Journal of Diabetes Science and Technology
Volume 7, Issue 3, May 2013

ORIGINAL ARTICLE

The Impact of a Decision Support Tool Linked to an Electronic Medical Record on Glycemic Control in People with Type 2 Diabetes

Waruna Gunathilake, M.D.,[1,2,3] Sajith Gunawardena,[4] Ranga Fernando,[5] George Thomson, MbChB,[2,3] Devaka Fernando, M.D., FRCP[2,3,6]

Abstract

Aims:

We retrospectively compared glycemic control and glycemic burden in type 2 diabetes patients treated by general physicians with access to decision support with those treated by general physicians without access to decision support.

Methods:

A total of 875 patients [471 (53.8%) males] aged 54.3 [standard deviation (SD) 13.1] years followed up over 84 months. A total of 342 patients (39%) were managed with decision support, and effects on glycosylated hemoglobin (HbA1c) were assessed.

Results:

There was no difference between groups in starting HbA1c [7.6 (SD 1.8) versus 7.5 (SD 1.5); p = not significant] at baseline. Patients treated with decision support were more likely to have planned review of HbA1c, adjustment of medication, prescription of statins, dietetic and nurse educator inputs (71.3% versus 58.5%; Chi squared = 14.7; p = .001). The mean HbA1c in the group treated with decision support was not significantly reduced within the first year [7.5% (SD 1.8) versus 7.6% (SD 1.5); p = not significant; 95% confidence interval (CI) -0.33 to 0.17], but statistically significant differences were apparent at year 2 [7.2% (SD 2.0) versus 8% (SD 3.4); p = .0001; 95% CI -1.3 to -0.5] and sustained through year 3 [7.2% (SD 2.0) versus 8.0% (SD 2.0); p = .0001; 95% CI -1.2 to -0.6], year 4 [7.2% (SD 2.3) versus 8.2% (SD 2.5); p = .0001; 95% CI -1.2 to -0.6], year 5 [7.0% (SD 2.3) versus 8.3% (SD 2.6); p = .001; 95% CI -1.5 to -0.8], year 6 [7.0% (SD 2.0) versus 8.2% (SD 2.4); p = .001; 95% CI -1.5 to -0.9], and year 7 [6.9% (SD 1.2) versus 8% (SD 1.8); p = .001; 95% CI -1.4 to -1.0].

Conclusion:

Use of a decision support system showed benefits in adherence to clinical care pathways and achieving significant improvements in glycemic control.

J Diabetes Sci Technol 2013;7(3):653–659

Author Affiliations: [1]Ministry of Health Sri Lanka, Colombo, Sri Lanka; [2]Sheffield Hallam University, Sheffield, United Kingdom; [3]Sherwood Forest Hospitals National Health Service Foundation Trust, Nottinghamshire, United Kingdom; [4]Open University, Colombo, Sri Lanka; [5]Birkdale School, Sheffield, United Kingdom; and [6]University of Sheffield, Sheffield, United Kingdom

Abbreviations: (CI) confidence interval, (EMR) electronic medical record, (HbA1c) glycosylated hemoglobin, (SD) standard deviation, (T2DM) type 2 diabetes mellitus

Keywords: bundles of care, clinical decision system, electronic health record, type 2 diabetes mellitus

Corresponding Author: Devaka Fernando, M.D., Department of Diabetes and Endocrinology, Sherwood Forest Hospitals National Health Service Foundation Trust, Sutton-in-Ashfield, Nottinghamshire NG17 4 JL, UK; email address devaka.fernando@sfh-tr.nhs.uk

Introduction

The value of managing people with type 2 diabetes mellitus (T2DM) through early initiation of a goal-oriented strategy with intention to treat to target is undisputed.[1] Regular review is an essential prerequisite for such a treatment strategy, which not only gives an opportunity for reinforcing and supporting people with T2DM to gain confidence and competency in self-care, but also gives health care professionals an opportunity to adjust current medication or introduce additional therapies in a timely manner if treatment targets are not achieved. This approach may improve glycemic control and reduce associated microvascular complications due to prolonged periods of poor glycemic control.[1]

Failure to treat to target has been attributed to clinically significant apathy, leading to a negative impact on self-care behavior in people with diabetes without depression[2] as well as clinical inertia on the part of health care professionals.[3–5] Interventions that support nonspecialist providers of care and address both issues have been shown to improve outcomes in primary care.[6] The World Health Organization has developed tools for implementing an innovative care for chronic conditions framework,[7] which consist of four components of proven efficacy: self-management support, delivery system design, decision support,[8] and clinical information systems.

