

Trial of Decision Support to Improve Diabetes Outcomes

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Principal Investigator:
Randall D. Cebul, MD

Team members:

Neal V. Dawson, MD*
Douglas Einstadter, MD*
Peter Greco, MD*
Thomas Love, PhD*
Mark Votruba*

Mary Joan Roach, PhD[†]
Scott Husak^{††}
C. Martin Harris, MD[§]
Anil Jain, MD*
Betty Vandebosch, PhD*, [‡]

*Investigator
[†] Project Manager
^{††} Statistician

[§] Cleveland Clinic Foundation PI
[‡] Case Western Reserve University

Performing Organization:
MetroHealth Medical System

Project Officer:
Robert Borotkanics, PhD

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The Agency for Healthcare Research and Quality (AHRQ)
U.S. Department of Health and Human Services
540 Gaither Road
Rockville, MD 20850
www.ahrq.gov

Abstract

Purpose: To estimate the effects of EMR-centered diabetes decision support (CDS-DM²) on: 1) quality; and 2) utilization. Secondary analyses examine adoption of CDS.

Scope: 200 physicians in 24 practices of two health systems.

Methods: Parallel 2-year trials with a common feature (DM²) across the systems. System A compared DM² with EMR alone; DM² included real-time clinical decision support for physicians. System B's groups included: patient portal access to their records (EMR-PA); EMR-PA enhanced by diabetes-specific features (PA-E); and PA-E plus DM² (Both). Quality was measured by changes in: 1) A1c levels; and 2) an 8-item ADA score, sub-divided into patient-centered⁵ and MD-centered³ components.

Results: There were no significant cross-group changes in A1c levels associated with DM², borderline improvements in the ADA-8 score, and significant 25% relative improvements in the 3-item MD-centered sub-score (p<0.001). DM² was associated with a 20% reduction in hospitalizations (p=0.01) but no significant reductions in ED or primary care visits. There was more web portal adoption among patients in the PA-E and "Both" groups as compared to PA alone.

CDS substantially improved physician-centered, but not patient-centered, quality measures, and it appears to have improved hospitalization rates. Disease-enhanced features may increase patient web-portal use.

Key Words: Diabetes, Health Information Technology, Decision Support

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Final Report

Purpose

Diabetes is epidemic in the United States and the most common cause of adult blindness, amputations, kidney failure and cardiovascular disease. The disease and its complications are more prevalent among African-Americans and Hispanics than among Caucasian Americans. The CDC estimates that 90% of these complications could be eliminated if we closed the gap between what is possible and what is actually done in the care of diabetic patients. Much of this care depends on physician decision-making in clinical settings, while a growing body of work also highlights the key roles of patient-centered self-management and contextual variables, such as the adequacy of health insurance.

Whether electronic medical record (EMR)-catalyzed clinical decision support (CDS) can help close the gap is unclear. Approaches that are now possible include sophisticated CDS focused on physicians and helping their practices undertake disease management for diabetes (DM²) as well as patient-centered web-portal access (PA) CDS that can be enhanced by disease-specific features (PA-E). Whether disease-specific enhancements to PA coupled with physician-centered CDS (PA-E plus DM²) could be synergistic for improving patient outcomes is untested.

In the current investigation, we examine the quality and utilization-related effects of CDS on patients with diabetes in 24 practice sites of two large health care systems. Parallel 2-year cluster trials were undertaken that included a common feature (DM²). Specific aims include:

Primary Aim 1. To estimate the incremental effects of DM² on patient quality measures, including changes in Hemoglobin A1c levels and a composite 8-item ADA score, further divided into sub-scores related to patient-centered standards (ADA-5) and physician-centered standards (ADA-3).

Secondary Aim 1a. To estimate the effects of insurance on baseline glycemia, adjusting for patient demographics, clinical co-morbidities and adherence-related measures, census-derived contextual measures, and site of care.

Secondary Aim 1b. To estimate the incremental effects of DM² on patient quality measures in specific sub-groups, including race/ethnicity and insurance status (Medicare, Commercial, Medicaid, Uninsured).

Primary Aim 2. To estimate the incremental effects of DM² on health services utilization, overall, and in categories divided according to desirability.

Secondary Aim 2a. To estimate the incremental effects of DM² on health services utilization in specific sub-groups, including race/ethnicity and insurance status, as above.

Secondary Aim 3. To examine adoption of our CDS interventions, including physician adoption of and satisfaction with DM² and patient adoption of PA, PA-E, and PA-E plus DM² (Both).

Secondary Aim 4. To describe general and intervention-specific unintended consequences of our interventions, including consequences related to patient safety and care for co-morbid illnesses.

Scope

Background and Significance

Epidemiology of Diabetes: Burden of Suffering and Cost. Diabetes is a chronic and costly disease associated with multiple co-morbid illnesses¹. Affecting more than 18 million Americans¹ it is an independent risk factor for cardiac disease and stroke, two of the three major causes of death in the United States, and it is the most common cause of end stage kidney disease and blindness among adults². In addition to \$132 billion in direct medical costs each year, diabetes is estimated to cost society another \$40 billion in indirect costs due to lost productivity.¹

Type 1 diabetes is a disease largely of children and young adults, while Type 2 diabetes is a disease mostly of adults that has been linked to obesity and insulin resistance³. Type 2 diabetes accounts for 90-95% of prevalent cases. The prevalence of diagnosed diabetes has increased 61% since 1991, to 6.9%, and it is projected to more than double by 2050⁴⁻⁶. Hispanics and non-Hispanic blacks have both a greater prevalence of diabetes^{7,8} and an anticipated greater increase in diabetes incidence during this time⁴. Using data from the National Health Interview Survey, Narayan and colleagues⁹ estimated the lifetime risk of developing diabetes for individuals born in the year 2000 as an astonishing 32.8% for males and 38.5% for females, with the greatest lifetime risk among Hispanics (males, 45.4% and females, 52.5%).

Clinical Epidemiology of Diabetes: Care and Outcomes. The complex relationships of diabetes care to outcomes can be summarized by describing the influence of glycemic control on outcomes and by evidence about the preventability of diabetes' major complications. Glycemic control, as reflected by hemoglobin A1c (A1c) values, is felt to be fundamental to prognosis and management. The average A1c value among nondiabetic adults is 5.2%, and, among American Type 2 diabetics, 7.8%¹⁰. Analyses of the U.K. Prospective Diabetes Study (UKPDS), a randomized controlled trial of intensive as compared to standard treatment of Type 2 diabetics^{11,12}, estimated a 14% reduction in all-cause mortality and myocardial infarction for every 1% absolute reduction in A1c¹³; this relationship appears to be linear, with no threshold or lower limit of A1c at which further lowering has no benefit^{2,13}. Cardiovascular disease (CVD) is the cause of death in about 65% of diabetics², and is accelerated by the frequently coexisting conditions of hypertension and dyslipidemias¹⁴. In addition to direct evidence from the UKPDS trial favoring aggressive glycemic control, expert consensus has targeted specific blood pressure levels and low density lipoprotein (LDL) cholesterol values that should be achieved in diabetics to favorably affect CVD risk². End-stage renal disease (ESRD) affects about 43,000 diabetics annually, and is presaged by the occurrence of microalbuminuria². Importantly, progression to

ESRD can be retarded by treatment with specific classes of medicines ('ACE' inhibitors and 'ARBs') (15-18) and by aggressive glycemic and blood pressure control (2,11,12). Diabetic eye disease affects about 13,000 diabetics in the U.S. each year, and is presaged by vascular changes that can be identified on retinal examination. Once neovascular changes have been identified, the incidence of blindness can be substantially reduced by treatment with panretinal photocoagulation surgery (19-23), resulting in recommendations for annual dilated eye examinations in diabetics². The CDC estimates that attention to these measures could reduce the incidence of diabetes-related CVD mortality by about 30%, ESRD by about 50%, and blindness by 90%¹.

