

## Preface

Some professional colleagues, treating patients with diabetes, often claim that no major breakthrough has occurred in diabetes since 1921 when the use of insulin in diabetic patients was first discovered. We cannot disagree more with that statement.

Over almost a decade some new and innovative means have been developed, such as the introduction of synthetic humanised insulin and, years later, the development of more sophisticated insulin analogues. The development of the new insulin analogues increased the variability of options available for patients and the treating diabetic team and allowed the use of short-acting insulin analogues, very short-acting analogues, long-acting insulin analogues and plenty combinations of them. Over the years many options of insulin delivery systems have been developed such as syringes, pens, jets and pumps and recently the patch-pumps which improved the quality of life of patients dramatically and helped them achieve better compliance to their therapy and better control of their diabetes. The introduction, in the 1980s, of self blood glucose measurement technology helped patients and medical teams to make better decisions of insulin doses and other therapeutic measures and had a tremendous impact on the way we treat our patients today.

Nowadays with the abundant use of insulin pumps and the increasing use of continuous glucose measurements we are again facing a new era in the treatment of diabetes. The introduction of pumps and sensors is followed by extensive effort to computerise the process of decision making, helping patients enjoy the technologies that already exist. The use of personal computers and the internet already allow patients to get access to up to date knowledge and better communication with the professional teams and, in the near future, will free patients from some of the duties they have today in running their daily activities.

Tremendous efforts are invested nowadays by researchers in academic institutions and industry to find ways to close the loop, thus creating the artificial pancreas. At the same time huge investments focus on trying to prevent type 2 diabetes by coping with the obesity epidemic in different ways including bariatric measures. Efforts are made to prevent, or at least stop, the destruction of the islet cells in pre-

diabetic or newly diagnosed type 1 patients by different modalities of immunomodulation. Attempts are also made to improve the handling of the daily life of diabetic patients, their life expectancy and their quality of life.

This growing interest in the development of new and advanced technologies and devices for the treatment of diabetes gave rise to numerous manuscripts in many medical journals relating to this topic. With this in mind, we decided that a *Yearbook in Advanced Technologies and Treatment for Diabetes* that will summarise in a critical way the most important and contributory articles published in the recent 2 years in this field is timely. We believe that the community of professionals in the fields of diabetes, endocrinology and metabolism will find this book helpful as will diabetes technology developers, general and family medical practitioners and other professionals involved with the care of diabetic patients.

This first ATTD Yearbook is based on manuscripts published from 2008 until the first part of 2009. It includes abstracts of published articles with annotations and comments by the editors and the associate editors who are well-known experts in the field.

### Conflicts of interest

MP has no potential conflicts to declare. TB has acted as a paid consultant to Bayer and Medtronic, obtained speaker's fees from Medtronic, Eli Lilly and Novo Nordisk, and received funding for research from Abbott.

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## Advanced Technologies and Treatments for Diabetes

# Information Technology

### Internet and information technology use in treatment of diabetes

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This chapter contains clinical studies and reviews of the state-of-the-art regarding how information technology can help improve outcomes for patients with diabetes through enhanced education and support.

With the increasing sophistication of diabetes treatment protocols and diabetes-related devices this new modality offers a remarkable opportunity for clinicians and patients. For the first time, with online tools clinicians are in a position to have a major impact on diabetes outcomes by providing robust and affordable just-in-time support to large numbers of patients who want to improve their diabetes outcomes through enhanced self-management of the complex behaviours so essential for good outcomes.

Patients with diabetes often need a complex set of services and support ranging from glucose monitoring, insulin and other medication management, psychotherapy and social support, to physical activity promotion, nutrition counselling and more. Integrating these supports into a patient's therapeutic regimen presents challenges that need to be addressed through a variety of strategies.

Patient self-management of diabetes enabled by information technology is becoming an important factor in the way providers deliver healthcare. Approaches using information technology to support clinical services are being dramatically altered by the confluence of several trends.

