Research paper

Use of automated reminder letters to improve diabetes management in primary care: outcomes of a quality improvement initiative

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ABSTRACT

Background Effective management of patients with diabetes mellitus (DM) can be time-consuming and costly. One patient-centred quality improvement strategy is to generate reminder letters to prompt patient action(s), but this strategy's effect on DM outcomes is uncertain.

Aim To determine whether using the electronic medical record to automatically generate reminder letters for patients not meeting recommended DM targets is associated with improvement in practice-level quality metrics for DM management.

Methods Over 15 months, letters were sent monthly to all patients with DM in a large, urban, primary care teaching practice whose records for haemoglobin A_{1c} (HbA_{1c}), low-density lipoprotein (LDL) or blood pressure (BP) indicated non-compliance with recommended levels and testing intervals. Logistic regression was used to analyse cross-sectional, practice-level differences in the proportion of patients meeting DM quality metrics ($HbA_{1c} < 7\%$, $LDL < 100$ mg/dl and $BP < 130/80$ mmHg; rates of checking each value within the last 12 months; and a composite of these five measures) across four time points: six months before the intervention, start of the intervention, end of the 15-month intervention period and six months after the intervention.

Results The number of letters sent per month ranged from 284 to 392, representing 28–38% of all patients with DM. At the end of the intervention, patients' odds of being at goal were higher than before the intervention began for $LDL < 100$ mg/dl, and for HbA_{1c} and LDL tested once within the last 12 months (or 1.24, $P = 0.005$; or 1.35, $P = 0.03$; or 1.48, $P < 0.001$, respectively). Post intervention, declines were seen in LDL checked within the last 12 months (or 0.76, $P = 0.003$) and in the composite endpoint (or 0.78, $P = 0.005$).

Conclusions The automated patient-reminder letter intervention was associated with modest improvements in several, but not all DM measures. This approach may be an effective tool for improving quality of care for patients with DM.

Keywords: blood pressure, diabetes mellitus, HbA_{1c}, LDL cholesterol, quality improvement

How this fits in with quality in primary care

What do we know?
Diabetes mellitus (DM) is a major health concern in the USA. Primary care providers play a critical role in facilitating quality DM care where improvements can be time-consuming and costly. Electronic medical record (EMR) systems can be an efficient, patient-centred tool to enhance DM outcomes. There are conflicting results for the use of EMR-generated reminder letters to improve DM outcome and process measures. Few clinic-based studies have been published, and those studies have involved relatively small cohorts of patients.

What does this paper add?
Our quality improvement study utilised an EMR automated reminder letter system to co-ordinate care for approximately 1000 clinic-based patients with DM. Some process and outcome process measures were positively affected by the reminder system.

Introduction

Diabetes mellitus (DM) is one of the most common and costly chronic diseases worldwide.[1–4] A key focus for helping patients reduce their risk for complications from DM is helping them reach recommended target levels for glycosylated haemoglobin (HbA_{1c}), blood pressure (BP) and serum low-density lipoprotein (LDL). Specific targets based on 2008 American Diabetes Association standards are $HbA_{1c} < 7\%$, $LDL < 100$ mg/dl (in adults without cardiovascular disease) and systolic $BP < 130$ mmHg.[5] Despite strong evidence supporting the value of treatments to reduce these measures in patients with DM,[6] achievement of recommended levels in clinical care settings has been suboptimal.[7–9] For example, a review of data from the United States National Health and Nutrition Examination Survey found that only 7.3% of participants with DM had achieved all three recommended goals.[8,9]

In the USA, numerous quality improvement initiatives have been launched at national, state, and local levels to improve the management of patients with chronic disease.[10,11] Specifically for DM care, benefits have been reported for interventions that engage a co-ordinated team of healthcare professionals in patient care management, such as using dyads of nurse practitioners and primary care physicians,[12] or involving dieticians for the delivery of medical nutrition therapy.[13] However, the increased personnel time inherent in these approaches can be expensive. Another effective approach is self-management education for patients with DM,[14,15] but these programmes are also time-intensive. Sustainable interventions for the primary care setting must be not only effective, but also cost- and time-conscious.