Health Services Research in Diabetes: Quality and Safety in Diabetes Care. The data above imply a major gap between what is possible to achieve and our current performance in diabetes care. These data also highlight the multitude of care processes that are required to achieve optimal diabetes outcomes – including screening, monitoring, specialist referrals, and medical and non-medical treatment of diabetes, its complications, and its co-existing conditions. A variety of interventions to improve diabetes care and outcomes have been investigated, including patient empowerment and self-management (24,25), disease and case management (26-29), and approaches that use health information technology (HIT) to provide decision support for providers or their diabetic patients (30-35). Self-management programs are motivated by evidence of significant deficits in knowledge and skill in as many as 80% of people with diabetes (24,36). The effectiveness of patient training in self-management has been summarized in a systematic review of studies that have collectively demonstrated positive effects on knowledge and self-reported behaviors (e.g. blood glucose monitoring) and short-term improvements in glycemic control, but variable effects on other measures (24,25). The literature highlights the importance of patient education and engaging the diabetic in her own care. This research is amplified by the work of Peterson and colleagues³⁷, which demonstrated a strong linear relationship between a diabetic patient's "readiness to change" and changes in her A1c values after a diabetes educational program. Disease management and case management approaches for diabetes care have been used singly and in combination²⁴. Diabetes disease management programs focus health care on systems (e.g., guidelines, information systems) to monitor care and outcomes for all diabetic patients/enrollees, whereas case management programs typically develop individual care plans for that are "managed" by an individual who typically is not a provider of direct medical care. In a systematic review by Norris et al.²⁸, both approaches have been shown to have significant albeit modest and mostly short-term effects on glycemic control²⁸. Collectively, disease/case management interventions have demonstrated their ability to effect moderate improvements in process of care measures (24,28). They have been less effective in demonstrating significant changes in A1c levels – with experimental vs. control group differences typically being on the order of 0.3-1.0% - and have rarely reported favorable effects on other important intermediate outcome variables, such as weight control, lipid levels, and blood pressure. Notable for their absence in these studies are investigations of the appropriate use of statins for management of dislipidemias and the use of ACE inhibitors or ARBS for treatment of proteinuria.

Use of Health Information Technology to Improve Care. While many argue that HIT has the potential to improve patients' health and quality of life³⁸, there has been considerable disagreement about which technologies to use, how much is enough or too much, and whether

the technologies are providing value for the money spent^{39,40}. Decision support systems have shown a great deal of promise in reducing errors⁴¹⁻⁴⁴. Computer-based decision support interventions have also been shown to improve physicians' compliance with outpatient preventive care^{45,46}, inpatient preventive care⁴⁷ and inpatient drug-monitoring guidelines^{43,48}. However, few studies of computer-based decision support have assessed patient outcomes and only a small proportion of them have found benefits. Hunt and colleagues⁴⁹ conducted a systematic review of 68 studies of the effects of clinical decision support systems on physician performance and patient outcomes. Only 14 studies assessed patient outcomes and only 6 documented benefit⁴⁹. In a more recent review, Kaplan⁵⁰ found that studies examining the effects of decision support systems on patient outcomes showed little improvement and raised concern about clinician adoption.

To date, research on clinical decision support systems has not convincingly demonstrated its effectiveness in the management of chronic diseases^{50,51}. For example, Meigs and colleagues³⁰ tested the effectiveness of a web-based decision support tool to improve evidence-based management of Type 2 diabetes. Although they found modest but significant increases in rates of testing for levels of A1c and LDL cholesterol, there were no significant improvements in glycemic and lipid control. Tierney and colleagues⁵² tested the effect of an intensive, computer-based, intervention to reduce errors of omission among patients with heart disease. Although opportunities to improve care were frequent, the intervention had no positive effect on either adherence to the guidelines or any patient outcomes, principally because physicians lacked enthusiasm and thought the guidelines were oversimplified "cookbook" medicine. A similar study of patients who had asthma or angina found that the median number of times physicians accessed the decision support system was zero, despite substantial work to make it user friendly³².

It would seem that systems that merely provide additional information to the physician fail to improve effectiveness of care for chronic medical conditions. Older systems may be more effective for triggering "1-time" events than for ongoing management of a chronic medical condition, underscoring the need for HIT solutions that incorporate the key principles of delivering effective chronic illness care, particularly improved care coordination and patient self-management support that activates patients to participate in their own care⁵¹. For example, Zrebiec and Jacobson⁵³ describe a web-based system used by diabetics or their family members to exchange ideas and experiences in a mediated forum. Topics that the website covered included motivation, emotion, blood glucose levels and complications. The website logged over 45,000 visits over a 21 month period, although no information about outcomes was provided. In summary, there are several examples of promising web-based support systems for chronic disease management. Although the promise of the systems are immense, results to date have been mixed, and clear evidence of improved patient outcomes is largely lacking.

Unintended Consequences. The implementation of any technology including HIT is not without the risk of unintended consequences. Becher and Chassin⁵⁴ identify two ways that physicians make errors: through lack of knowledge or skill (error of omission) and through slips and attention lapses (error of commission). The authors acknowledge the benefit of information and technology, but recognize that increasing complexity increases the probability of the two types of error. In the management context, Schultze and Vandebosch⁵⁵ found that the overabundance of information provided by an information system results in an increasingly complex work environment. This in turn leads to a greater reliance on information and increased

information intensity, increasing the likelihood of errors due to information overload. The authors suggest the need for additional processing of information in order to provide the right information to the right person at the right moment.

Information overload can lead professionals to trust the course suggested by the computer more than is actually called for⁵⁶. Studies have also shown that HIT can impose additional work tasks on healthcare professionals⁵⁷. In an extensive review of qualitative studies, Ash et al.⁵⁸ reported many instances in which HIT applications seem to foster errors rather than reduce their likelihood. They have stressed the need of multidisciplinary research to ensure better understanding of work flow, systems design, and IT implementation in health care.

Cost and Financial Benefits of Health Information Technology. While published evidence on the value of health information technology is scarce, for the most part, it points toward positive financial benefits. In a cost-benefit analysis of electronic medical records in primary care, Wang et al.⁵⁹ estimated a net benefit of \$86,400 per provider over a 5-year period. Benefits occurred primarily from savings in drug expenditures, appropriate utilization of radiology tests, better capture of charges, and decreased billing errors. In early work, Tierney and colleagues⁶⁰ found that automated order entry resulted in a 12.7 percent decrease in total charges and a 0.9 day decrease in length of stay. LDS Hospital demonstrated that a program that assisted with antibiotic management resulted in a fivefold decrease in the frequency of excess drug dosages with substantially lower total costs and lengths of stay⁴¹. In light of the growing body of evidence suggesting that physician order entry and decision support systems may decrease error rates, thereby improving outcomes and decreasing hospital length of stay, they probably reduce costs indirectly. Unfortunately, there is also little evidence about the long-term cost effectiveness of patient-centered decision support systems and patient monitoring.