- Patients want an active role in managing their own health and a collaborative relationship with their healthcare providers.
- Widespread, low-cost internet access is erasing existing geographic, economic and demographic barriers to obtaining health information online, and with advanced Web 2.0 technologies high levels of interactivity can engage the patient.
- Clinicians and researchers now have a deeper understanding of how people learn and respond online, and that knowledge can be crafted into solutions that produce effective, long-term behaviour change.

Technology enabled approaches that show great promise to improve outcomes use new models of service provision in which technology enabled self-management support (SMS) provides patients with

- just-in-time delivery of tailored messages and experience that speak to each person based on their unique characteristics, their performance on key behaviours and their needs at that moment in time;
- ways to easily and accurately keep track of their performance and use that knowledge to plan and implement new approaches to reaching their goals;
- ways to link directly to family and friends for critical support, and to link to their many providers to help integrate medical care with everyday life.

Online tools can extend health practices and provide this support through cost-effective programmes that help clinicians guide their patients to better manage their diabetes. The best internet self-management education and support programmes are rich in pertinent content, provide engaging interactive elements, and offer a tailored, personalised learning experience. They contain self-assessment tools and ways for the individual to monitor performance and changes in biological measurements such as blood sugar, insulin dosage, physical activity, weight, blood pressure and mood. The patient can access their information, input their data, and receive support 24 h a day – at a time and place most convenient for them, and not limited to clinicians' office hours.

Web-based learning and support technology benefits both clinician and patient; patients learn to overcome barriers and to self-document activities and interactions, permitting clinician review and feedback at any time. In addition to automating much of the educational content, this time shifting element is one of the keys to making the process efficient and low cost. The ability to perform an automated review of the patient's activities and performance also provides the clinician with a valuable tool that increases both effectiveness and efficiency.

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NK is founder, owner and CEO of DPS Health, a software development company.

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As with online intervention, a 'virtual coach' can provide individualised guidance and support based on readily available analyses of each patient's characteristics and performance. In addition, the clinician can communicate frequently and efficiently, offering personalised email support to each patient without requiring in-person meetings, as well as monitor 'virtual support groups' where patients interact with others online via informational chat rooms and blogs. By incorporating web-based patient self-management and support into traditional treatment methods, one clinician can effectively support many patients – one patient at a time.

## Care Coordination/Home Telehealth: the systematic implementation of health informatics, home telehealth and disease management to support the care of veteran patients with chronic conditions

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*Telemedicine and e-Health 2008; 14(10): 1118–26*

**Aims:** Between July 2003 and December 2007, the Veterans Health Administration (VHA) introduced a national home telehealth programme, Care Coordination/Home Telehealth (CCHT). Its purpose was to coordinate the care of veteran patients with chronic conditions and avoid their unnecessary admission to long-term institutional care. By 2011, CCHT will meet 50% of VHA's anticipated non-institutional care (NIC) provision (> 110,000 NIC patients).

**Methods:** CCHT involves the systematic implementation of health informatics, home telehealth and disease management technologies. It helps patients live independently at home. CCHT is now a routine NIC service provided by VHA to support veteran patients with chronic conditions as they age. CCHT patients are predominantly male (95%) and aged 65 years, meeting standardised clinical, technology and managerial requirements. VHA has trained 5000 staff to provide CCHT.

**Results:** Routine analysis of data obtained for quality and performance purposes from a cohort of 17,025 CCHT patients showed that the cost of CCHT is \$1600 per patient, which is substantially less than other NIC programmes and nursing home care. The programme led to a 25% reduction in numbers of bed days of care, a 19% reduction in numbers of hospital admissions, and a mean satisfaction score rating of 86% of patients per annum.

**Conclusions:** The authors conclude that an enterprise-wide home telehealth implementation is an appropriate and cost-effective way

of managing chronic care patients in both urban and rural settings.