One sustainable strategy may be the use of patient-reminder letters. Reminder letters have been shown to improve rates of Pap smear testing,[16–20] childhood and adult vaccinations,[21–23] colon cancer screening,[24,25] glucose tolerance testing in women with gestational diabetes[26] and breast cancer screening.[27,28] A few reports on the use of patient-reminder letters in DM have been published,[11,29–32] although results differ across studies. Some found that reminder letters improve adherence with DM process measures such as rate of checking LDL and HbA_{1c} or having retinal exams,[29,31,32] whereas other studies did not find statistically significant differences in testing rates.[30] The discordance in outcomes might be attributed to differences in sample size, study design (randomisation versus comparison to matched controls, alone or in combination with other interventions), or the specific intervention being tested. For example, one intervention included patient reminders as part of a multi-component strategy that also included physician-focused initiatives (audit and feedback, training in diabetes registry use).[29] Another approach included a financial incentive for patients who came in for screening.[32]

Despite a lack of consistency in specific outcomes, there is reasonable evidence from the literature to suggest a possible benefit to employing patient-reminder letters to improve DM care. Moreover, such a strategy has great potential for being scaled to large numbers of patients in a cost- and labour-effective manner – a critical feature for successful quality improvement initiatives within the setting of busy primary care practices.

We sought to test this premise directly by implementing and evaluating a new DM quality improvement initiative in our academic medical centre's busy primary care clinic. The initiative leveraged the clinic's electronic medical record (EMR) reporting software to automatically assess adult patients' compliance with recommended DM targets. Based on these patient-specific results (acquired monthly), letters were automatically generated and sent to individuals not meeting these targets. Our aim was to encourage increased compliance with diabetes care standards

and to improve the quality of diabetes care in our practice, while minimising the economic impact and time burden on clinic personnel. We evaluated the initiative by examining cross-sectional, practice-level differences in the proportion of patients meeting DM quality metrics (recommended levels of HbA_{1c}, LDL and BP; blood tests drawn or BP checked at recommended intervals; and a 5-point composite measure) across four time points falling before and after delivery of the 15-month-long intervention.

Methods

Practice setting and patient population

The quality initiative was implemented at the University of Minnesota Medical Center's Primary Care Clinic (hereafter referred to as the PCC) in Minneapolis, Minnesota. This urban, academic, practice setting has approximately ten full-time equivalent primary care providers (general internists and family medicine physicians), 18 internal medicine residents and 25 000 patient visits per year. The majority of patients receiving care at the PCC are insured, with approximately 20% covered by the US government's federal Medicare and Medicaid plans. Most patients are Caucasian (87%), between 16 and 65 years old (80.7%) and have at least a college-level education (84%).[33]

Patients were flagged for monthly, automated assessment of DM measures if they were aged 18 years and older, had a DM designation (type I or II) in their EMR problem lists, had been assigned a primary care provider in the clinic, and had been seen in the clinic within the last 24 months. Because the state of Minnesota's quality metrics (defined below) combined both types of diabetes, we did not separate our patients into two populations for our quality initiative. The provider designation in the EMR is filled in for patients prior to or at their first visit to the PCC. This designation is considered valid until it is determined that the patient is no longer being cared for by a clinic provider.

Quality initiative

The University of Minnesota Institutional Review Board approved the protocol for this quality improvement project and determined that it was exempt from the requirement for written informed consent. During the timeframe of our study, no other specific DM improvement initiatives were in progress at the PCC, except for a general focus on improving hypertension.

The patient-reminder initiative began in July 2008 after a brief pilot and was completed in October 2009.

Over this 15-month period, the EMR was automatically queried monthly to identify and print computer-generated reminder letters to patients with DM if they were not meeting target values or measurement interval criteria. Specifically, one letter was sent monthly to each patient with DM if one or more of the following was true: (1) their HbA_{1c} was > 7.0% and had not been checked in the last three months; (2) their LDL was > 100 mg/dl and had not been checked in the last three months; or (3) their BP was > 130/80 mmHg and had not been checked in the last month. Target levels for HbA_{1c}, LDL and BP were based on current guidelines.[5] The three- and one-month durations were chosen because by that time, any changes that providers and patients had made would likely have taken effect, and it would be reasonable to request a follow-up visit if a patient's outcome measures were still not at target. The strategy of sending letters reminding patients to attend follow up in the PCC was adopted because it was easily automated and integrated with the EMR and required no direct intervention by providers. Additionally, the letters could be copied back into the EMR database for each patient, thereby providing a means of on-going quality feedback with minimal additional effort.

