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Computerized Prompting and Feedback of Diabetes Care: A Review of the Literature

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Abstract

Background:

The objective of this study was to assess published literature on computerized prompting and feedback of diabetes care as well as to identify opportunities to strengthen diabetes care processes.

Methods:

Medline (1970–2008), Cumulative Index to Nursing and Allied Health Literature (1982–2008), and Cochrane Central Register of Controlled Trials (4th quarter 2008) were searched, and reference lists from included articles were reviewed to identify additional studies. Patient sample, clinician sample, setting, duration of the trial, intervention description, control description, and results were abstracted from each study.

Results:

Fifteen trials were included in this review. The following elements were observed in the interventions: general prompt for a particular patient to be seen for diabetes-related follow-up (5 studies), specific prompt reminding clinicians of particular tests or procedures related to diabetes (13 studies), feedback to clinicians in addition to prompting (5 studies), and patient reminders in addition to clinician prompts (5 studies). Twelve of the 15 studies (80%) measured a significant process or outcome from the intervention.

Conclusions:

The majority of trials identified at least one process or outcome that was significantly better in the intervention group than in the control group; however, the success of the information interventions varied greatly. Providing and receiving appropriate care is the first step toward better outcomes in chronic disease management.

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Abbreviations: (HbA1c) hemoglobin A1c

Keywords: diabetes mellitus, feedback, outcomes of care, process of care, randomized controlled trials, reminder systems

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Introduction

The discrepancy between what is known and what is done in diabetes care suggests the need for better knowledge management to improve processes and outcomes through sharing and leveraging information. For example, the first trial on the benefit of early treatment of diabetic retinopathy was published in 1976.[1] The American Diabetes Association started recommending annual eye examinations in 1988 and has restated the recommendation annually.[2] According to the Centers for Disease Control and Prevention, the age-adjusted rate of annual dilated eye exams among adults with diabetes is 69.1%.[3] The landmark trial for diabetes foot care was published in 1989,[4] and the Centers for Disease Control and Prevention reports the age-adjusted rate for self-exam of feet is 64.6%.[3]

Information interventions are ways of delivering knowledge and can provide clinicians with decision support at appropriate times in order to improve health care processes and patient health outcomes.[5] Researchers in diabetes health informatics face challenging opportunities to design clinical information systems to change clinical processes and patient outcomes.[6] A variety of trials have focused on information intervention techniques (e.g., reminders and feedback) for modifying clinical processes and patient outcomes. Some reviews have found these interventions to be very effective in improving the quality of health care processes and outcomes,[7–9] while other reviews have found that the interventions do not always produce the expected change.[10–11]

The objective of this study was to identify computerized information interventions targeted at clinicians that can effectively accelerate the translation of evidence into practice, thereby improving clinician processes and patient outcomes in diabetes. This review assessed the published literature on computerized prompting and feedback of diabetes care and identifies opportunities to strengthen diabetes care processes.

Methods

Data Sources

Medline (1970–2008), Cumulative Index to Nursing and Allied Health Literature (1982–2008), and Cochrane Central Register of Controlled Trials (4th quarter 2008) were searched for eligible articles using combinations of the following search terms: (1) diabetes mellitus, type 1 diabetes mellitus, or type 2 diabetes mellitus and (2) reminder systems, practice guidelines as topic, computer-assisted decision making, clinical decision support systems, computer-assisted therapy, prompt, and remind. The reference lists of included studies were also searched.

Study Selection

The authors screened the titles and abstracts of the identified citations and articles based on the following criteria. The inclusion criteria were any randomized controlled trial evaluating computerized prompting or feedback of diabetes care. We excluded studies that were not randomized, without a control group, not reporting results, or not written in English.

Data Extraction

From each eligible article, the authors collected the following information: patient sample (number, clinical situation condition, age, percent male), clinician sample (number, specialty), setting, duration of the trial, intervention description, and results (measure, process or outcome, significance level). Coding disagreements were resolved by discussion among the authors.

Results

The literature searches identified 90 articles. The titles and abstracts of these articles were read, and 31 articles were determined to be potentially relevant. After reading the full articles, 15 articles met the eligibility criteria (**Table 1**).[12–26] Articles were excluded if they did not include a computerized clinician prompting intervention for diabetes (65 articles), were not randomized (3 articles), were without a control group (2 articles), did not report results (4 articles), or were not written in English (1 article).