Methods

Setting

Study sites included 24 primary care (Internal Medicine or Family Practice) practices at the MetroHealth System (MHS-10) and Cleveland Clinic (CCF-14) in Northeast Ohio.

Participants

Approximately 20,000 diabetic patients (over age 18) of the practices' approximately 200 PCPs were included in the study. Diabetes was defined by its listing on the patient's problem list and at least one encounter identifying diabetes as the reason for the patient's visit. Subjects were excluded if they are unable to speak English, are blind, are pregnant, or at CCF, if they stated they were physically incapable of using a computer. No prisoners or institutionalized patients were included. The study was approved by the Institutional review Boards at both the MetroHealth System (MHS) and Cleveland Clinic (CCF).

Study Design

Two-year parallel cluster randomized trials (CRT) at the two health care systems, with sites randomly assigned EMR-based disease management (DM²) in one cluster of 5 practices at MHS, and, at CCF, web portal-based patient access (PA) to one cluster of 4 practices, PA enhanced by diabetes-specific functions for patient entry and feedback to a cluster of 6 practices (PA-E), and PA-E supplemented by DM² (Both) to one cluster of 4 practices. Assignment of sites to study groups and random assignment of study groups to interventions has been described in detail ⁶¹.

Data sources and Collection

There were two broad categories of data collected in this investigation: 1) administrative and clinical data, including EMR related data from the health care systems; and 2) survey data from patients and their PCPs. Roster-related data (for each PCP's patient registry) were updated continuously; e.g., a new adult diabetic seen for patient care by a practice site PCP were linked automatically to that PCP's roster. Practice profile data for the DM² intervention was updated monthly at CCF, data pertaining to E.D. visits and in-hospital care at a CCF-owned hospital was retrospectively obtained by CCF. These data were transferred to the Data Management and Analysis Group at MHS.

Survey data from PCPs and patients were obtained at the time of enrollment in the CRT: a second round of survey data from both patients and PCPs was collected during CRT months 23-24. Paper surveys were distributed for a potentially eligible subject at the time of his/her first visit with the PCP during the trial period. Patients in the PA-E and Both study groups were offered the opportunity to consent to the PA-E intervention, to complete the survey, or both. Patients declining to participate in the PA-E intervention still provide survey data, enabling a comparison of attributes between adopters and non-adopters of this intervention.

Intervention

Electronic Medical Record-Disease Management for Diabetes Mellitus (DM²). The EMR-DM² intervention consisted of EMR components and Disease Management components. The EMR components consisted of EMR functionalities represented by the acronym ALLPEP, for Alerts, Links, Letters, tailored Patient Education, and Profiles. Further, the EMR components consist of Encounter-Centered functionalities - available at the time of a patient visit to his/her PCP - and Practice-Centered functionalities - available to the PCP at any time, in his/her examination room, office, or home. The disease management components of the EMR-DM² intervention was a combination of disease management and case management, linking a nurse coordinator both to patients and their PCPs. These have been described elsewhere ⁶².

Encounter- centered Alerts actively informed the PCP of overdue recommended interventions or test results that were beyond ADA thresholds. Alerts appeared automatically within the patient's Epic encounter workspace and were Linked to order sets to facilitate specific referrals (Ophthalmology, Nephrology, Podiatry, Diabetes Self-Management Program), tests (A1c; lipid profile, including LDL; urine microalbumin; blood chemistries that include kidney function tests);and immunizations (pneumococcal and influenza) or treatment changes (ACE inhibitors or ARBs for microalbuminuria; statins for elevated LDL levels, changes in anti-

hypertension medications). Each of these messages facilitated, but did not mandate, actions: the language used was “consideration should be given to "X" action” variety, but links to specific order sets were provided that enabled the suggested orders to be executed easily. These Links were also associated with opportunities for the PCP to print tailored Patient Education materials.

Practice-centered functionalities consisted of two distinct parts: ¹ using the Epic Roster function, the PCP could view, and act upon, a list of all of his/her diabetic patients and the status of their diabetes measures, as well as their medical record and telephone numbers; ² using a hyperlink to an external database, the PCP could view a Profile of his/her performance, as reflected in bar charts and pie charts of his/her diabetic panel's measures, as compared to ADA standards, and as compared with practice-wide and health care system-wide peers. Diabetes measures in Epic rosters included the most recent A1c level and the interval (in months) since last obtained; most recent LDL level and the interval since last obtained; most recent urine microalbumin level, and, if abnormal, whether the patient is on an ACE inhibitor or ARB; interval since last dilated eye examination; and, date of most recent pneumococcal vaccination and most recent influenza vaccination. For each patient on the list, all measures were color-coded, with red indicating an abnormal measure (result or interval) and green indicating a normal measure. By highlighting a particular column (e.g. A1c levels), the PCP was able to sort all of his/her patients by that measure, identifying all of his/her patients needing a pneumococcal vaccination. Importantly, the PCP could act on upon these findings in one of two ways: ¹ contacting the patient directly, or ² Linking to the disease management nurse coordinator.

Electronic Medical Record-Patient Access (PA). The PA intervention engaged the diabetic patient in his/her own care and decision-making through web-portal access to his/her own health-and diabetes-related data and the health care system. *MyChart* was accessed securely by the patient from any web browser.

General health-related services enable the patient to:

1. Renew Prescriptions. Patients could choose to renew their diabetes medicines by selecting them from their active medication list, including the duration of the prescription up to 90 days.
2. Schedule Appointments. Patients could choose from a list of physicians and clinical departments in which they have been seen in the past two years and request an appointment, including preference for day of week and time of day.
3. Message the Institution. The patient could send a message to the system that he/she has changed telephone numbers, or is experiencing technical difficulties with MyChart.
4. View Personal Health Information. Patients may view diagnoses, results, messages, and letters that their PCP's have released to them. The diabetic patient could choose to review the Health Maintenance Module and request an appointment to obtain a recommended pneumococcal vaccination.

Diabetes-specific services, in the PA-E study group, enable the patient to

1. Enter and view glucometer results. A diabetic patient could log onto the system to enter his/her glucometer readings, and view a graph of recent results.
2. Learn about his/her diabetes. In reviewing his/her diagnoses, the patient could select a hyperlink that discusses the disease; or, in reviewing test results, he/she may select a hyperlink to learn about A1c tests.
3. Identify emergent situations. If the patient attempted to enter a glucometer reading that was less than 20 or greater than 699, he/she received a message requesting re-entry. Values entered that were less than 65 or greater than 299 resulted in a message informing the patient to immediately contact his/her physician, go to an emergency room, or call 911. All such readings and alerts transmitted to the patient were simultaneously transmitted to the patient's PCP through the EMR. In addition, the alert and values were transmitted to clinical nurse pools for immediate response.

Electronic Medical Record Control Group (EMR only). The ambulatory EMR at both sites implements similar Epic applications of passive (e.g., Health Maintenance module) and active (e.g. Alerts) functions. At both MHS and CCF, flags linked to patients with diabetes highlight a HM schedule that recommended a yearly full lipid profile, ophthalmology examination, and urine microalbumin; twice yearly A1c determinations; and a one-time pneumococcal vaccination.

Measures

Dependent Variables. Our primary dependent variables addressed issues of patient quality/safety of care (Aim 1 and secondary Aim 1a) and health care utilization (Aim 2 and secondary Aim 2a), the latter categorized as "desirable" and "undesirable." Our secondary dependent variables are subject adoption of our EMR-centered interventions (Aim 3) and selected unintended consequences of our interventions (Aim 4).