Despite a successful nurse education program with overseas partners, creating a core group of trained health professionals qualified to provide telephone support and provision of guidelines,[8–10] multidisciplinary working has remained an underutilized resource. However, there is clear evidence that such inputs improved patient education coverage and staff compliance with benchmarks such as screening for blood pressure, foot examination, eye examination, checking and treatment of lipids, and testing microalbumin, glycemic control, and blood pressure.[11]

We used a database integral to the electronic health record system to evaluate the impact of the decision support system on diabetes care by assessing improvements to glycemic control in patients managed with and without a decision support system.

Patients and Methods

We used an electronic medical record (EMR) that provided audit information on the process and results of care for all patients attending health care institutions where the system was deployed (EMR and decision support prompts were developed by Sajith Gunawardena as part of a university project through SS Technologies Ltd., Panadura, Sri Lanka).

This study included data from a cohort of 875 patients [471 (53.8%) males], mean age 54.3 [standard deviation (SD) 13.1] years, with T2DM and mean glycosylated hemoglobin (HbA1c) 7.5 (SD 1.6) who were discharged from specialist care by an endocrinologist in a community clinic based at a general practitioner surgery facility to the care of a team of general physicians practicing outside the hospital (internists in primary care) who replaced the endocrinologist in the community clinic. Hence this is an opportunistic retrospective study of unselected patients.

Electronic medical records are not routinely used in Sri Lanka. The clinic described in this article is the first in the country to use an EMR. The development of an EMR within the country, purchase and maintenance of computers, and training of health care staff were funded by charitable donations. Further grants supported salaries of medical staff at a not-for-profit health center.

A total of 342 patients (39%) were managed by six general physicians (internists) with access to the decision support system, and the remaining 533 by five general physicians (internists) without access to the decision support system. Follow up was conducted for 84 months. The transfer of care from specialist to generalist was only for patients with T2DM with no evidence of retinopathy; nephropathy; neuropathy; established coronary, peripheral, or cerebrovascular disease; or chronic kidney disease. Patients taking off-license medication combinations of insulin and oral agents concurrently and patients with comorbidity requiring specialist expertise remained under specialist care and were transferred to specialist clinics. No prompts were available before the current comparison. We chose to

compare outcomes between use of the system versus no use of the system rather than use historical comparisons of endocrinologist alone versus nonendocrinologist with prompt.

The EMR administrator support system included provider reminder systems and patient reminder systems that prompted administrative staff to contact patients to attend appointments and to have regular monitoring.[8,9]

The triggers for causing the decision support rule to be applied included HbA1c above 7.5% or absence of recent value within the past 3 months, failure to document retinopathy screening, high body mass index, high waist circumference, elevated blood pressure or absence of record within the past 3 months, failure to document annual dietetic review, and failure to document annual podiatry screening. The input data were entry of abnormal value or failure to enter value of triggers into the patient record. The intervention through clinical decision support was achieved through a series of prompts that directed health care professionals to use established guidelines and permitted deviation from guidelines but held them accountable. As such, the system was not an autopilot that took over from a health care professional but offered them support in guiding them to relevant guidance in the form of professional society guidelines. There was no direct prompting of patients, but users were encouraged to use the graphs provided to explain the decision making process to patients whenever changes were made to treatment. Choices were offered in terms of single mouse click options to refer patients to the appropriate clinician, to change medication dose, or to notify when maximum dose was reached.