• **Comments:** The article summarises the United States VHA's early experiences with its CCHT programme. This effort is an attempt to use home telemonitoring technology linked to care nurses to lower the cost and improve the quality of services to the increasingly aging population of veterans with chronic diseases cared for in the VHA system. This ambitious effort is showing early success but at a considerable administrative cost. One key to success is the extensive training provided to the clinical staff and the depth of the technological support created to manage the programmatic requirements. This investment is expected to pay a significant dividend as the service is rolled out to larger numbers of VHA members. Of note, this programme did not automate any of the care processes, patient education or patient SMS. These enhancements, if implemented, might be associated with improved outcomes and even further cost reductions.

## Effects of self-management support on structure, process and outcomes among vulnerable patients with diabetes: a three-arm practical clinical trial

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*Diabetes Care 2009; 32: 559–66*

**Aims:** Despite the importance of SMS, few studies have compared SMS interventions, involved diverse populations or entailed implementation in safety net settings. The authors examined the effects of two SMS strategies across outcomes corresponding to the chronic care model.

**Methods:** A total of 339 outpatients with poorly controlled diabetes from county-run clinics were enrolled in a three-arm trial. Par-

ticipants, more than half of whom spoke limited English, were uninsured and/or had less than a high school education, were randomly assigned to usual care, interactive weekly automated telephone SMS with nurse follow-up (ATSM), or monthly group medical visits with physician and health educator facilitation (GMV). The authors measured 1-year changes in structure [Patient Assessment of Chronic Illness Care (PACIC)], communication processes [Interpersonal Processes of Care (IPC)] and outcomes (behavioural, functional and metabolic).

**Results:** Compared with the usual care group, the ATSM and GMV groups showed improvements in PACIC, with effect sizes of 0.48 and 0.50, respectively ( $p < 0.01$ ). Only the ATSM group showed improvements in IPC (effect sizes 0.40 vs. usual care and 0.25 vs. GMV,  $p < 0.05$ ). Both SMS arms showed improvements in self-management behaviour versus the usual care arm ( $p < 0.05$ ), with gains being greater for the ATSM group than for the GMV group (effect size 0.27,  $p = 0.02$ ). The ATSM group had fewer bed days per month than the usual care group (–1.7 days,  $p = 0.05$ ) and the GMV group (–2.3 days,  $p < 0.01$ ) and less interference with daily activities than the usual care group (odds ratio 0.37,  $p = 0.02$ ). The authors observed no differences in A1c.

**Conclusions:** The authors conclude that patient-centred SMS improves certain aspects of diabetes care and positively influences self-management behaviour. ATSM seems to be a more effective communication vehicle than GMV in improving behaviour and quality of life.

• **Comments:** This is an important randomised controlled trial to enhance SMS for low-income and low educational level adults with type 2 diabetes. One limb of the study received automated 6–10 min phone calls, another received group medical visits and another received usual care. While the intervention was 'low tech' (automated phone calls linked to nurses) it demonstrated that information technology, when appropriately designed for a target population, can have significant positive outcomes. Increasing the ability of clinicians to help their patients help themselves (SMS) is the hallmark of modern diabetes education and key to improving patient outcomes. A worldwide challenge

exists to provide such support and this approach, elegantly simple and scalable, is one that is worth considering in a variety of settings and with a variety of populations.

## Veterans Affairs research on health information technologies for diabetes self-management support

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*J Diabetes Sci Technol* 2008; 2(1): 15–23

**Aims:** Like many patients with diabetes, the Department of Veterans Affairs (VA) patients frequently fall short of self-management goals and experience multiple barriers to self-care. Health information technologies (HITs) may provide the tools that patients need to manage their illness under the direction of their primary care team.

**Methods:** VA researchers are developing HITs that seek to bolster a variety of potential avenues for SMS, including patients' relationships with other patients, connections with their informal care networks, and communication with their healthcare teams. The authors describe several ongoing projects focused on HIT resources for self-management in the VA.