For Aim 1, the dependent variables examined for quality/safety of care were: A) A1c levels; B) a composite score of 8 standards of the American Diabetes Association (ADA-8), including: 1) Hemoglobin A1c<7%, 2) LDL cholesterol value <100 mg/dl, 3) blood pressure<130/80mmHg, 4) body mass index (BMI)<30, 5) documented status as a non-smoker, 6) urine testing for microalbuminuria within the past year or on treatment with an ACE inhibitor or ARB medication, 7) receipt of an eye examination by an ophthalmologist within the past year; and 8) documented receipt of a pneumococcal vaccination. The ADA-8 was sub-divided a priori into sub-scores consisting of 5 patient-centered standards of intermediate outcomes (ADA-5) – standards #1-5, above, and 3 provider-centered process-oriented standards (ADA-3) – standards #6-8 above.

For Aim 2, our dependent variables for utilization were categorized as “desirable” utilization and “undesirable” utilization. Desirable utilization is defined as patient visits to his/her PCP and visits to designated appropriate specialty physicians or services, including Ophthalmology; Nephrology, for patients with serum creatinine values of 2.0 or higher; and Endocrinology or Diabetes, for patients with A1c values of 9.0% or higher. Undesirable utilization is defined as Emergency Department visits or hospitalizations for any cause.

For secondary Aim 3, there were several measures of subject adoption of our CDS. We focus here on PCP actions taken in relation to Alerts generated in the DM2 intervention and several specific uses of the web portal by patients in the PA, PA-E, and Both intervention groups.

For secondary Aim 4, we measured selected general and intervention-specific unintended consequences. We focus here on the occurrence of outpatient-documented episodes of hypoglycemia; the performance of Pap smears and mammograms in relevant patient groups; and ED visits for asthma and CHF for relevant patient groups.

Survey Measures. The patient survey domains measured in the pre-CRT phase were: attitude towards technology, subjective norms, perceived behavioral control, behavioral intention, and readiness-to-change. Patient surveys included 69 items on the 5 dimensions.

Analyses for Aim 1 (Cross-Group Changes in Quality). We describe comparisons of patients in intervention and control sites for four key outcomes: hemoglobin A1c level (%), and three composite measures described above, the ADA-8 and its patient and physician-centered sub-scores, the ADA-5 and ADA-3, respectively. We begin with descriptive graphical and numerical summaries of unadjusted results and then present models to predict values of each of the four main outcomes at the end of the patient's enrollment in the study. Predictors for each model include an indicator for intervention group and covariate information. All models account for clustering of practice sites using robust standard errors. For each outcome, Model 1 incorporates as predictors the baseline value of the outcome of interest, number of weeks of the study, age, gender and race. Model 2 for each outcome adds insurance payor (Commercial, Medicare, Medicaid or Uninsured), comorbidities (operationalized as 0, 1, 2, and 3 or more of nine conditions) and baseline smoking status. Model 3 adds census block estimates of neighborhood median income, educational attainment and % of households with female heads and children. For A1c, we also present Model³ results for two subsets of interest – patients with baseline A1c values below 7 and above 9.

Analyses for Aim 1a (Insurance Effects on Baseline Glycemic Control). We examined the effect of insurance type on hemoglobin A1c values using sequential logit models that sequentially added: 1) age, sex, and race; 2) clinical and adherence-related variables (smoking status, “no show” rates); 3) income and other census-derived socioeconomic variables; and 4) site of care. Commercially insured patients were used as the referent.

Analyses For Aim 2 (Cross-Group Changes in Utilization). Difference-In-Differences analysis, employing Negative Binomial regressions models. A difference-in-difference strategy was adopted to adjust for pre-existing differences (i.e. prior to intervention) in the utilization by patients in different sites. Site-level differences in utilization of ED visits and hospitalizations prior to initiation of the intervention were found to be substantial, likely reflecting a larger amount of unmeasured utilization at sites more distant to the main hospital. The Negative Binomial model is employed to most appropriately accommodate the distribution of outcomes, which are in the form of counts with substantial dispersion in the right tail. We utilize a general form of the Negative Binomial model, which allows the level of dispersion to be a function of the included covariates. Standard errors in all models are corrected for residual clustering at the site level.

Results

Principal Findings: Aim 1—Intervention Effects on Quality Measures and Standards

Changes in A1c. We begin in Table 1 by considering Hemoglobin A1c for the 5881 patients with distinct A1c values at baseline and their last visit during the study.

Table 1. A1c starting and ending values for DM² and control patients

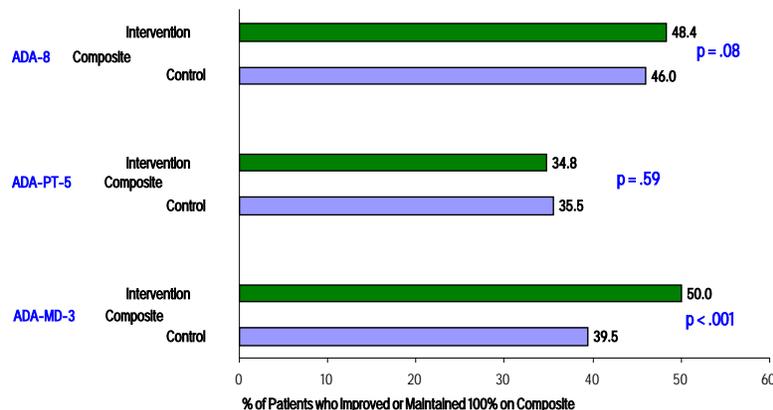
	# Patients	Starting A1c Mean (SD)	Ending A1c Mean (SD)	Difference (95% CI)
DM ²	3568	7.57 (2.08)	7.41 (1.86)	0.16 (0.09, 0.22)
Control	2313	7.52 (2.08)	7.38 (1.87)	0.14 (0.07, 0.23)

In this unadjusted comparison, there was almost no incremental effect on A1c in the intervention group beyond the secular trend observed in the control sites. While mean A1c improved over the trial for both intervention and control patients, the incremental intervention effect was not significant (effect size = 0.02 percentage points of A1c; 95% CI: [-0.10, 0.11]; $p = .89$.) Sub-group analyses by baseline A1c values (good, average, poor), and results of multivariate models above, were no different.

Changes in ADA-8 and its Sub-Scores. We turn now to our three ADA composite summary measures, where we describe results for a sample of 6510 patients. For each patient, we calculate all three ADA composites at baseline and study exit. Figure 1 displays the percentage of patients in each trial arm who either improved from baseline to study exit or maintained a perfect composite score at both baseline and study exit.

The results clearly indicate that our intervention had a significant beneficial effect on the physician-centered more process-oriented standards in the ADA-8 (attention to nephropathy, eye examinations and pneumococcal vaccinations), but not on the patient-centered ones.

Figure 1. Percentage of patients improving or maintaining perfect scores on ADA composites, by trial arm



To examine whether differences in the baseline distribution of composite scores across the two arms of the trial could effect the results, we examined the ADA composite scores at study exit across the two trial arms within strata of starting value of the composite, with our results displaying similar findings across strata. We further examined changes in the ADA-3 using sequentially additive regression models (Table 2), with similar results.