The decision support system facilitated access to clinical data by providers and consumers to enhance both provider education and the promotion of self-management among people with diabetes. It contained prompts to review and change medication if targets were not reached. These prompts were placed in the form of a care bundle of attention to glycemic control, screening and management of comorbidities such as vascular risk, screening for complications, control of blood pressure, referrals to dietetics, and foot screening. The system permitted variance from treatment pathways, but it was possible to audit any variance such as not adjusting medication, where clinically appropriate, if HbA1c was elevated. It included a graphic tool that enabled patients to track HbA1c progress through visual representation of data and to view their progress. The system encouraged multidisciplinary working by encouraging patients' engagement in self-care and prompted medical practitioners of the need for inputs from dietitians, educators, and, where relevant, specialists, and for standardized management practice outlined in national guidelines.[10]

The decision support offered was modeled on the intensive care practice of using bundles of care and high-impact interventions. The measures were grouped as a collection of interventions (e.g., checking microalbumin, podiatry screening, retinopathy screening, checking blood pressure) to be applied to the management of T2DM and regarded as unit of care that must be adhered to in an "all or none" approach[12] unless variance could be justified on the grounds that tight metabolic control was not in the patient's best interests. Concordance with the bundle was assessed on the basis that all the components (changes to glycemic medications; use of statins, aspirin, or antihypertensives; referrals for screening where relevant) were utilized in all patients.

We retrospectively evaluated the effect of deployment of the decision support system by comparing two groups of patients deemed to benefit from tight glycemic control within the same geographical area attending a not-for-profit clinic during the development phase of the system. One group of health care professionals had access to the decision support.

We compared this group with those attending the same clinic managed conventionally by health care professionals who used the EMR and administrative functions for appointments and recall but did not have access to the decision support functions. Those not having access to the electronic decision support had access to paper copies of booklets of guidelines, but the doctors did not receive electronic prompts. There was no difference in training, experience, or qualification between community-based doctors who were general physicians engaged in community/office-based practice, and no one was a specialist endocrinologist. All patients' HbA1c data were available on the electronic health record for both groups. Both groups of doctors received provider education in the form of educational workshops, meetings, and lectures and educational outreach visits and distribution of educational materials.[9]

The HbA1c was measured at each clinic visit. These were scheduled at 3 months, but where patients do not attend, the interval was longer than 3 months. All patients did attend four times per year, but the HbA1c tests were not performed quarterly in these patients (as it would be pointless to do HbA1c testing more frequently). Venipuncture was performed at a community-based nonhospital clinic (office-based practice), and the laboratory measurement was performed at a hospital clinical pathology laboratory.

Statistical analysis was performed using Students *t*-test and Chi-squared test.

The data on patients held in the electronic database maintained by the Endocrine and Metabolic Disease Trust Sri Lanka[9] was made available for research after anonymization and removal of patient-identifiable data, in keeping with institutional guidance on anonymized data, and was approved by the database regulator.

Results

There was no significant difference between patients treated without access to the decision support system and those treated with access to the decision support system (**Table 1**) in mean age [53.9 (SD 12.2) versus 54.7 (SD 13.4) years; p = not significant], mean HbA1c [7.6% (SD 1.8) versus 7.5% (SD 1.5); p = not significant], patients already on insulin [22 (3.9%) versus 12 (3.5%)], mean duration of diabetes [7.6 (SD 8.1) and 6.6 (SD 7.1) years; p = not significant], and female-to-male ratio [146/196 (Chi square 1.3) versus 258/275, 1.06 (Chi square 2.7); p = not significant].

Table 1.
Characteristics of Groups at Baseline

	Clinical decision support	No clinical decision support
HbA1c, % (SD)	7.6 (1.8)	7.5 (1.5); not significant
Male:female	146/196	258/ 275; not significant
Mean age, years (SD)	53.9 (12.2)	54.7 (13.4); not significant
Mean duration of diabetes, years	7.6 (8.1)	6.6 (7.1); not significant

There were no differences in the proportion of patients reaching target level of HbA1c below 7.5% between those receiving decision support and those not receiving decision support at inception (57.3% versus 60.6%; Chi square = 0.94; p = not significant) and at 1 year (62% versus 58%; Chi square = 1.27; p = not significant), but there were significant differences at 2 years (71.6% versus 50.1%; Chi square = 39.8; p = .0001), 3 years (73.1% versus 50.1%; Chi square = 45.6; p = .0001), 4 years (76.6% versus 51.6%; Chi square = 54.9; p = .0001), 5 years (80.1% versus 47.7%; Chi square = 91.7; p = .0001), 6 years (80.4% versus 46.5%; Chi square = 99.5; p = .0001), and 7 years (80.4% versus 45.4%; Chi square = 105.6; p = .0001). During the course of the 7 years of follow-up, 92.1% in the decision support group and 78.2% of those not receiving decision support achieved a target level of HbA1c at least once (Chi square = 29.3; p = .0001).