Crystal Reports software (SAP Crystal Solutions) was used to automatically query the clinic's EMR database (Allscripts) and to generate and print the letters. The software combined the data for each patient into a letter with an address header, the reason for the letter, the values that were out of optimal range, and a request with instructions to contact the clinic for a follow-up appointment (Box 1). Specific provider names and signatures were not included. Clinic staff contacted patients by phone for any letters returned because of an invalid address. On a monthly basis, the software automatically populated a spread sheet with a list of all active patients in the clinic with DM along with their last values of HbA_{1c}, LDL and BP, and the dates on which those values were obtained. These data were formatted by an analyst working for the health-care organisation, and then provided to the investigators.

Quality metrics: DM outcome and process measures

To evaluate the impact of our quality improvement initiative, we examined changes in cross-sectional, practice-level, quality metrics for DM care at four time points: six months before the intervention started (T1, January 2008; $n = 1020$ patients with DM), at the start of the intervention (T2, July 2008; $n = 1021$), at the end of the intervention (T3, October 2009; $n = 1000$) and six months after the intervention ended (T4, April 2010; $n = 1025$). Data were collected around

Box 1 Example letter sent to patients

Name and Address   *Date*

Dear (Patient Name),

Please make an appointment with us within one month.

We have your blood glucose test results. Your haemoglobin A1C should be less than 7. As of (date) your A1C is (number).

Controlling your glucose is part of good diabetes control. It will help prevent health problems such as stroke, heart attack, blindness, loss of a limb or kidney failure.

We look forward to working with you to reach the goals of your treatment plan.

Sincerely,
Primary Care Center
University of Minnesota
(clinic phone number)

If your records show our data is not correct, please let us know. Thank You.

the 15th of each month. Consistent with a clinic-wide quality improvement approach, we calculated the percentage of all patients with DM – not just patients present at all four time points – who met a specific metric.

The quality metrics that we used were the percentage of patients meeting (yes/no) the following targets: (1) $HbA_{1c} < 7.0\%$, (2) LDL < 100 mg/dl, (3) BP < 130/80 mmHg, (4) HbA_{1c} checked within the last 12 months, (5) LDL checked within the last 12 months, (6) BP checked within the last 12 months and (7) a 5-point composite that combined the target levels for HbA_{1c}, LDL and BP and the target testing intervals for HbA_{1c} and LDL. We chose the 12-month data limit as a testing interval to be consistent with existing clinic quality metrics in Minnesota.[34] This testing interval is independent of how often we queried our medical records to evaluate patients' 'compliance' with the metric (monthly) and the duration of our reminder letter intervention (15 months). The state-wide composite measure included these five measures but also included BP checked within the last 12 months, appropriate aspirin use and no tobacco use. We had a high rate of compliance with each of these (96, 92 and 89%, respectively) with little variation starting six months prior to the study, so they were excluded from our composite number.

Statistical analysis

We used logistic regression to examine differences in the proportion of patients with DM meeting a specific quality metric at times T1 (six months before the intervention), T2 (start of the intervention), T3 (end of the 15-month intervention) and T4 (six months after the intervention ended). This statistical model was chosen because it is the principal regression model for analysis of binary outcome data (i.e. a patient did/did not meet a quality metric). We used Generalised Estimating Equations methodology to analyse correlated data arising from repeated measurements on the same individual over time. Outcomes at different time points were compared by using odds ratios (OR). *P*-values < 0.05 were considered statistically significant. All analyses were performed with SAS 9.1.3 (SAS Institute Inc., Cary, NC) statistical software.

Results

Intervention delivery

During each month of the quality initiative (from July 2008 to October 2009), an average of 329 letters were sent to individuals with DM who were not meeting one or more of the assessment criteria specified above. The number of letters sent per month ranged from 284 to 392, representing 28–38% of all patients with DM. The number of letters received by the same patient over the course of the study ranged from 0 to 12.

Descriptive statistics for quality metrics

Table 1 lists the proportion of patients with DM who successfully met the target measures at indicated time points. These proportions are presented graphically in Figure 1. Because nearly 100% of patients had their BP checked within the previous 12 months during the study, we do not report this process measure separately. Aside from BP testing, the highest percentages of patients being 'at goal' were observed for compliance with HbA_{1c} testing (range 89.8–93.2% of patients at goal over the four time points), followed by compliance with LDL testing (79.4–86.4%), LDL level (64.6–71.4%), BP level (52.7–61.6%), and HbA_{1c} level (49.6–55.2%). The composite measure was the most difficult target to reach, with only 18–21.9% of patients achieving this at any time point.