Table 2. Results of three models for ending ADA-3 composite score

Model	Description [n = 6510]	Intervention Effect (95% CI)	p
1	Intervention group, Baseline A1c, age, sex, race, weeks in trial	5.66 (2.85, 8.46)	.002
2	Add insurance, comorbidities and smoking status to Model 1	5.82 (3.15, 8.48)	.001
3	Add census-based neighborhood SES estimates to Model 2	5.59 (2.77, 8.42)	.002

Principal Findings: Aim 1a—Effect of Insurance on Baseline Glycemic Control

Among the 6987 patients with complete baseline data, 34% were insured by Medicare, 26% by commercial insurers, 27% by Medicaid, and 20% were uninsured. Using conventional criteria for “poor glycemic control” used in performance incentive systems (A1c>9%), poor values were observed in 11.6% of Medicare, 19.5% of commercial, 24.7% of Medicaid, and 28.6% of uninsured patients. Insurance effects were robust to the addition of potential confounders: in the final model (see Analysis section above), Medicare patients were 19% less likely (P<0.05) and uninsured patients were 44% more likely (p<0.01) to have poor glycemic values than commercially insured patients.

Principal Findings: Aim 2—Intervention Effects on Utilization

Table below reports the count of patients and mean measures of utilization, by site and cohort. We highlight three principal findings from this table: 1) For PCP visits, there was no difference in means across intervention and control sites in the pre-analytic cohort. 2) For ED visits and hospitalizations, there are large pre-existing differences in utilization by patients in different sites. Patients in intervention sites had, on average, 0.56 more ED visits and 0.43 more hospitalizations. 3) The difference in mean ED visits and hospitalizations across intervention and control sites is substantially smaller in the analytic cohort, suggesting exposure to the intervention (DM²) reduced these forms of utilization

Table 3. Mean utilization by site and cohort

	N patients PAC	N patients AC	# PCP Visits PAC	# PCP Visits AC	# ED Visits PAC	# ED Visits AC	# Hospitalizations PAC	# Hospitalizations AC
Intervention Sites	3422	4514	7.70	8.41	1.48	1.39	0.90	0.61
Intervent. site 1	499	853	7.51	8.37	0.83	1.22	0.46	0.45
Intervent. site 2	845	1389	8.34	9.56	1.97	1.54	1.07	0.70
Intervent. site 3	1577	1756	7.04	7.79	1.64	1.51	1.09	0.72
Intervent. site 4	501	516	8.87	7.53	0.71	0.84	0.49	0.31
Control Sites	1918	1995	7.70	8.75	0.92	1.00	0.48	0.39
Control site 1	365	466	7.18	7.51	1.09	1.37	0.58	0.53
Control site 2	103	148	6.71	8.76	0.72	0.80	0.51	0.14
Control site 3	581	489	8.22	10.39	1.33	1.37	0.55	0.47
Control site 4	372	431	7.95	8.78	0.39	0.31	0.37	0.22
Control site 5	497	461	7.50	8.23	0.75	0.92	0.38	0.43
Mean Difference (Int-Control sites)			0.00 (0.14)	-0.34* (0.15)	0.56** (0.08)	0.39** (0.07)	0.43** (0.05)	0.22** (0.04)

Table notes: “PAC” refers to pre-analytic cohort; “AC” refers to analytic cohort. “Mean Difference” reports Intervention Sites mean minus Control Site mean (standard error in parentheses).

Estimates from the Negative Binomial models appear to confirm these suggestive findings. Treatment is associated with a 5 percent reduction in PCP visits (IRR=.95; 95% CI=[.89,1.01]; p=.08), a 10 percent reduction in ED visits (IRR=.90; 95% CI=[.78,1.04]; p=.13), and a 20 percent reduction in hospitalizations (IRR=.80; 95% CI=[.67,.95]; p=.01), although only the hospitalization estimate is statistically significant. If confirmed by additional analyses, these results support the hypothesis that exposure to the EMR-DM² intervention substantially reduced patients’ rate of hospitalizations, a primary driver in the medical costs associated with diabetes.

Principal Findings: Secondary Aim 3 (Adoption and satisfaction with CDS)

In the DM² arms of the trials, there were 8 Alerts that were accompanied by linked order sets as actions that might be appropriate for the PCPs to take. Adoption Rate was calculated as the proportion of Alerts that were accompanied by these Actions across 62 experimental group PCPs in the MetroHealth trial. Figure 2 summarizes our findings. Adoption Rate was 28% overall; i.e., more than 1 in 4 opportunities for action were taken, with the highest rate for recommendations that an A1c test be ordered (48.6%) and lowest for consideration to refer to Nurse Case Management (NCM, 9.1%). PCP Satisfaction with the CDS was determined by survey questions pertaining to whether various computer-centered components of DM² should be Kept (yes-no) after trial completion. Figure 3 summarizes our results, highlighting a high degree of satisfaction with our Alerts and Related order sets (97% “Keep” after trial) and lesser but still impressive Keep rates for our more complex registry and performance reports (77%) and Nurse Case Management prompts (81%).

For the web portal access arms of the trial at CCF, we measured this web-based patient portal activity for all 851 consented patients within our 3 study arms at our site. Activities that were “measured” included: Number of sessions that the patient logged into the portal; Number of sessions that the patient reviewed their health maintenance activities; Number of sessions that the patient reviewed laboratory tests; Number of messages exchanged between health care system

and patient; Number of self-monitoring blood glucose (SMBG) submissions made to the patient’s provider. This activity was limited only to those in the PA-E or Both groups.

Figure 2. Adoption of alerts by PCPs

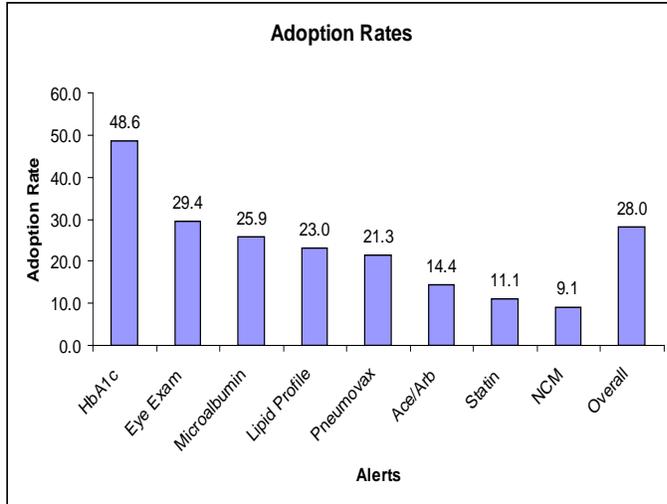
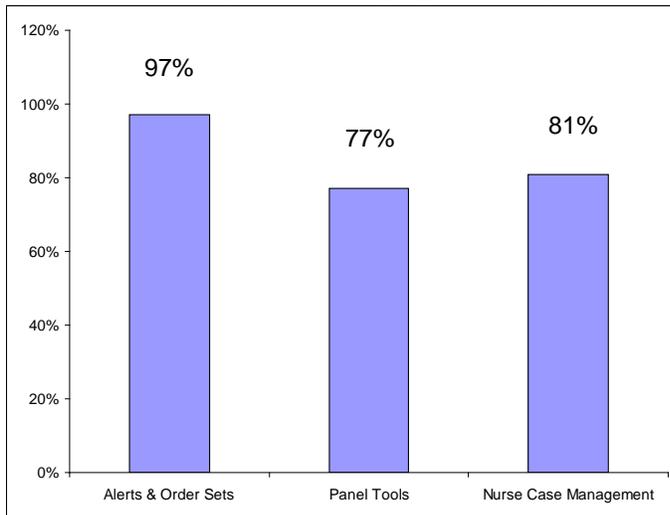