The HbA1c levels greater than 8% and 10% at inception were seen, respectively, in 38.3% and 13.3% in the decision support group and 29.1% and 8.1% of those not receiving decision support (Chi square = 8.05; p = .005; Chi square = 5.97; p = .015). The HbA1c levels greater than 8% and 10% at 7 years were seen, respectively, in 12.3% and 2.6% in the decision support group and 44.3% and 14.8% of those not receiving decision support (Chi square = 34.22; p = .001; Chi square = 98.4, p = .0001).

Patients treated by doctors using the decision system were more likely to have the complete care bundle of planned review of HbA1c, where appropriate adjustment of medication and prescription of statins and dietetic and nurse educator inputs (71.3% versus 58.5%; Chi square = 14.7; p = .0001). At 84 months, 133 (15.2%) were insulin treated. A total of 79 out of 533 (14.8%) in those treated without decision support and 54 out of 342 (15.8%; Chi square = 0.151; p = not significant) of those treated with decision support were treated with insulin. There were no significant differences in attendance rates at clinics in the two groups (98.7% versus 99.7%; Chi square = 2.40; p = not significant).

The mean HbA1c in the group treated with decision support was not significantly reduced within the first year [7.5% (SD 1.8) versus 7.6% (SD 1.5); p = not significant; 95% CI -0.33 to 0.17], but statistically significant differences were apparent at year 2 [7.2% (SD 2.0) versus 8% (SD 3.4); p = .0001; 95% CI -1.3 to -0.5] and sustained through year 3 [7.2%

(SD 2.0) versus 8.0% (SD 2.0); p = .0001; 95% CI -1.2 to -0.6], year 4 [7.2% (SD 2.3) versus 8.2% (SD 2.5); p = .0001; 95% CI -1.2 to -0.6], year 5 [7.0% (SD 2.3) versus 8.3% (SD 2.6); p = .001; 95% CI -1.5 to -0.8], year 6 [7.0% (SD 2.0) versus 8.2% (SD 2.4); p = .001; 95% CI -1.5 to -0.9], and year 7 [6.9% (SD 1.2) versus 8% (SD 1.8); p = .001; 95% CI -1.4 to -1.0].

Discussion

Management of glycemic control in people with T2DM is complex and involves a combination of adherence to both lifestyle changes and concordance with pharmacological interventions. In addition to glycemic control, managing T2DM requires an integration of managing comorbidities and preventing such comorbidities. All this requires interaction with many health care professionals for screening and visits due to any intercurrent illness. Some evidence exists to support individual components,[6,13–15] which are incorporated into routine practice and are considered a part of a health care delivery package or bundle in diabetes services.

Unfortunately, randomized double-blind controlled studies of multiple interventions are scarce, as there are major barriers to determining details of potential synergy between these interventions, including the complexity of study design, large sample size, and long duration of follow-up required. Hence, we attempted to address this issue by retrospectively analyzing data from a historical cohort of patients using a case control model, where exposure to the system was considered as a case and nonexposure a control, and by considering the process of combining many interventions in a care bundle, as has been the case with evaluating interventions in intensive care settings.[12]

The use of a decision support system linked to an electronic health care record showed benefits in adherence to clinical care pathways and achieving significant reductions in HbA1c and glycemic burden with improvements in treatment target rates. The changes in HbA1c showed marked differences in the groups.