**Results:** VA HIT research projects are developing services that can address the needs of patients with multiple challenges to disease self-care, including multimorbidity, health literacy deficits and limited treatment access. These services include patient-to-patient interactive voice response (IVR) calling systems, IVR assessments with feedback to informal caregivers, novel information supports for clinical pharmacists based on medication refill data, and enhanced pedometers.

**Conclusions:** The authors concluded that large healthcare systems such as the VA can play a critical role in developing HITs for diabetes self-care. To be truly effective, these efforts should include a continuum of studies: observational research to identify barriers to self-management, developmental studies (e.g. usability testing), efficacy trials, and implementation studies to evaluate utility in real-world settings. VA HIT researchers partner with operations to promote the dissemination of efficacious services, and such relationships will be critical to move HIT innovations into practice.

• **Comments:** This review article from the US Department of Veterans Affairs serves as a good summary of some of the approaches needed to understand the potential benefits of

HIT in the real world. It also serves as a logical first place to start for any healthcare system interested in exploring the impact of their own HIT programme on diabetes patient self-management related outcomes. Areas addressed include peer-to-peer support, patient–clinician communications, patient assessment feedback to informal caregivers, enhanced pedometers, information support for pharmacists etc. In addition, persuasive arguments are made regarding leveraging existing information systems, performing a range of diabetes-focus HIT evaluations and getting researchers, clinicians and health system managers to work together – now that would be a sight for sore eyes.

## Web-based collaborative care for type 2 diabetes: a pilot randomised trial

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*Diabetes Care* 2009; 32: 234–39

**Aims:** To test web-based care management of glycaemic control using a shared electronic medical record with patients who have type 2 diabetes.

**Methods:** The authors conducted a trial of 83 adults with type 2 diabetes randomised to receive usual care plus web-based care management or usual care alone between August 2002 and May 2004. All patients had A1c  $\geq 7.0\%$ , had web access from home and could use a computer with English language based programmes. Intervention patients received 12 months of web-based care management. The web-based programme included patient access to electronic medical records, secure email with providers, feedback on blood glucose readings, an educational website, and an interactive online diary for entering information about exercise, diet and medication. The primary outcome was change in A1c.

**Results:** A1c levels declined by 0.7% [95% confidence interval (CI) 0.2–1.3] on average among intervention patients compared with usual care patients. Systolic blood pressure, diastolic blood pressure, total cholesterol levels and use of in-person healthcare services did not differ between the two groups.

**Conclusions:** The authors conclude that care management delivered through secure patient web communications improved glycaemic control in type 2 diabetes.

• **Comments:** This relatively small ( $n = 83$  adults) randomised controlled trial (done

between 2002 and 2004 with old internet technology) demonstrated that web-based diabetes SMS was effective at improving outcomes. Patients were provided feedback on blood glucose values, access to their medical record, secure email with providers, an educational website and interactive online diary. Of note, this study was performed with a conscious effort to integrate the patient's web-based support with his or her primary care physician and healthcare team. The results, improved A1c in those with access to the web intervention, are impressive, all the more promising since the intervention was provided over 5 years ago – a veritable lifetime ago compared with present day advances in internet technology (modern social networking sites, higher connection speeds, improved cell-phone technology to name just a few).

## Diabetes management assisted by telemedicine: patient perspectives

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*Telemedicine and e-Health* 2008; 14: 647–55

**Aims:** This qualitative research focuses on understanding the experiences of elderly patients with diabetes who participated in a telemedicine case management intervention, to better understand the barriers to success of telemedicine with the elderly.

**Methods:** Telephone interviews were conducted with elderly patients with diabetes prior to and 6 and 12 months after participating in a case management intervention delivered via a computer that allowed them to teleconference with a nurse and dietitian, upload blood glucose and blood pressure data, and access educational materials.