Figure 3. “Yes” responses to keeping CDS components after trial completion



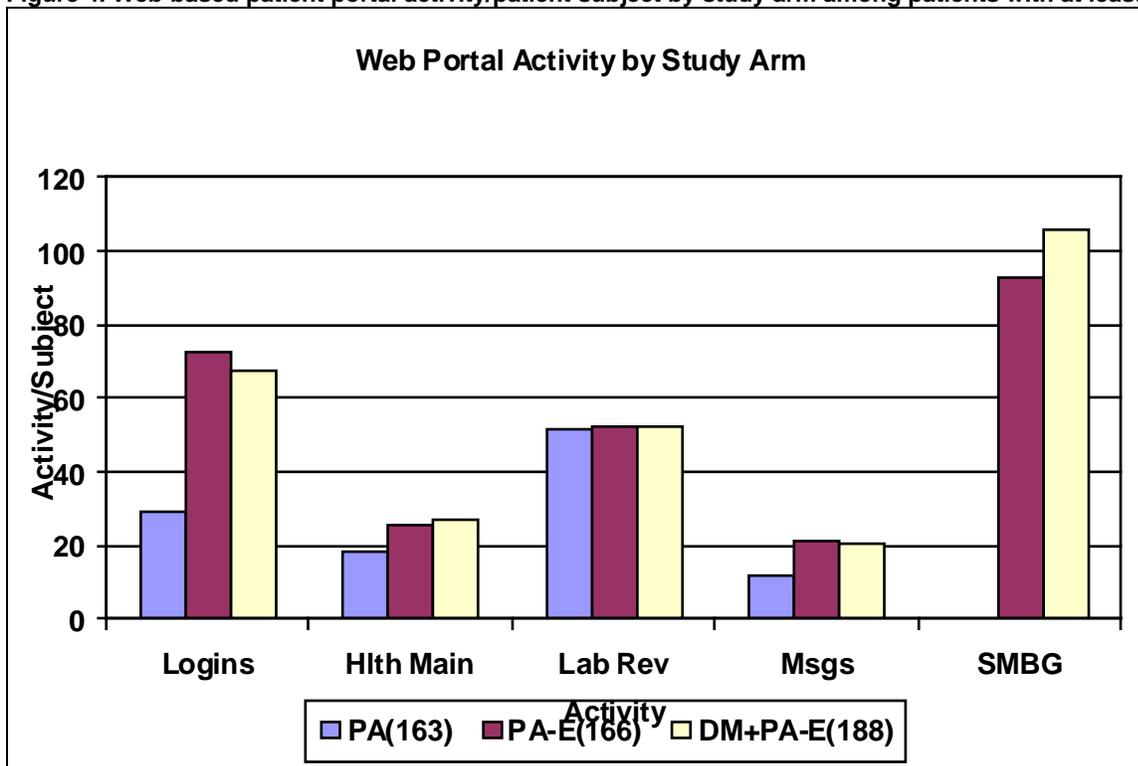
Use of the web-based portal activities varied across groups among the 851 patients participating in the study (Figure 4). In the PA group, 163 of 313 (52.1%) used the web-based patient portal as compared with 166/270 or 61.5% in the PA-E group and 188/268 or 70.1% in the Both group. The values are normalized to the amount of activity per patient to compensate for differences in the number of patients that are in each arm of the study. There is an increase in the number of login sessions that patients have in the enhanced portal groups (PA-E and Both) when compared to the PA group. Moreover, there are also more messages exchanged within these PA-E groups. However, there are also differences between the PA-E and Both groups.

Despite similar activity around messaging, reviewing laboratory results and health maintenance and fewer logins in the Both group, there is an increase in the amount of SMBG activity. These results suggest that disease-based enhancements to web-based patient portals lead to more use of these systems. Moreover, there may be a patient activation effect of having “diabetes” specific enhancements within the EHR targeted to providers. For example, patients may be more inclined to utilize the web-based portal for blood sugar submissions from home, if when they present to their physician, the diabetes specific enhancements in the EHR direct the provider to focus on the diabetic care of their patient

Principal Findings: Secondary Aim 4 (unintended consequences)

Analyses used a difference-in-difference approach, as with our utilization analyses more generally, due to substantial baseline differences across sites in baseline utilization. We examined whether there were more episodes of documented hypoglycemia among experimental group patients (2.8% in both groups with one or more episodes, $p=0.96$), fewer mammograms ordered among women aged 50-75 (51.9% vs. 56.4% in the control groups, $p=0.01$), Pap smears (45.9% vs. 44.9%, $p=0.55$), and ED visits for asthma ($p=0.17$).

Figure 4. Web-based patient portal activity/patient subject by study arm among patients with at least 1 login



References

- Centers for Disease Control and Prevention. Diabetes: Disabling, deadly, and on the rise. http://www.cdc.gov/nccdphp/aag/pdf/aag_ddt2004.pdf. U.S. Dept. of Health and Human Resources. 2004.
- American Diabetes Association. Standards of medical care for patients with diabetes mellitus. Position Statement. *Diabetes Care*. 2002;25 (Suppl 1):S33-S50.
- Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. *Diabetes Care*. 2002;25 (Suppl.1):S5-S20.
- Boyle JP, Honeycutt AA, Narayan KM et al. Projection of diabetes burden through 2050: impact of changing demography and disease prevalence in the U.S. *Diabetes Care*. 2001;24(11):1936-1940.
- Mokdad AH, Ford ES, Bowman BA et al. Diabetes trends in the U.S.: 1990-1998. *Diabetes Care*. 2000;23(9):1278-1283.
- Mokdad AH, Ford ES, Bowman BA et al. The continuing increase of diabetes in the US. *Diabetes Care*. 2001;24(2):412.
- Cowie, C. C. and Harris, M. I. Physical and metabolic characteristics of persons with diabetes. In *Diabetes in America* 2nd ed. Bethesda, MD. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. 117-164 (NIH publ. no. 95-1468). 1995.
- Wisdom K, Fryzek JP, Havstad SL et al. Comparison of laboratory test frequency and test results between African-Americans and Caucasians with diabetes: opportunity for improvement. Findings from a large urban health maintenance organization. *Diabetes Care*. 1997;20(6):971-977.
- Narayan KM, Boyle JP, Thompson TJ et al. Lifetime risk for diabetes mellitus in the United States. *JAMA*. 2003;290(14):1884-1890.
- Harris MI. Health care and health status and outcomes for patients with type 2 diabetes. *Diabetes Care*. 2000;23(6):754-758.
- UK Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet*. 1998;352(9131):837-853.
- UK Prospective Diabetes Study (UKPDS) Group. Effect of intensive blood-glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). *Lancet*. 1998;352(9131):854-865.
- Stratton IM, Adler AI, Neil HA et al. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. *BMJ*. 2000;321(7258):405-412.
- American Diabetes Association. Consensus development conference on the diagnosis of coronary heart disease in people with diabetes: 10-11 February 1998, Miami, Florida. *Diabetes Care*. 1998;21(9):1551-1559.
- Heart Outcomes Prevention Evaluation Study Investigators. Effects of ramipril on cardiovascular and microvascular outcomes in people with diabetes mellitus: results of the HOPE study and MICRO-HOPE substudy. *Lancet*. 2000;355(9200):253-259.
- Brenner BM, Cooper ME, de Zeeuw D et al. Effects of losartan on renal and cardiovascular outcomes in patients with type 2 diabetes and nephropathy. *N Engl J Med*. 2001;345(12):861-869.
- Lewis EJ, Hunsicker LG, Clarke WR et al. Renoprotective effect of the angiotensin-receptor antagonist irbesartan in patients with nephropathy due to type 2 diabetes. *N Engl J Med*. 2001;345(12):851-860.
- Parving HH, Lehnert H, Brochner-Mortensen J et al. The effect of irbesartan on the development of diabetic nephropathy in patients with type 2 diabetes. *N Engl J Med*. 2001;345(12):870-878.
- Diabetic Retinopathy Study Research Group. Photocoagulation treatment of proliferative diabetic retinopathy: clinical application of Diabetic Retinopathy Study (DRS) findings: DRS report no. 8. *Ophthalmology*. 1981;88:583-600.
- Diabetic Retinopathy Study Research Group. Four risk factors for severe visual loss in diabetic retinopathy: the third report of the Diabetic Retinopathy Study. *Arch Ophthalmol*. 1979;97:654-655.
- Diabetic Retinopathy Study Group. Design, methods, and baseline results: DRS report no. 6. *Invest Ophthalmol Vis Sci*. 1981;21:149-209.