Analysis of cross-sectional differences in quality metrics

We used logistic regression to determine whether the observed changes in quality metrics across time points were statistically significant. Table 1 shows the OR for meeting DM targets when the values at each time point are compared to the value at T1 (six months before the intervention started). Table 2 shows the OR for meeting DM targets when the values at each time point are compared to values at adjacent time points; an increase in an OR during the intervention (T2 to

Table 1 Odds of meeting target measures for diabetes mellitus (DM), compared with six months prior to the start of the quality initiative (time T1)

DM target measure	Time	% of DM patients meeting target[a]	Odds ratio (95% CI) compared with T1	P
$HbA_{1c} < 7.0\%$	T1, six months before	55.2	1	–
	T2, start intervention	53.2	0.94 (0.85–1.04)	0.25
	T3, end intervention	51.2	0.85 (0.74–0.97)	**0.02**
	T4, six months after	49.6	0.77 (0.67–0.88)	**< 0.001**
LDL < 100 mg/dl	T1, six months before	64.6	1	–
	T2, start intervention	66.4	1.11 (0.99–1.23)	0.06
	T3, end intervention	71.4	1.38 (1.18–1.62)	**< 0.001**
	T4, six months after	68.4	1.24 (1.06–1.45)	**0.006**
BP < 130/80 mmHg	T1, six months before	52.7	1	–
	T2, start intervention	59.1	1.28 (1.11–1.47)	**< 0.001**
	T3, end intervention	61.6	1.39 (1.19–1.64)	**< 0.001**
	T4, six months after	58.2	1.24 (1.05–1.45)	**0.01**
HbA_{1c} checked within 12 months	T1, six months before	89.8	1	–
	T2, start intervention	91.2	1.07 (0.85–1.34)	0.58
	T3, end intervention	93.2	1.44 (1.09–1.91)	**0.01**
	T4, six months after	92.6	1.29 (0.97–1.70)	0.08
LDL checked within 12 months	T1, six months before	79.4	1	–
	T2, start intervention	80.7	1.02 (0.86–1.21)	0.83
	T3, end intervention	86.4	1.51 (1.22–1.87)	**< 0.001**
	T4, six months after	82.9	1.15 (0.94–1.41)	0.18
5-point composite[b]	T1, six months before	18.0	1	–
	T2, start intervention	19.8	1.11 (0.92–1.34)	0.27
	T3, end intervention	21.9	1.22 (0.99–1.50	0.06
	T4, six months after	18.1	0.95 (0.77–1.18)	0.64

[a] Number of clinic patients with DM = 1020 at T1, 1021 at T2, 1000 at T3 and 1025 at T4. [b] Met if all of the other five targets are simultaneously met.
P values in bold are less than or equal to 0.05 and are associated statistically significant observations.
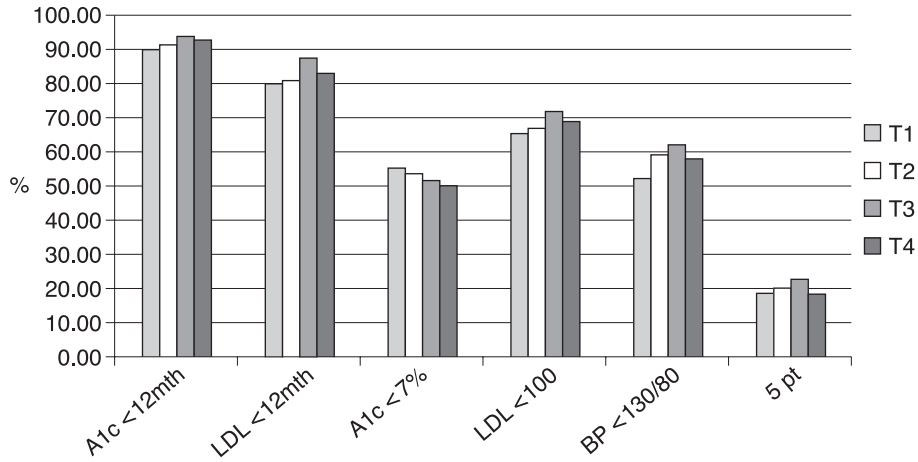
Figure 1 Percentage of patients meeting targeted measures at each time point