**Results:** Qualitative analyses revealed that patients enrolled primarily because healthcare providers encouraged them. Their goals were to improve diabetes control, with few expectations of an effect on emotional health or family relationships. After involvement, they particularly valued the emphasis on monitoring of health outcomes and supportive contact with diabetes staff to encourage, remind and answer questions.

**Conclusions:** The authors concluded that their findings illustrate the potential value of telemedicine with elderly patients with diabetes, if supported by primary care providers and including consistent, supportive interac-

tions with knowledgeable diabetes healthcare providers.

• **Comments:** This study analysed the perspectives of elderly patients with diabetes who were part of a telemedicine intervention. Contrary to common belief, these elderly patients had very positive experiences with telemedicine as a way to help them manage their diabetes. Key findings were (i) patients want telemedicine interventions to be linked to their healthcare team, (ii) patients want their providers to have interpersonal and communication skills and (iii) patients appreciate having the ability to monitor their glucose levels and disease progress. The importance of this study is to dispel the myth that older individuals are not able to effectively use telemedicine interventions and to emphasise the importance of linking technology-based intervention to trusted clinical relationships.

## Computerised learning technologies for diabetes: a systematic review

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*J Diabetes Sci Technol* 2008; 2(1): 139–46

**Aims:** The objective of this study was to evaluate computerised learning technology interventions that can empower patients in the self-management of diabetes and support diabetes education over a distance.

**Methods:** The authors searched Medline (1966–2006), CINAHL (1982–2006) and the Cochrane Central Register of Controlled Trials (first quarter 2007) databases. The authors also reviewed reference lists from included studies to identify additional studies. They included 25 articles representing 21 randomised controlled trials that evaluated a computerised learning technology and measured the outcome of patient care. Patient sample, intervention, educational content topics, outcome measures and statistical significance were extracted.

**Results:** Of 21 eligible trials, 18 trials (85.7%) reported significant positive outcomes. Almost 44% (43.8%) of the outcomes demonstrated significant improvements (49 of 112 outcomes).

**Conclusions:** The authors concluded that patient self-management behaviours are important in chronic disease management, and initial evidence suggests that computerised learning technology interventions can play a significant role in the future.

• **Comments:** This article summarises the impact of a variety of computerised interventions designed to empower patients in the self-management of diabetes and support diabetes education over a distance. The interventions addressed different goals and used different approaches to support patients with diabetes. The main conclusions are that many of the interventions were effective at increasing patients' knowledge, helping patients adopt healthy behaviours and improving clinical outcomes. This report is very encouraging especially since these studies were published from 1996 to 2006 with technology that is at least 4–5 years old or older. The major improvements in web-based technologies in the past 3–4 years can be expected to make these approaches even better, more appropriate for wider audiences and at lower cost.

## Diabetes self-management care via cell phone: a systematic review

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*J Diabetes Sci Technol* 2008; 2(3): 509–17

**Aims:** The objective of this study was to evaluate the evidence on the impact of cell-phone interventions for persons with diabetes and/or obesity in improving health outcomes and/or processes of care.

**Methods:** The authors searched Medline (1966–2007) and reviewed reference lists from included studies and relevant reviews to identify additional studies. They extracted descriptions of the study design, sample size, patient age, duration of study, technology, educational content and delivery environment, intervention and control groups, process and outcome measures, and statistical significance.

**Results:** In this review, the authors included 20 articles, representing 18 studies, evaluating the use of a cell phone for health information for persons with diabetes or obesity. Thirteen of 18 studies measured health outcomes and the remaining five studies evaluated processes of care. Outcomes were grouped into learning, behaviour change, clinical improvement and improved health status. Nine out of 10 studies that measured haemoglobin A1c reported significant improvement among those receiving education and care support.

Cell-phone and text message interventions increased patient–provider and parent–child communication and satisfaction with care.