22. Diabetic Retinopathy Study Research Group. Indications for photocoagulation treatment of diabetic retinopathy: DRS report no. 14. *Int Ophthalmol Clin.* 1987;27:239-253.
23. Diabetic Retinopathy Study Research Group. Preliminary report on effects of photocoagulation therapy. *Am J Ophthalmol.* 2004;81:383-396.
24. Task Force on Community Preventive Services. Recommendations for healthcare system and self-management education interventions to reduce morbidity and mortality from diabetes. *Am J Prev Med.* 2002;22(4 Suppl):10-14.
25. Norris SL, Engelgau MM, Narayan KM. Effectiveness of self-management training in type 2 diabetes: a systematic review of randomized controlled trials. *Diabetes Care.* 2001;24(3):561-587.
26. Aubert RE, Herman WH, Waters J et al. Nurse case management to improve glycemic control in diabetic patients in a health maintenance organization. A randomized, controlled trial. *Ann Intern Med.* 1998;129(8):605-612.
27. Norris SL, Nichols PJ, Caspersen CJ et al. Increasing diabetes self-management education in community settings. A systematic review. *Am J Prev Med.* 2002;22(4 Suppl):39-66.
28. Norris SL, Nichols PJ, Caspersen CJ et al. The effectiveness of disease and case management for people with diabetes. A systematic review. *Am J Prev Med.* 2002;22(4 Suppl):15-38.
29. Sadur CN, Moline N, Costa M et al. Diabetes management in a health maintenance organization. Efficacy of care management using cluster visits. *Diabetes Care.* 1999;22(12):2011-2017.
30. Meigs JB, Cagliero E, Dubey A et al. A controlled trial of web-based diabetes disease management: the MGH diabetes primary care improvement project. *Diabetes Care.* 2003;26(3):750-757.
31. Biermann E, Dietrich W, Standl E. Telecare of diabetic patients with intensified insulin therapy. A randomized clinical trial. *Stud Health Technol Inform.* 2000;77:327-332.
32. Eccles M, McColl E, Steen N et al. Effect of computerised evidence based guidelines on management of asthma and angina in adults in primary care: cluster randomised controlled trial. *BMJ.* 2002;325(7370):941.
33. Kwon HS, Cho JH, Kim HS et al. Establishment of blood glucose monitoring system using the internet. *Diabetes Care.* 2004;27(2):478-483.
34. Piette JD, Weinberger M, McPhee SJ et al. Do automated calls with nurse follow-up improve self-care and glycemic control among vulnerable patients with diabetes? *Am J Med.* 2000;108(1):20-27.
35. Piette JD, Weinberger M, Kraemer FB, McPhee SJ. Impact of automated calls with nurse follow-up on diabetes treatment outcomes in a Department of Veterans Affairs Health Care System: a randomized controlled trial. *Diabetes Care.* 2001;24(2):202-208.
36. Clement S. Diabetes self-management education. *Diabetes Care.* 1995;18(8):1204-1214.
37. Peterson KA, Hughes M. Readiness to change and clinical success in a diabetes educational program. *J Am Board Fam Pract.* 2002;15(4):266-271.
38. Shiffman RN, Liaw Y, Brandt CA, Corb GJ. Computer-based guideline implementation systems: a systematic review of functionality and effectiveness. *J Am Med Inform Assoc.* 1999;6(2):104-114.
39. Eisenberg JM. Ten lessons for evidence-based technology assessment. *JAMA.* 1999;282(19):1865-1869.
40. Bodenheimer T, Grumbach K. Electronic technology: a spark to revitalize primary care? *JAMA.* 2003;290(2):259-264.
41. Evans RS, Pestotnik SL, Classen DC et al. A computer-assisted management program for antibiotics and other antiinfective agents. *N Engl J Med.* 1998;338(4):232-238.
42. Classen DC, Evans RS, Pestotnik SL et al. The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. *N Engl J Med.* 1992;326(5):281-286.
43. Bates DW, Leape LL, Cullen DJ et al. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. *JAMA.* 1998;280(15):1311-1316.
44. Institute of Medicine. Crossing the quality chasm: A new health system for the 21st century. Washington, D.C.: National Academy Press, 2001.
45. Litzelman DK, Dittus RS, Miller ME, Tierney WM. Requiring physicians to respond to computerized reminders improves their compliance with preventive care protocols. *J Gen Intern Med.* 1993;8(6):311-317.
46. Tierney WM, Hui SL, McDonald CJ. Delayed feedback of physician performance versus immediate reminders to perform preventive care. Effects on physician compliance. *Med Care.* 1986;24(8):659-666.

47. Dexter PR, Perkins S, Overhage JM et al. A computerized reminder system to increase the use of preventive care for hospitalized patients. *N Engl J Med*. 2001;345(13):965-970.
48. Overhage JM, Tierney WM, Zhou XH, McDonald CJ. A randomized trial of "corollary orders" to prevent errors of omission. *J Am Med Inform Assoc*. 1997;4(5):364-375.
49. Hunt DL, Haynes RB, Hanna SE, Smith K. Effects of computer-based clinical decision support systems on physician performance and patient outcomes: a systematic review. *JAMA*. 1998;280(15):1339-1346.
50. Kaplan B. Evaluating informatics applications--clinical decision support systems literature review. *Intl J Med Informatics*. 2001;64(1):15-37.
51. Rollman BL, Hanusa BH, Lowe HJ et al. A randomized trial using computerized decision support to improve treatment of major depression in primary care. *J Gen Intern Med*. 2002;17(7):493-503.
52. Tierney WM, Overhage JM, Murray MD et al. Effects of computerized guidelines for managing heart disease in primary care. *J Gen Intern Med*. 2003;18(12):967-976.
53. Zrebiec JF, Jacobson AM. What attracts patients with diabetes to an internet support group? A 21-month longitudinal website study. *Diabet Med*. 2001;18(2):154-158.
54. Becher EC, Chassin MR. Improving quality, minimizing error: making it happen. *Health Aff (Millwood)*. 2001;20(3):68-81.
55. Schultze U, Vandenbosch B. Information overload in a groupware environment: Now you see it, now you don't. *J Organizational Comp Electr Commerce*. 1998;8(2):127-148.
56. Tsai TL, Fridsma DB, Gatti G. Computer decision support as a source of interpretation error: the case of electrocardiograms. *J Am Med Inform Assoc*. 2003;10(5):478-483.
57. Massaro TA. Introducing physician order entry at a major academic medical center: I. Impact on organizational culture and behavior. *Acad Med*. 1993;68(1):20-25.
58. Ash J, Berg M, Coiera E. Some unintended consequences of information technology in health care: The nature of patient care information system-related errors. *J Am Med Inform Assoc*. 2004;11:104-112.
59. Wang SJ, Middleton B, Prosser LA et al. A cost-benefit analysis of electronic medical records in primary care. *Am J Med*. 2003;114(5):397-403.
60. Tierney WM, Miller ME, Overhage JM, McDonald CJ. Physician inpatient order writing on microcomputer workstations. Effects on resource utilization. *JAMA*. 1993;269(3):379-383.
61. Love, TE, Cebul, RD, Einstadter, D, Jain, AK, Miller, H., Harris, CM, Greco, PJ, Husak, SS, and Dawson, NV, for the DIG-IT Investigators. Electronic Medical Record-Assisted Design of a Cluster-Randomized Trial to Improve Diabetes Care and Outcomes. 2008. *JGIM* 23(4); pp. 383-91.
62. Cebul RD. Using Electronic Medical Records to Measure and Improve Performance. *Trans Am Clin Climatol Assoc*. 2008; 119: (in press).