Site and Sample

Based on preexisting databases and electronic patient records, automated prompts or summaries were generated for more than 2030 clinicians caring for 63,987 persons with diabetes. One study did not provide information on the number of participating clinicians.[13] The clinician specialties included endocrinology,[18] family practice,[15–17] general practice,[13,14] internal medicine,[12,18–26] nurse practitioner,[17,18] and physician assistant.[17] Eight of the studies included medical residents.[12,17–20,22,25,26]

Table 1.
Study Characteristics[a]

Reference	Clinician sample size	Clinician specialty	Patient sample size	Patient age (mean in years)	Patient gender (% male)	Setting	Intervention and follow-up duration (months)	Intervention characteristics
Demakis *et al.* (2000)[12]	275	IM	12989	66	98	HC	17	G
DICET (1994)[13]	NA	GP	274	59	56	HC	24	G, P
Filippi *et al.* (2003)[14]	300	GP	15343	65% age 64+	47	CC	7	S
Holbrook *et al.* (2005)[15]	48	FP	511	60	50	CC	6	S, P
Kenealy *et al.* (2005)[16]	107	FP	19187	27% age 50+	NA	CC	2	G, P
Lobach and Hammond (1994)[17]	58	FP, NP, PA	483	NA	NA	CC	6	G, S, F
McDonald (1976)[18]	63	E, IM, NP	257	NA	NA	HI	8	S
Meigs *et al.* (2003)[19]	66	IM	598	68	48	HC	12	S
Nilasena and Lincoln (1995)[20]	35	IM	164	NA	NA	HC	6	G, S
Persell *et al.* (2008)[21]	19	IM	334	58	37	CC	6	S, P
Phillips *et al.* (2005)[22]	345	IM	4138	59	33	HC	24	S, F
Sequist *et al.* (2005)[23]	194	IM	4549	64	44	CC, HC	7	S
Smith *et al.* (2008)[24]	97	IM	639	61	47	CC	30	S, F
Thomas *et al.* (2007)[25]	78	IM	483	NA	NA	HC	10	S, F, P
Ziemer *et al.* (2006)[26]	345	IM	4038	59	33	CC	36	G, S, F

[a] CC, community-based outpatient clinic; E, endocrinology; F, clinician feedback; FP, family practice; G, general clinician prompt; GP, general practice; HC, hospital-based outpatient clinic; HI, hospital inpatient care; IM, internal medicine; NA, not available; NP, nurse practitioner; P, patient prompt; PA, physician assistant; S, specific clinician prompt

The mean age of participating patients ranged from 58[21] to 68.[19] Two studies provided information on age as a proportion of patients above a certain age.[14,16] Four studies did not provide any information on the mean age of patients.[17,18,20,25] The percentage of male patients in the studies ranges from 33%[22,26] to 98%.[12] Five studies did not provide information about patient gender. One study intervened for diabetes prevention.[16] Eleven studies intervened for persons with type 1 or type 2 diabetes.[12–15,17,18,20,21,23–25] Three studies intervened for persons with type 2 diabetes only.[19,22,26] Finally, three studies intervened for cardiovascular disease in addition to diabetes.[12,14,23]

The studies took place in five countries: Canada,[15] Italy,[14] New Zealand,[16] the United Kingdom,[13] and the United States.[12,17–26] Nine of the studies occurred in academic settings.[17–22,24–26] Most of the studies took place in community-based outpatient clinics[14–17,21,23,24,26] or hospital-based outpatient clinics.[12,13,19,20,22,23,25] Only one study occurred in an inpatient setting.[18]

Interventions

The primary intervention in this group of 15 studies was aimed at physicians and consisted of clinically relevant and diabetes guideline-based computerized reminders and feedback (**Table 2**). A general prompt reminding clinicians of the need for a particular patient to be seen for diabetes-related follow-up was observed in five studies.[13,16,17,20,26] A specific prompt reminding clinicians of particular tests or procedures related to diabetes that are needed was observed in 13 studies.[12,14,15,17–26] Feedback to clinicians, in addition to prompting, was provided in five studies.[17,22,24–26] Patient prompts, in addition to clinician prompts, were provided in five studies.[13,15,16,21,25] Specific prompts and feedback were provided to clinicians about hemoglobin A1c (HbA1c),[12,15,17,19,22,24–26] glycemic control,[20,24,26] blood pressure,[15,22,24–26] cholesterol,[15,17,19,23–25] microalbuminuria,[12,15,17,19] weight,[15,22,24,26] eye exam,[12,15,17,19,20,24] foot care,[12,15,17,19,20,24] nutritional counseling,[12] lab tests,[18,22] macrovascular care,[20] neurologic care,[20] renal care,[20] physical exam,[17] influenza vaccinations,[17] pneumococcal vaccinations,[17] medications,[22,23,26] aspirin,[21,23] and antiplatelet drugs.[14] One study provided only a general reminder of a needed diabetes appointment,[13] while another study provided a general reminder of a need for diabetes screening and a diabetes self-risk assessment.[16] The length of the intervention and follow-up ranged from 2[16] to 36 months[26] with an average of 13 months.