**Conclusions:** The authors concluded that providing care and support with cell phones and text message interventions can improve clinically relevant diabetes-related health outcomes by increasing knowledge and self-efficacy to carry out self-management behaviours.

• **Comments:** This article is a review of the impact of cell-phone-based interventions on outcomes for patients with obesity or diabetes. A common key to the success of an intervention was the integration of the cell-phone support within the context of regular diabetes care. Cell phones were used to augment routine patient education by giving individualised and timely feedback from daily to weekly in frequency on a variety of topics including ways to upload and track blood sugar values. The cell phone is an important addition to the clinical continuum of education and support service ranging from in person to telephone to cell phone (with and without internet access) to computer-based internet interventions. The ubiquitous nature and relatively low cost of cell phones makes this an attractive addition to integrated care approaches.

## Web-based collaborative care for type 1 diabetes: a pilot randomised trial

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*Diabetes Technol Ther* 2009; 11(4): 211–17

**Aims:** To determine whether a web-based diabetes case management programme based on an electronic medical record can improve glycaemic control (primary outcome) and diabetes-specific self-efficacy (secondary outcome) in adults with type 1 diabetes.

**Methods:** A 12-month randomised trial tested a web-based case management programme in a diabetes specialty clinic. Patients 21–49 years old with type 1 diabetes receiving multiple daily injections with insulin glargine and rapid-acting analogues who had a recent A1c > 7.0% were eligible for inclusion. Participants were randomised to receive either (i) usual care plus the nurse-practitioner-aided web-based case management programme (intervention) or (ii) usual clinic care alone (control). The authors compared

patients in the two study arms for changes in A1c and self-efficacy measured with the diabetes empowerment scale.

**Results:** A total of 77 patients were recruited from the diabetes clinic and enrolled in the trial. The mean baseline A1c among study participants was 8.0%. The authors observed a non-significant decrease in average A1c (−0.48%; 95% CI −1.22% to 0.27%;  $p = 0.160$ ) in the intervention group compared with the usual care group. The intervention group had a significant increase in diabetes-related self-efficacy compared with usual care (group difference of 0.30; 95% CI 0.01–0.59;  $p = 0.04$ ).

**Conclusions:** The authors concluded that the use of a web-based case management programme was associated with a beneficial treatment effect on self-efficacy, but change in glycaemic control did not reach statistical significance in this trial of patients with moderately poorly controlled type 1 diabetes. Larger studies may be necessary to further clarify the intervention's impact on health outcomes.

• **Comments:** This randomised controlled trial with 77 patients with type 1 diabetes attempted to demonstrate the effectiveness of a web-based care system on A1c outcomes and diabetes-related self-efficacy. While the results did not show improved A1c values it nonetheless demonstrated that patients can use this type of intervention and that the intervention is able to enhance patient self-efficacy. Key to the negative results was the small sample size and the lack of robust engagement by many of the study subjects. While web-based interventions have great potential to improve outcomes at affordable cost, key to success is patient engagement often requiring innovative ways to maintain patient interest. Linking an intervention to other important people in the patient's life (e.g. clinical team, family, friends, others with diabetes) can also be expected to improve outcomes.

## Improving diet and physical activity with ALIVE: a worksite randomised trial

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*Am J Prev Med* 2009; **36**(6): 475–83

**Aims:** To determine if an email-based education programme improves nutrition and physical activity behaviours in adults.

**Methods:** A randomised controlled trial, conducted in 2006, of a 16-week email pro-

gramme offered individually tailored, small-step goals; a personal homepage with tips; educational materials; and tracking and simulation tools. A total of 787 employees in the administrative offices of a large healthcare organisation volunteered to participate.