List of Publications and Products

Papers

Cebul RD, Dawson NV and Love TE. Cluster- Randomized Trials, and Their Relevance to Health Care Research in Health Care Research published in *Textbook of Clinical Trials*. Eds. David Machin, Simon Day and Sylvan Green, Wiley, Inc. 2006.

Love TE, Cebul RD, Einstadter D, Jain AK, Miller H, Harris CM, Greco PJ, Husak SS, Dawson NV; DIG-IT

Investigators. Electronic medical record-assisted design of a cluster-randomized trial to improve diabetes care and outcomes. *J Gen Intern Med*. 2008 Apr; 23(4):383-91.

Cebul RD. Using Electronic Medical Records to Measure and Improve Performance. *Trans Am Clin Climatol Assoc*. 2008; 119: (in press).

Presentations

Peter J. Greco, Randall D. Cebul: Epic Opportunities for Cluster Randomized Trials in Health Care Delivery, Madison, WI, September 19, 2005

Peter J. Greco, Anil Jain, Holly Miller: Diabetes Population Management. Madison, WI, September 20, 2005

C. Martin Harris will present "RHIOs: A National View" at NOHIMSS, Cleveland, November 11, 2005.

M.J. Roach, K. Bauchens, D. Kaiser, D. Einstadter, S. Husak, P. Greco, and R. Cebul, for the DIG-IT Team. Epic-catalyzed Nurse Case Management: Early results from DIG-IT. MetroHealth Research Festival. Sept. 30, 2005

T.E. Love, D. Einstadter, N.V. Dawson, and R. Cebul for the DIG-IT Investigators. Cluster Randomized Trial Design in the Electronic Medical Records Era: The DIG-IT Trial. MetroHealth Research Festival. Sept. 30, 2005

M.J. Roach, K. Bauchens, D. Kaiser, D. Einstadter, S. Husak, P. Greco, and R. Cebul, for the DIG-IT Team. Epic-catalyzed Nurse Case Management: Early results from DIG-IT. Ohio Health Technology Symposium. Columbus, OH October 17, 2005.

M.J. Roach, K. Bauchens, D. Kaiser, D. Einstadter, S. Husak, P. Greco, and R. Cebul, for the DIG-IT Team. Epic-catalyzed Nurse Case Management Diabetes Association of Greater Cleveland's Dietrich Diabetes Research Institute (DDRI) and Case School of Medicine Diabetes Research Retreat, November 18, 2005

T Murphy. and D Kaiser. Inside the Black Box of Nurse Case Management: Diabetes Case Conference. CME course at MetroHealth Medical Center. March 2006.

RD Cebul. EMR-Catalyzed Nurse Case Management: Early Results from DIG-IT. Patient Safety and Health IT Conference, June 4th-7th 2006. Washington DC.

RD Cebul. EMR-Catalyzed Nurse Case Management: Early Results from Patient Safety and Health IT Conference, June 4th-7th 2006, Washington DC.

T. E. Love, D. Einstadter, N.V. Dawson, SS Husak, A. Jain, and R.D. Cebul for the DIG-IT Investigators. EMR-Facilitated Design of a Cluster-Randomized Trial of Clinical Decision Support for Diabetes. Annual Meeting of Medical Decision Making, October 2006.

K. Bauchens, D. Kaiser, R. Ellert, P. Greco, S. Husak, T. Love, M.J. Roach, and R.

Electronically-Facilitated Adoption of Nurse Case Management to Improve Diabetes Care and Outcomes. Cleveland's Dietrich Diabetes Research Institute and Case

School of Medicine. Diabetes Research Retreat, November 17, 2006

M.J. Roach, P. Greco, S. Husak, T. Love, D. Einstadter, N.V. Dawson, and R. Cebul

Real-Time Clinical Decision Support to Improve Diabetes Care: Interim Results of Physician Adoption. Cleveland's Dietrich Diabetes Research Institute and Case School of Medicine. Diabetes Research Retreat, November 17, 2006.

Cebul RD, Roach MJ, Votruba ME, Greco PJ, Einstadter D, Dawson NV, Husak SS, and Love TE. Glycemic Control Among Diverse Diabetics Cared for in a Single Health Care System: Implications for Pay for Performance and Public Health. MetroHealth Research Festival, Sept. 2007.

Cebul RD. Using electronic Medical records for Measuring and Improving Performance: Opportunities and Lessons We're Learning. Presented at the Annual Meeting of the American Clinical and Climatologically Association. October 19, 2007, Tucson, AZ.

Cebul RD. Using EMRs for PM, PI, PR, and P4P: Opportunities and Lessons We're Learning. Presentation at AHRQ HIT Annual Meeting Panel on Transformation of Health Quality through Health IT. Moderator: Jon White. September 26, 2007. Bethesda, Maryland.

Cebul RD. Clinical Decision Support to Improve Diabetes Care: The Search for Unintended Consequences. Presentation at AHRQ HIT Annual Meeting Panel on Improving Patient Safety Using Health IT. Moderator: Teresa Zayas Caban. September 16, 2007. Bethesda, Maryland.

RD Cebul, D Einstadter, PJ Greco, MJ Roach, and A Jain. Clinical Decision Support to Improve Diabetes Care AHRQ-HIT; WIP August 1, 2007.

MJ Roach, NV Dawson, PJ Greco, and TS Love. Do Physicians Find Decision Support Embedded In The Electronic Medical Record System Useful In Managing Diabetic Patients? Annual Conference of the Society for Medical Decision Making in October, 2007 in Pittsburgh, PA.

TS Love, RD Cebul, D Einstadter, and A Jain. Influence of EMR-Based Clinical Decision Support for Diabetes on Measures Under Varying Levels of Provider Control. Annual Conference of the Society for Medical Decision Making in October, 2007 in Pittsburgh, PA.

RD Cebul chaired Symposium: "Real-Time Decision Support in the EMR Era" (with Carol Cain, Ph.D., Mary Goldstein, M.D., and Blackford Middleton, M.D.), 2006 Annual Meeting of the Society for Medical Decision.