Our results are comparable to randomized nonblinded studies of clinical decision systems that have resulted in improved glycemic control.[16] Holman and coauthors demonstrated that, in the United Kingdom Prospective Diabetes Study, the sustained "legacy effect" of initial tight glucose control resulted in a reduction of risk of microvascular complications and emergent macrovascular disease, even when glycemic control deteriorated after the study.[17] The limited data we have do not permit detailed cost-benefit or cost-effective analyses. However, based on a comparison of achieving target HbA1c and reduction in HbA1c, extrapolation of our data to studies from Canada suggest that we would obtain similar results. The cost-effectiveness ratio achieved in Canada was $160,845 per quality-adjusted life year.[18]

Studies on the effects of systems on physician behavior using commercially available systems showed smaller than expected improvements,[19] whereas our study showed significant improvements in both process and outcome. Evaluation studies of clinical decision support systems have assessed commercially available systems against a set of standards and concluded that successful systems were seen in sites that have developed systems themselves and not commercial systems.[20] The success of our system may be the result of its development by a team of clinicians and academic programmers working together.

Our conclusions should be interpreted with the caveat that they are from an opportunist, retrospective comparison of a historical cohort of patients using a case control model from a nonrandomized nonblinded study. We did not introduce any novel technology but assessed the role of prompting professionals through simple measures within the functional capability of many currently available EMR systems. Our work should be regarded as a proof of concept that prompting health care professionals can result in improving the process and outcome of care. The data should not be interpreted as results being applicable to a particular commercial system. We do not feel that we have merely evaluated a computer program, but that we have tested a concept. Wider implementation of the system beyond its current setting in a single clinic will require further evaluation and development in terms of long-term trials with a wider range of users in different health care settings. Factors such as availability of sustainable resources to develop and maintain knowledge bases of clinical decision support, ability to integrate with workflow of health care staff, availability of a sound financial basis, and requirement of such systems to obtain and maintain regulatory or accreditation status are likely to be major determinants of wider deployment of the electronic health record and the system more widely.

The prompts to adopt a multidisciplinary approach may have facilitated the improved referrals as well as nurse and dietitian involvement for which there is clear evidence.[13]

The improved outcome may have been related to improved adherence. It is possible that the explanations about the significant HbA1c values and its reinforcement with graphic assistance in tracking HbA1c above the target level as part of the care bundle may have enabled patients to identify the need to reduce HbA1c and improve adherence.[14,15]

We conclude that decision support through directing clinicians to use available knowledge resources at the time of consultation enabled staged diabetes care to be delivered as a multifaceted intervention (within an organizational culture that respected the clinical freedom to assess patients individually, consider patient preference, and determine appropriate intensity of glycemic control and the need to use the bundle) and is a useful measure that supports clinical teams to treat T2DM effectively. The mechanism of action in this instance could be a combination of provider reminder systems, facilitated relay of clinical data to providers, audit and feedback, provider education, patient education, patient reminder systems, and financial incentives leading to promotion of self-management achieved through changes in culture within the organization and in people attending the service.

Funding:

We are grateful to the Endocrine and Metabolic Research Fund Sherwood Forest Hospitals National Health Service Foundation Trust, the World Diabetes Foundation, and the Endocrine and Metabolic Disease Trust Sri Lanka for financial support. Waruna Gunathilake was supported by a scholarship from the Postgraduate Institute of Medicine, University of Colombo; Sheffield Hallam University; and the Ministry of Health Sri Lanka through study fellowships. Sajith Gunawardena was supported by a grant from Sherwood Forest Hospitals National Health Service Foundation Trust and received scholarship fees for a university degree from the Endocrine and Metabolic Disease Trust.

Disclosures:

Sajith Gunawardena has established SS Technologies Panadura Sri Lanka as sole proprietor.

Acknowledgments:

We thank Ms. Tracy Tasker, Ms. Rachel Cooke, Ms. Tina Bleakley (in the United Kingdom), and Ms. S. M. de Silva (in Sri Lanka) for administrative support.