Table 2.
Reminders and Process / Outcome Measures[a]

Reference	Reminders	Measures
Demakis *et al.* (2000)[12]	HbA1c, dipstick urinalysis for protein, eye exam, foot care, nutritional counseling	**Process:** HbA1c, general adherence (NS); nutrition counseling, general adherence (NS); urinalysis, general adherence (0.001); eye examination, general adherence (0.001); foot examination, general adherence (0.03); HbA1c, visit-specific adherence (0.001); nutrition counseling, visit-specific adherence (0.02); urinalysis, visit-specific adherence (0.01); eye examination, visit-specific adherence (0.001); foot examination, visit-specific adherence (0.001)
DICET (1994)[13]	general reminder of appointment needed	**Process:** routine diabetic care visits (0.05); glycated hemoglobin (0.05); blood pressure (0.05); creatinine (NS); visual acuity (0.05); funduscopy (0.05); peripheral pulses (0.05); neurological examination (0.05); feet (0.05). **Outcome:** glycated hemoglobin (NS); creatinine (NS); body mass index (NS); systolic blood pressure (NS); diastolic blood pressure (NS); knowledge of diabetes (NS); knowledge of urine and blood testing (NS); knowledge of foot care (NS); knowledge of general management (NS); diabetes questionnaire total knowledge score (NS); diabetes questionnaire eating problems (NS); diabetes questionnaire anxiety (NS); diabetes questionnaire depression (NS); diabetes questionnaire support (0.05); beliefs in personal control (NS); beliefs in medical control (0.05); beliefs in situation control (NS); beliefs in satisfaction with treatment (NS); well-being (NS)
Filippi *et al.* (2003)[14]	antiplatelet drugs	**Process:** patients with antiplatelet drug prescriptions (0.01)
Holbrook *et al.* (2005)[15]	eyes, feet, blood pressure, cholesterol, HbA1c, microalbuminuria, body mass index	**Process:** physician visit (0.0001); blood pressure (0.0001); LDL cholesterol (0.0001); HbA1c (0.0001); microalbuminuria (0.0001); body mass index (0.0001); feet (0.0001); eye (0.0001). **Outcome:** blood pressure (0.007); HbA1c (0.001)
Kenealy *et al.* (2005)[16]	diabetes screening, diabetes self-risk assessment	**Process:** blood glucose test to screen for diabetes (0.001)
Lobach and Hammond (1994)[17]	pneumococcal vaccination, foot exam, annual complete physical exam, HbA1c, urine protein determination, cholesterol, eye exam, influenza vaccination	**Process:** diabetes guidelines adherence (0.02)
McDonald (1976)[18]	lab tests based on drugs the patient is taking	**Process:** lab test reminders for old test (0.0001); lab test reminders for abnormal test (0.026)
Meigs *et al.* (2003)[19]	eye exam, foot exam, HbA1c, cholesterol, urine albumin	**Process:** HbA1c test in past 12 months (NS); number of HbA1 test/year (0.008); cholesterol, at least one LDL test in past 12 months (NS); cholesterol, number of LDL test/year (0.02); blood pressure measurement past 12 months (NS); eye exam by an eye care professional in the past 12 months (NS); foot exam in past 12 months (0.003). **Outcome:** HbA1c < 7% (NS); HbA1c (NS); LDL < 130 mg/dl (NS); mean LDL cholesterol (NS); blood pressure < 130/85 mmHg (NS); systolic blood pressure (0.03); diastolic blood pressure (NS)
Nilasena and Lincoln (1995)[20]	renal care, foot care, eye exam, glycemic control, macrovascular care, neurologic care	**Process:** compliance with recommended care (NS)
Persell *et al.* (2008)[21]	aspirin use	**Process:** regular use of aspirin (NS)
Phillips *et al.* (2005)[22]	HbA1c, medications, lab values, weight, blood pressure	**Outcome:** HbA1c % (0.014); blood pressure (NS); LDL cholesterol (NS)
Sequist *et al.* (2005)[23]	cholesterol, angiotensin-converting enzyme inhibitors, aspirin use, medications	**Process:** annual cholesterol exam (0.001); biennial HbA1c exam (NS); annual dilated eye exam (NS); hypertension/angiotensin-converting enzyme inhibitor use (NS); statin use for LDL cholesterol (NS)