T1 = six months prior to intervention, T2 = start of intervention, T3 = end of intervention, T4 = six months after intervention. The 5-point composite measure was met if all of the other five measures were simultaneously met

Table 2 Odds of meeting target measures for diabetes mellitus (DM) within each time interval

DM target measure	Time interval	Odds ratio (95% CI) comparing adjacent time points	P
$HbA_{1c} < 7.0\%$	T1 vs. T2, pre-intervention	0.94 (0.85–1.04)	0.25
	T2 vs. T3, intervention	0.90 (0.79–1.02)	0.10
	T3 vs. T4, post intervention	0.91 (0.82–1.00)	0.051
LDL < 100 mg/dl	T1 vs. T2, pre-intervention	1.11 (0.99–1.23)	0.06
	T2 vs. T3, intervention	1.24 (1.07–1.45)	**0.005**
	T3 vs. T4, post intervention	0.90 (0.81–1.00)	0.06
BP < 130/80 mmHg	T1 vs. T2, pre-intervention	1.28 (1.11–1.47)	**< 0.001**
	T2 vs. T3, intervention	1.09 (0.93–1.28)	0.29
	T3 vs. T4, post intervention	0.89 (0.77–1.02)	0.09
HbA_{1c} checked within 12 months	T1 vs. T2, pre-intervention	1.07 (0.85–1.34)	0.58
	T2 vs. T3, intervention	1.35 (1.03–1.77)	**0.03**
	T3 vs. T4, post intervention	0.89 (0.69–1.15)	0.37
LDL checked within 12 months	T1 vs. T2, pre-intervention	1.02 (0.86–1.21)	0.83
	T2 vs. T3, intervention	1.48 (1.21–1.82)	**< 0.001**
	T3 vs. T4, post intervention	0.76 (0.63–0.91)	**0.003**
5-point composite[a]	T1 vs. T2, pre-intervention	1.11 (0.92–1.34)	0.27
	T2 vs. T3, intervention	1.10 (0.91–1.33)	0.34
	T3 vs. T4, post intervention	0.78 (0.66–0.93)	**0.005**

[a] Met if all of the other five targets are simultaneously met.
P values in bold are less than or equal to 0.05 and are associated statistically significant observations.

T3) or a decrease during the post-intervention period (T3 to T4) would suggest that the intervention was associated with a favourable impact. To ensure that there was no special variation in values at the four time points we selected for analysis, we also compared values at two months before and two months after each time point. Although our chosen value for any particular measure may have been the highest or lowest number within those time frames, there was no systematic variation across the measures that would alter the overall conclusions.

Changes in quality metrics for HbA$_{1c}$, LDL and BP levels

As shown in Table 1, the odds of a patient being at goal for HbA$_{1c}$ level declined at each time point (suggesting a lack of favourable impact of intervention), with the differences at T3 and T4 compared with T1 reaching statistical significance (51.2% vs. 55.2%, OR = 0.85, $P = 0.02$; and 49.6% vs. 55.2%, OR = 0.77, $P < 0.001$, respectively). Conversely, the odds of reaching the target LDL level increased over time (suggesting a favourable impact of intervention), with the differences at T3 and T4 compared with T1 reaching statistical significance (71.4% vs. 64.6%, OR = 1.38, $P < 0.001$ and 68.4% vs. 64.6%, OR = 1.24, $P = 0.006$, respectively). The proportion of patients achieving recommended BP levels was significantly higher at all time points compared with T1.

As shown in Table 2, patients were more likely to be at goal for LDL at the end of the intervention period than at the start of the intervention (T3 vs. T2, OR = 1.24, $P = 0.005$). The improvements seen at T3 subsequently declined, but not significantly, by six months post intervention. The proportion of patients at goal for BP level significantly increased during the pre-intervention period only (OR = 1.28, $P < 0.001$).

Changes in quality metrics for HbA$_{1c}$ and LDL testing rates

Table 1 shows that there was a significant increase at T3, compared with T1, in the likelihood of patients having had their HbA$_{1c}$ checked within the last 12 months (93.2% vs. 89.8%, OR = 1.44, $P = 0.01$) and LDL checked within the last 12 months (86.4% vs. 79.4%, OR = 1.51, $P < 0.001$). Both of these quality metrics significantly improved during the intervention period (T2 vs. T3, see Table 2). Whereas both metrics declined by six months post intervention, the decline was significant only for LDL testing rate (T3 vs. T4, OR = 0.76, $P = 0.003$).