References:

1. Brown JB, Nichols GA, Perry A. The Burden of Treatment Failure in Type 2 Diabetes. Diabetes Care. 2004;27(7):1535–40.
2. Padala PR, DeSouza CV, Almeida S, Shivaswamy V, Ariyarathna K, Rouse L, Burke WJ, Petty F. The impact of apathy on glycemic control in diabetes: a cross-sectional study. Diabetes Res Clin Pract. 2008;79(1):37–41.
3. Hicks PC, Westfall JM, Van Vorst RF, Bublitz Emsermann C, Dickinson LM, Pace W, Parnes B. Action or inaction? Decision making in patients with diabetes and elevated blood pressure in primary care. Diabetes Care. 2006;29(12):2580–5.
4. Grant R, Adams AS, Trinacty CM, Zhang F, Kleinman K, Soumerai SB, Meigs JB, Ross-Degnan D. Relationship between patient medication adherence and subsequent clinical inertia in type 2 diabetes glycemic management. Diabetes Care. 2007;30(4):807–12.
5. Schmittdiel JA, Uratsu CS, Karter AJ, Heisler M, Subramanian U, Mangione CM, Selby JV. Why don't diabetes patients achieve recommended risk factor targets? Poor adherence versus lack of treatment intensification. J Gen Intern Med. 2008;23(5):588–94.
6. Phillips LS, Ziemer DC, Doyle JP, Barnes CS, Kolm P, Branch WT, Caudle JM, Cook CB, Dunbar VG, El-Kebbi IM, Gallina DL, Hayes RP, Miller CD, Rhee MK, Thompson DM, Watkins C. An endocrinologist-supported intervention aimed at providers improves diabetes management in a primary care site: improving primary care of African Americans with diabetes (IPCAAD) 7. Diabetes Care. 2005;28(10):2352–60.
7. World Health Organization. Innovative care for chronic conditions: building blocks for action. Geneva: World Health Organization; 2002.
8. 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):202–8.
9. Gunathilake W, Idampitiya CA, Siriwardana A, Lenora D, Thomson G, Fernando D. An international partnership to implement innovative systems of health care delivery for diabetes in a developing country. Pract Diab Int. 2009;26(4):145–7.
10. Devapura GH, Fernando DJ. A desktop guide to type 2 diabetes mellitus. J Ceylon College Phys. 2000;33(1): 33–43.
11. Idampitiya C, Lenora D, Lau S, Thomson GA, Fernando DJ. Improving the quality of diabetes care in a Sri Lankan diabetes clinic through a diabetes nurse educator. Diabetes Res Clin Pract. 2008;80(1):e25–6.

12. Winters BD, Gurses AP, Lehmann H, Sexton JB, Rampersad CJ, Pronovost PJ. Clinical review: checklists - translating evidence into practice. Crit Care. 2009;13(6):210.

13. Guldberg TL, Vedsted P, Lauritzen T, Zoffmann V. Suboptimal quality of type 2 diabetes care discovered through electronic feedback led to increased nurse-GP cooperation. A qualitative study. Prim Care Diabetes. 2010;4(1):33–9.

14. Ancker JS, Chan C, Kukafka R. Interactive graphics for expressing health risks: development and qualitative evaluation. J Health Commun. 2009;14(5):461–75.

15. Iqbal N, Morgan C,Maksoud H, Idris I. Improving patients' knowledge on the relationship between HbA1c and mean plasma glucose improves glycaemic control among persons with poorly controlled diabetes. Ann Clin Biochem. 2008;45(Pt 5):504–7.

16. O'Connor PJ, Sperl-Hillen JM, Rush WA, Johnson PE, Amundson GH, Asche SE, Ekstrom HL, Gilmer TP. Impact of electronic health record clinical decision support on diabetes care: a randomized trial. Ann Fam Med. 2011;9(1):12–21.

17. Holman RR, Paul SK, Bethel MA, Matthews DR, Neil HA. 10-year follow-up of intensive glucose control in type 2 diabetes. N Engl J Med. 2008;359(15):1577–89.

18. O'Reilly D, Holbrook A, Blackhouse G, Troyan S, Goeree R. Cost-effectiveness of a shared computerized decision support system for diabetes linked to electronic medical records. J Am Med Inform Assoc. 2012;19(3):341–5.

19. Shojania KG, Jennings A, Mayhew A, Ramsay C, Eccles M, Grimshaw J. Effect of point-of-care computer reminders on physician behaviour: a systematic review. CMAJ. 2010;182(5):E216–25.

20. Wright A, Sittig DF, Ash JS, Sharma S, Pang JE, Middleton B. Clinical decision support capabilities of commercially-available clinical information systems. J Am Med Inform Assoc. 2009;16(5):637–44.