**Results:** Changes were self-reported for total physical activity; moderate physical activity (MPA); vigorous physical activity (VPA); walking; sedentary behaviour; and intake of fruits and vegetables, saturated and trans fats, and added sugars in the intervention group compared with the control group. In intent-to-treat analyses (conducted in 2007 and 2008) that set change in non-responders to the follow-up questionnaire to zero, the intervention group reported increases of 28.0 min/week of MPA (SE = 7.4,  $p = 0.0002$ ), 12.5 min/week of VPA (SE = 5.7,  $p = 0.03$ ) and 21.5 min/week of walking (SE = 5.5,  $p = 0.0003$ ) relative to the control group. Intake of both saturated and trans fats (g/day) declined ( $\beta = -0.95$ , SE = 0.36,  $p = 0.01$ ;  $\beta = -0.29$ , SE = 0.12,  $p = 0.02$ , respectively). The consumption of fruits and vegetables increased significantly ( $p = 0.03$ ), and the consumption of added sugars decreased marginally ( $p = 0.08$ ). The largest changes were in participants who did not meet behavioural recommendations at baseline (increase of 55.4 min/week of MPA and decrease of 1.15 g/day of trans fats, relative to the control group). Differences between the intervention and control groups were still observed 4 months after the intervention ended.

**Conclusions:** The authors concluded that ALIVE is an effective programme for achieving significant improvement in diet and physical activity.

• **Comments:** This randomised controlled trial ( $n = 787$ ) provided a 16-week email programme to employees designed to increase physical activity and improve nutrition. Individuals in the intervention group were given a choice to address physical activity, fats/sugars or fruit/vegetables. The intervention included individually tailored modest goals, a personal homepage with tips, educational materials, and tracking and simulation tools. Improvements were seen in the intervention group at the end of the 16-week programme and 4 months after the intervention was completed. Positive effects were seen in the intervention group even in behaviours that were not being specifically addressed by the intervention. This study demonstrated the usefulness of email-based behaviour change interventions. It also gives further support for the importance and effectiveness of tailoring messages to the unique characteristics of the individual using

the programme. These types of programmes can be delivered to a large number of individuals at an affordable cost. To enhance their outcomes they should be linked to additional services and supports targeted to those who either are not engaged with the programme or are not meeting their goals. Linking to healthcare providers for motivation, encouragement and additional services for specific morbidities can also add to their effectiveness.

## Practice-linked online personal health records for type 2 diabetes mellitus: a randomised controlled trial

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*Arch Intern Med* 2008; **168**(16): 1776–82

**Aims:** Web-based personal health records (PHRs) have been advocated as a means to improve type 2 diabetes mellitus care. However, few web-based systems are linked directly to the electronic medical record used by physicians. This study was designed to see if PHRs in the context of primary care practice can improve outcomes for patients with diabetes.

**Methods:** The authors randomised 11 primary care practices. Intervention practices received access to a diabetes-specific PHR that imported clinical and medications data, provided patient-tailored decision support, and enabled the patient to author a 'Diabetes Care Plan' for electronic submission to their physician prior to upcoming appointments. Active control practices received a PHR to update and submit family history and health maintenance information. All patients attending these practices were encouraged to sign up for online access.

**Results:** The authors enrolled 244 patients with diabetes (37% of the eligible population with registered online access, 4% of the overall population of patients with diabetes). Study participants were younger (mean age 56.1 vs. 60.3 years;  $p < 0.001$ ) and lived in higher-income neighbourhoods (median income \$53,784 vs. \$49,713;  $p < 0.001$ ) but had similar baseline glycaemic control compared with non-participants. More patients in the intervention arm had their diabetes treatment regimens adjusted (53% vs. 15%;  $p < 0.001$ ) compared with active controls.

However, there were no significant differences in risk factor control between study arms after 1 year ( $p = 0.53$ ).

**Conclusions:** The authors concluded that pre-visit use of online PHR linked to the electronic medical record increased rates of diabetes-related medication adjustment. Low rates of online patient account registration and good baseline control among participants limited the intervention's impact on overall risk factor control.