Changes in the 5-point composite measure

For the composite measure, one significant difference was observed: a decline in the proportion of patients meeting this metric during the post-intervention time interval (T3 vs. T4, OR = 0.78, $P = 0.005$).

Discussion

Our findings demonstrate that a strategy of automatically generating reminder letters for patients with DM who are not meeting recommended clinical targets is feasible on a broad scale and may positively affect patient outcomes. Three practice-level quality metrics for DM care – compliance with recommended LDL levels and rates of testing for LDL and HbA$_{1c}$ – improved in our primary care setting by using simple, automated letters enabled by the EMR. Improvement was indicated by stability in the three measures during the six-month pre-intervention interval, followed by modest, but significant increases in the proportion of patients meeting targets during the intervention period. For the LDL process measure, a significant decline was also seen by six months after the end of the intervention, which could suggest an intervention-specific effect.

Although the magnitude of the observed improvements over 15 months was relatively small (2.0–5.7%), these modest gains are in alignment with those observed in other studies of reminder letters to improve clinical goals. Lafata, for example, showed statistically improved rates of diabetes testing and outcomes in patients who received letters versus those who did not, but the absolute increase in improvement only ranged from 3.2 to 5.0%.[31] Similarly, increases of approximately 6–10% in testing rates were reported in studies of patient-reminder interventions focused on Pap smears,[19,20] colon cancer screening[24] and mammography.[27,28] Because the financial and time investment needed to implement a patient-reminder quality initiative is minimal compared with many other approaches,[3,4] such small improvements may be justified, particularly for high volume clinical settings.

Despite our success in improving the proportion of patients whose HbA$_{1c}$ levels were checked within the last 12 months, the odds of achieving the HbA$_{1c}$ < 7.0% outcome actually declined at each time point. This may reflect the reality that control of elevated cholesterol and blood pressure is easier to accomplish with medication changes during a single office visit than control of HbA$_{1c}$. Multiple medication regimens, more frequent visits, regular self-monitoring of blood glucose, risks of hypoglycaemia and increased body weight are potential obstacles to optimising HbA$_{1c}$, necessitating substantial effort by clinicians and patients.

During the pre-intervention period, we expected and observed little change in the quality metrics, except for an improvement in the proportion of patients with a BP < 130/80 mmHg. For the BP outcome, the trend toward improvement was seen before the intervention started and persisted after the intervention ended. We attribute this to on-going clinic-wide quality improvement efforts focused on BP.

During the timeframe of our study, no other specific DM improvement initiatives were in progress at the PCC. Even so, we cannot definitively exclude an effect of secular trends in the community at large on

our observed outcomes. A design that compared patients receiving automated letters and patients not receiving letters might have helped account for the potential influence of institutional and/or secular trends. However, the nature of quality improvement studies is to allow all patients to potentially benefit from a given intervention and to encourage intervention modification over time in response to obstacles and outcomes.[35]

Our study looked at a snapshot in time each month for the entire clinic population of patients with diabetes. We did not track individual patients to assess whether receiving one or more letters resulted in a visit. Instead, we implemented an efficient, automated patient-reminder protocol and assessed outcomes of the entire clinic population to track practice-wide improvements. Future studies designed to follow individual patients over time could be conducted, including an assessment of whether clinic appointments and other outcomes are dependent on the number of letters sent.

Additional study limitations must be acknowledged. Our quality initiative relied on the accuracy of the EMR problem lists used to generate the automated letters. If these contained errors, we may not have included the entire cohort of patients in the clinic with DM, or (less likely) some patients may have been included due to being mislabelled as having DM. We also did not determine whether automated letters sent to patients who were already achieving target goals might further improve their level of care. Lastly, we do not know how representative our sample was relative to national samples or patient populations in other primary care or specialty medical clinics (e.g. endocrine clinics).

In summary, a quality improvement strategy that leveraged the EMR to automatically generate and send letters to patients with DM who were not meeting HbA_{1c}, LDL or BP goals was associated with improvement in LDL outcomes and with process measures such as checking HbA_{1c} and LDL. Use of automated letters was not associated with improved HbA_{1c} outcomes. The strategy imposed little additional cost and time burden on providers. It may be an effective tool to improve DM care, either alone or in combination with other approaches for improving diabetes management in primary care settings.[36] Moreover, the automated approach could potentially be extended to other quality improvement initiatives for preventive healthcare.