continued →

Table 2. Continued

Reference	Reminders	Measures
Smith *et al.* (2008)[24]	blood glucose, lipid profile, blood pressure, HbA1c, foot care, height and weight, eye exam	**Process:** American Diabetes Association, NCQA provider score (NS). **Outcome:** Minnesota community aggregate optimal diabetes score (NS); HbA1c (NS); LDL-C < 130 mg/dl (0.045); LDL-C < 100 mg/dl (NS); blood pressure < 130/80 (NS); not smoking or advised to quit (0.04); oral agent only (NS); insulin (NS); Metformin (NS); aspirin (0.001); angiotensin-converting enzyme inhibitor (NS); statins (NS); HbA1c median range (NS); LDL-C median (NS); blood pressure median systolic (NS); blood pressure median diastolic (NS); estimated 10-year coronary artery disease risk (NS)
Thomas *et al.* (2007)[25]	HbA1c, cholesterol, blood pressure	**Process:** HbA1c monitoring within 6 months (0.01); LDL cholesterol monitoring within 1 year (0.02). **Outcome:** HbA1c < 7.0% (NS); mean HbA1c (NS); mean reduction HbA1c (NS); LDL < 100 mg/dl (NS); mean LDL cholesterol (NS); mean reduction LDL cholesterol (NS); blood pressure < 130/85 mmHg (NS); mean systolic blood pressure (NS); mean diastolic blood pressure (NS)
Ziemer *et al.* (2006)[26]	glucose levels, HbA1c, weight, blood pressure, use of medications	**Process:** therapy intensification in response to glucose level (NS)

[a] LDL, low-density lipoprotein; NCQA, National Committee for Quality Assurance; NS, not significant

Process and Outcome Measures

Fifty processes and 57 outcomes were measured in the 15 studies (**Table 2**). Fourteen studies evaluated the effect the interventions had on the processes of care.[15–21,23–26] Thirty-five of 50 process measures (70%) were significantly improved. Three[13,15,17] of the five[13,15,17,20,24] studies that measured adherence with general diabetes guidelines for routine clinic visits were significantly improved. Process measures assessed in more than one study (e.g., blood pressure, cholesterol, eye exam, foot exam, and HbA1c) are summarized later. Blood pressure measurement was significantly improved in two[13,15] of three[13,15,19] studies. Cholesterol testing and monitoring was significantly improved in four[15,19,23,25] studies in which it was measured. Eye exam performance was significantly improved in three[12,13,15] of five[12,13,15,19,23] studies. Foot exams were significantly improved in four[12,13,15,19] studies in which they were measured. Hemoglobin A1c measurement and monitoring was significantly improved in five[12,13,15,19,25] of the six[12,13,15,19,23,25] studies in which it was measured. Five of the studies evaluated the effect the interventions had on the outcomes of care.[13,15,19,22,24] Nine of the 57 outcome measures (16%) were significantly improved. The significantly improved outcome measures include HbA1c,[15,22] blood pressure,[15,19] cholesterol,[24] regular aspirin use,[24] quit smoking,[24] belief in medical control,[13] and support from others.[13] Three studies[20,21,26] did not have any significant process or outcome measures.

Discussion

This review assessed published literature on computerized prompting and feedback of diabetes care. The 15 studies included in this review contributed information on the study characteristics as well as the associated processes and outcomes. Results of this review indicate that diabetes care processes can be improved by providing reminders and feedback to clinicians. Providing and receiving appropriate care is the first step toward better outcomes in chronic disease management.

Prompting and feedback can be used across the complete spectrum of diabetes care from prevention, diagnosis, and treatment, through monitoring. Each encounter with the healthcare system is an opportunity for a person with diabetes to keep current with the recommendations for diabetes care. However, prompting fatigue and the fragmentation of health care information can pose challenges for clinicians. Too many prompts can interfere with a busy clinician's schedule, especially when the patient's current reason for a visit takes precedence. In addition, verifying a patent's eligibility for a prompted service can be time-consuming when health care information is fragmented. It is also important to keep the guidelines, embedded in the medical record or other decision support system, current as well as maintain consensus with the rules that govern the reminders.

The results of this review should be interpreted with limitations in mind. We attempted to search the literature comprehensively; however, we may have unknowingly left out some studies that were eligible for inclusion. We did not include gestational diabetes among our search terms. Publication bias may exist, because studies that show a statistically significant outcome are more likely to be written by the investigator and published. We also limited our searches to randomized controlled trials. It is possible that including only randomized controlled trials excluded some studies that used historical controls instead of a current control group. The shortcomings of the available studies represent opportunities for future research. The follow-up period in most studies was not long enough to assess the long-term differences made by computerized reminders and feedback on the behavioral and clinical outcomes of diabetes. We did not explore the degree to which the outcomes were due to the clinical decision-making approach used in these studies. It should not be assumed that more information *per se* leads to better outcomes. Future studies should also consider the inclusion of an economic evaluation of the computerized interventions.

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