• **Comments:** This study randomised 11 primary care practices so that those in the intervention arm practices had access to a PHR to use prior to scheduled clinic visits. The PHR included a medication module allowing patients to review their records prior to office visits, edit inaccuracies, answer questions regarding adherence and barriers to healthy behaviours, view data regarding glucose values, and submit questions or concerns to the patient's clinician prior to a visit. Patients in practices with access to the PHR had more medication adjustments. No differences were seen in risk factor control. This study is emblematic of the difficulty in demonstrating important outcomes from technology enabled interventions. Since the unit of randomisation was the practice it would be unlikely that significant treatment effects would be demonstrated. Nonetheless, it is an important first step toward understanding better the importance of clinically linked information technology assisted interventions.

## Web-based management of diabetes through glucose uploads: has the time come for telemedicine?

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**Aims:** This review focuses on the burgeoning use of web-based systems allowing patient-initiated glucometer uploads to facilitate provider treatment intensification.

**Results:** Studies in type 1 diabetes tended to show equivalent HbA1c improvements in both intervention and control groups without statistically significant difference. In contrast,

type 2 patients seemed to do better than controls with significant differences in HbA1c. Patients were the beneficiaries of web-based diabetes management through savings both in time and cost.

**Conclusions:** Major obstacles to wider implementation are patient computer skills, adherence to the technology, architectural and technical design, and the need to reimburse providers for their care.

• **Comments:** This review describes 18 studies (eight type 1, four paediatric, one pregnancy, three adult; seven type 2; three gestational diabetes) that used web-based management of diabetes primarily focusing on glucose meter uploads. None used continuous glucose sensing. Studies were included even if they were not randomised controlled trials. The conclusions were that in patients with type 1 diabetes and gestational diabetes current interventions were not very effective in the management of blood glucose. In contrast many interventions were effective in patients with type 2 diabetes. The authors summarised some of the potential benefits from web-based interventions such as saving time and decreasing the cost of interventions. Obstacles to dissemination included lack of computer literacy among some patients (particularly older patients); poorly designed interventions; security, privacy and confidentiality; complexity of glucose monitoring technology; and current reimbursement policies. This review highlights the need for enhancements to current technology that not only make glucose uploading easier and more informative but also creatively increase patient engagement over time to optimised patient outcomes. Such interventions are most likely more effective when they are personalised for each patient based on his or her unique characteristics, measured performance on key behaviours and varying over time. Clinicians also need to have easy and time efficient ways to access and interpret the information ideally after the patient has received feedback and tried unsuccessfully to implement the appropriate changes in therapy.

## SUMMARY

The summarised articles demonstrate some of the key findings from the literature about the

effectiveness and efficiency of technology enabled self-management education and support to improve outcomes for patients with diabetes.

One challenge to advancing the field is that with the speed of innovations in information technology by the time a clinical study is completed and published (e.g. a 1-year randomised controlled trial takes at least 3–4 years from start to publication) the technology studied is usually obsolete (think of the rapid change and adoption of smart phone technology in just the last 2–3 years or the use of Facebook as a communication platform).

Creating effective interventions using information technology is a complex undertaking. To be successful, some core principles should be followed to increase the likelihood of success. Programmes should

- be solidly grounded in behaviour change theory and clinical expertise;
- be evidence based and research proven;
- be highly flexible in design and implementation so they can accommodate a wide variety of patients with a variety of clinical needs;
- allow choice of media and alternative learning pathways while providing continuous feedback and deep engagement;
- integrate easily and fully with clinical workflow and practice, and clinical technology including electronic medical records and biometric devices; and
- be evaluated and continuously improved.

Online self-management education and support for patients with diabetes have the potential to make not just an incremental difference in patient outcomes, but a profound change in the way providers engage with patients and patients interact with clinicians and with their support networks. To date, their use in clinical settings has been limited primarily because of the lack of reimbursement for online interventions. In the near future, clinicians may be able to use information technology, coupled with traditional treatment approaches, to support large numbers of patients with diabetes in an economical and practical manner.