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REFERENCES

1 Danaei G, Finucane MM, Lu Y *et al*. National, regional, and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2.7 million participants. *The Lancet* 2011;378(9785):31–40. PubMed PMID: 21705069

2 World Health Organization. *Diabetes Fact Sheet*. World Health Organization: Geneva, 2013. www.who.int/mediacentre/factsheets/fs312/en

3 American Diabetes Association. Economic costs of diabetes in the US in 2012. *Diabetes Care* 2013;36:1033–46. PubMed PMID: 23468086

4 Gilmer TP, O'Connor PJ, Manning WG and Rush WA. The cost to health plans of poor glycemic control. *Diabetes Care* 1997;20:1847–53. PubMed PMID: 9405905

5 American Diabetes Association. Standards of medical care in diabetes – 2008. *Diabetes Care* 2008;31(Suppl 1):S12–54.

6 American Diabetes Association. Standards of medical care in diabetes – 2013. *Diabetes Care* 2013;36(Suppl 1):S11–66.

7 Saaddine JB, Cadwell B, Gregg EW *et al*. Improvements in diabetes processes of care and intermediate outcomes: United States, 1988–2002. *Annals of Internal Medicine* 2006;144:465–74. PubMed PMID: 16585660

8 NHANES current data files. National Center for Health Statistics, Centers for Disease Control and Prevention: Atlanta, GA. www.cdc.gov/nchs/about/major/nhanes/NHANES99_00.htm (updated 11/07/13).

9 Saydah SH, Fradkin J and Cowie CC. Poor control of risk factors for vascular disease among adults with previously diagnosed diabetes. *JAMA* 2004;291:335–42. PubMed PMID: 14734596

10 Wagner EH. The role of patient care teams in chronic disease management. *BMJ* 2000;320(7234):569–72. PubMed PMID: 10688568

11 Shojania KG, Ranji SR, McDonald KM *et al*. Effects of quality improvement strategies for type 2 diabetes on glycemic control: a meta-regression analysis. *JAMA* 2006;296:427–40. PubMed PMID: 16868301

12 Litaker D, Mion L, Planavsky L, Kippes C, Mehta N and Frolkis J. Physician–nurse practitioner teams in chronic disease management; the impact on costs, clinical effectiveness, and patients' perception of care. *Journal of Interprofessional Care* 2003;17:223–37. PubMed PMID: 12850874

13 Franz MJ, Monk A, Barry B *et al*. Effectiveness of medical nutrition therapy provided by dieticians in the management of non-insulin-dependent diabetes mellitus: a randomized controlled clinical trial. *Journal of the American Dietetic Association* 1995;1009–17. PubMed PMID: 7657902

14 Norris SL, Lau J, Smith SJ, Schmid CH and Engelgau MM. Self-management education for adults with type 2 diabetes: a meta-analysis of the effect on glycemic control. *Diabetes Care* 2002;25:1159–71. PubMed PMID: 12087014

15 Deakin TA, McShane CE, Cade JE and Williams R. Group-based training for self-management strategies in people with type 2 diabetes results (Cochrane Re-

view). *The Cochrane Library Issue 2, 2005.* Update Software: Oxford. PubMed PMID: 15846663

16 Morrell S, Taylor R, Zeckendorf S *et al.* How much does a reminder letter increase cervical screening among under-screened women in NSW? *Australian and New Zealand Journal of Public Health* 2005;29:78–84. PubMed PMID: 15782877

17 Karwalajtys T, Kaczorowski J, Lohfeld L *et al.* Acceptability of reminder letters for Papanicolou tests: a survey of women from 23 family health networks in Ontario. *Journal of Obstetrics and Gynaecology Canada* 2007; 29:829–34. PubMed PMID: 17915066

18 De Jonge E, Cloes E, Op de Beeck L *et al.* A quasi-randomized trial on the effectiveness of an invitation letter to improve participation in a setting of opportunistic screening for cervical cancer. *European Journal of Cancer Prevention* 2008;17:238–42. PubMed PMID: 18414195

19 Heranney D, Fender M, Velten M and Baldauf JJ. A prospective randomized study of two reminding strategies: telephone versus mail in the screening of cervical cancer in women who did not initially respond. *Acta Cytologica* 2007;55:334–40. PubMed PMID: 21791902

