearity across CMPs. If CMPs tend to be implemented at the same time, this collinearity will reduce statistical power. While this does not alter the significance of identified CMPs, we may not have identified all important CMPs.

Implementing new CMPs can be disruptive in a busy practice. Although several CMPs demonstrate improvement, determining the best for an average practice requires additional consideration. Tracking laboratory tests (B1) significantly lowers BP, but the marginal effect of tracking laboratory tests is less than one-third of providing physician reminders for preventive services (C32). Substance abuse screening (D3) improves ODC; however, this change probably results from improved documentation of liver disease, increasing statin exemptions without changing clinical outcomes. Performance measurement (F1) increases statin use, but the impact is less than half that of C32. Since CMPs affect specific clinical outcomes differently, practices focusing on a particular clinical outcome should adopt CMPs effective for that outcome.

A balanced approach to quality improvement maximizes clinical improvement across multiple risk factors while limiting the disruption caused by introducing new services. Implementing patient reminders for tests (C24), after-visit follow-up (C28), and physician reminders for preventive services (C32) all provide a strong foundation for improving diabetes clinical outcomes (Fig. 1). These three CMPs account for about half (5.7 of 12.1%) of the total improvement in marginal effect size for ODC performance, 68% of A1c decrease, 21% of SBP reduction, and 55% of the increase in statin use. The support of these CMPs for providing proactive patient outreach and systematic visit-based care reinforces

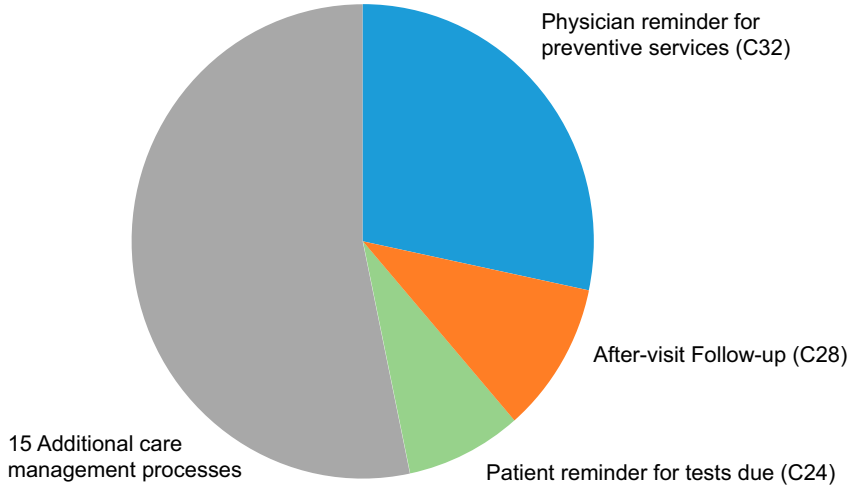

Figure 1—Contribution of statistically significant CMP to total improvement in optimal diabetes care.

previous work identifying these activities as the focus of high-performing practices (7).

CMPs that have not demonstrated significant improvement in outcomes may still be important for providing care. For example, adopting a diabetes registry (C1) may be necessary for the delivery of proactive care. Implementation of a diabetes registry alone, however, was not demonstrated as sufficient to improve outcomes. Other CMPs may alter processes or outcomes not measured by this study.

New quality improvement frameworks for diabetes care have catalyzed the worldwide emergence of partnerships to apply these frameworks to the diabetes population (35,36). The UNITED study provides important evidence that can help primary care practices identify the specific care management activities that effectively improve diabetes outcomes in an average primary care practice.

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