20 Tsent DS, Cox E, Plane MB and Hla KM. Efficacy of patient letter reminders on cervical cancer screening. A meta-analysis. *Journal of General Internal Medicine* 2001;16:563–8. PubMed PMID: 11556935

21 Baker AM, McCarthy BD, Gurley VF and Ulcickas YM. Influenza immunization in a managed care organization. *Journal of General Internal Medicine* 1998;13:469–75. PubMed PMID: 9686713

22 Jacobson Vann JC and Szilagyi P. Patient reminder and recall systems to improve immunization rates (Cochrane Review). *The Cochrane Library Issue 3, 2005.* Update Software: Oxford. PubMed PMID: 16034918

23 Thomas RE, Russell M and Lorenzetti D. Interventions to increase influenza vaccination rates of those 60 years and older in the community (Cochrane Review). *The Cochrane Library Issue 9, 2010.* Update Software: Oxford. PubMed PMID: 20824843

24 Sequist TD, Zaslavsky AM, Marshall R, Fletcher RH and Ayanian JZ. Patient and physician reminders to promote colorectal cancer screening: a randomized controlled trial. *Archives of Internal Medicine* 2009;169:364–71. doi: 10.1001/archinternmed.2008.564. PubMed PMID: 19237720

25 Lee JK, Reis V, Liu S *et al.* Improving fecal occult blood testing compliance using a mailed educational reminder. *Journal of General Internal Medicine* 2009; 24:1192–7. PubMed PMID: 19774423

26 Clark HD, Graham ID, Karovitch A and Keely EJ. Do postal reminders increase postpartum screening of diabetes mellitus in women with gestational diabetes mellitus? A randomized controlled trial. *American Journal of Obstetrics and Gynecology* 2009;200:634.e1–7. doi: 10.1016/j.ajog.2009.01.003. PubMed PMID: 19268878

27 Wager TH. The effectiveness of mailed patient reminders on mammography screening: a meta-analysis. *American Journal of Preventive Medicine* 1998;14:64–70. PubMed PMID: 9476837

28 Richardson JL, Mondrus GT, Danley K *et al.* Impact of a mailed intervention on annual mammography and physician breast examinations among women at high risk of breast cancer. *Cancer Epidemiology, Biomarkers & Prevention* 1996;5:71–6. PubMed PMID: 8770470

29 Thomas KG, Thomas MR, Stroebel RJ *et al.* Use of a registry-generated audit, feedback, and patient reminder intervention in an internal medicine resident clinic – a randomized trial. *Journal of General Internal Medicine* 2007;22:1740–4. PubMed PMID: 17973175

30 Chaudhry R, Tulledge-Scheitel SM, Thomas MR *et al.* Clinical informatics to improve quality of care: a population-based system for patients with diabetes mellitus. *Informatics in Primary Care* 2009;17:95–102. PubMed PMID: 19807951

31 Lafata JE, Baker AM, Divine GW *et al.* The use of computerized birthday greeting reminders in the management of diabetes. *Journal of General Interal Medicine* 2002;17:521–30. PubMed PMID: 12133142

32 Austin S and Wolfe BL. The effect of patient reminders and gas station gift cards on patient adherence to testing guidelines for diabetes. *Wisconsin Medical Journal* 2011; 110:132–7. PubMed PMID: 21748998

33 Abraham J, Sick B, Anderson J, Berg A, Dehmer C and Tufano A. Selecting a provider: what factors influence patients' decision making? *Journal of Healthcare Management* 2011;56:99–114; discussion 114–15. PubMed PMID: 21495529

34 MN Community Measurement. Minnesota Health-Scores: Diabetes. 2007–2009. www.mnhealthscores.org (updated 04/0411; accessed 23/04/11).

35 Wagner EH, Glasgow RE, Davis C *et al.* Quality improvement in chronic illness care: a collaborative approach. *Joint Commission Journal of Quality Improvement* 2001; 27(2):63–80. PubMed PMID: 11221012

36 Stellefson M, Dipnarine K and Stopka C. The chronic care model and diabetes management in US primary care settings: a systematic review. *Preventing Chronic Disease* 2013;10:E26. PubMed PMID: 23428085

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PEER REVIEW

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CONFLICTS OF INTEREST

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