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Diabetes: Going Digital

The role of technology in the prevention, treatment, and management of diabetes

world diabetes day
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The Role of Technology for People Living with Diabetes

In this interview Renza Scibilia, Manager of the Type 1 Diabetes and Community programs for Diabetes Australia (Victoria), who has lived with type 1 diabetes herself for 16 years, shares her insight and experience of the role that technology and digital solutions can have in the treatment and management of diabetes.

Australia has one of the highest rates of type 1 diabetes in the world. In the past year alone over 3,021 new cases of type 1 diabetes were registered (8 new cases every day). There are 118,000 Australians with type 1 diabetes of whom over 25,000 are young people under the age of 30[1].

Despite type 1 diabetes affecting less than 1% of the general population, complications alone are responsible for 4% of all ambulatory care or hospital admissions and 5% of all hospital bed days - more than angina or asthma[2].

The annual cost to the Australian health system of type 1 diabetes is at least $570M, with the average annual cost per person with type 1 diabetes costing $4,669 (ranging from $3,468 with no complications to $16,698 for both micro vascular and macro vascular complications[3]).

Technology can reduce some of this burden upon the health system, as well as providing significant improvements in the quality of life experienced by those having to live with the condition, on a daily basis.

"From a treatment perspective, there are some really great management tools, that make life a little bit easier, particularly for people living with type 1 diabetes" says Renza Scibilia, who, through her first-hand experience of living with diabetes in combination with knowledge and experience gained working for Diabetes Australia, is able to provide an insightful perspective on the types of technology and digital solutions that can deliver tangible benefits to diabetics.

"Looking at type 1 diabetes, insulin pumps have been around for a number of years as have continuous glucose monitors," says Scibilia, "where things have gotten exciting in the last 4-5 years is where you have an integrated system, whereby a continuous glucose monitor

will read directly to a pump, therefore cutting down the number of devices that you need."

Insulin pumps are an excellent tool for consistent delivery of insulin and assist with maintaining optimal blood glucose levels for people who choose to use them, and for whom it is clinically recommended. Some people with type 1 diabetes cannot achieve optimal blood glucose control without the use of an insulin pump. There are more than 14,990 insulin pump users in Australia, around 12% of people with type 1 diabetes. This number is significantly higher in other regions like the USA where it is estimated that up to 25% of people with type 1 diabetes use insulin pump therapy.

"There are also some really fantastic blood glucose monitors for people who are self-monitoring their blood glucose. That would be most people with type 1 diabetes, as all people with type 1 diabetes are advised to regularly monitor their blood glucose, as are people with type 2 diabetes using insulin. Even non-insulin treated people with type 2 diabetes may also choose to monitor their blood glucose. If they do, there are some really fabulous monitors that are capable of doing things such as identifying patterns and trends or highlighting issues. For example, they will say 'you checked your blood sugar at this time in the last three days, and on those three occasions you have been low, so perhaps you need to think about why.' Similarly, if your numbers have been high, then they will advise you to consider the reasons for that."

Modern blood glucose meters include data analysis functions, which are designed to help people gain a greater understanding of their condition and to learn to improve the way in which they self-manage.

Scibilia describes the impact that some of these features can have. "There are some tools that make day-to-day things a little easier. They can provide alerts and identify patterns so that people can respond to them. Modern blood glucose monitors are also much faster, they take less blood, and they are much more accurate. I have type 1 diabetes myself, I have had it for 16 years, and I can remember that my first meter took something like 40 seconds to give a blood glucose reading, it now takes just 5 seconds! It is amazing what you can do with those extra 35 seconds when you are doing ten blood glucose tests per day, and it is those sort of things are terrific when we are talking about [how technology can improve] the day-to-day management of diabetes."
The increased availability of smartphones and associated apps are also delivering innovative tools that can help and support diabetics to self-manage their condition.

"There are some absolutely fabulous apps out there, where you are able to record all of your data." continues Scibilia. "They can provide you with graphs, and again pick up trends in all sorts of things that will help you to make some adjustments to better manage your diabetes. I would say my favourite app is one called mySugr, which has been developed by a group of young people, with diabetes, living in Vienna. It has a lot of really innovative features, which include things like being able to photograph your food, and record carbohydrates, but it also has a reward system, which doesn't just reward what your number may be, but importantly how many times you are checking your blood sugar... The app looks great, it is fun to use, and I think that it is a really good example for younger people through to older people. When you have an app that has been developed by people with diabetes you get rid of a lot of the superfluous stuff, and keep the nuts and bolts of exactly what you need in a recording app."

The use of this type of technology is not always suited to everyone. Scibilia believes that different technologies appeal to different people depending upon their personal preferences.

"Some people love to have all of their data in front of them, and they love graphs and that type of thing, and then there are other people for whom it is not interesting for them at all. This type of person will consider the number that they get from their blood glucose meter, as a snapshot in time, to which they will respond at that time, but they are not then interested in knowing about historical data or trends. But, for those data driven people there are some really great apps and solutions that are targeted to them."

"When we are talking about technology I also like to talk about things like social media as a way of connecting people and providing that peer support that we know is really important to people living with chronic health conditions. The diabetes online community is an incredibly active, vibrant bunch of people and we all seem to harness technology in different ways, but the online presence and using that to form peer networks is incredibly useful for a lot of people who live with diabetes, or, for parents who have kids with diabetes, and for carers of people with diabetes."

Similarly, when it comes to type 2 diabetes, there are a range of digital solutions emerging which have the potential to help prevent the onset of diabetes or assist in the early diagnosis of people at risk from the disease. Scibilia suggests that the wider increase in general health and well-being applications, and technologies, that help people to track and record their individual health, can also be extremely beneficial in helping people to maintain healthier lifestyles and in turn potentially help to prevent the onset of diabetes. By allowing people to take greater ownership of their own medical data, technology can help people to use that information in ways that have a meaningful outcome on their personal health.

"Gone are the days when you would go and have a blood test and the doctor would hold onto that data and you wouldn't have those results. This is a way that you can keep all of that information and track it. You have a baseline and you have all your data recorded. Then when you go back in six months time you can see how that is tracking and use this to have a dialogue with your health care professional i.e. 'my blood pressure was this last time and it is this, this time – is that something to worry about, or is that an improvement?'."

When it comes to how some of this technology fits into people's lives Scibilia believes that there are a number of key factors that technology developers need to consider.

"Not having everything talk to each other is really, really frustrating. There is absolutely not enough integration. As consumer voices we really would like things to talk to each other, and we would like

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the software that we use to download the data to be really easy to use, because at the moment, none of it seems to be."

"The same goes for technology that we are using as a data record. Things need to be easy to use, and be able to be used very discretely. If you have an app that is going to take you 25 minutes to enter a piece of data, then we are not going to be using it, as it will take us away from everything else."

Diabetes is a condition that presents a unique set of challenges for those living with it day-to-day. As someone living with diabetes Scibilia can easily outline some of the pressures that the condition brings.

"So much about diabetes is focused on numbers, e.g. 'what is your blood sugar?', or 'what is your HbA1c?' But, the main thing is the fact that it is chronic."

"Generally, a person with diabetes gets somewhere between 4-6 hours per year with a Health Care Professional and the rest of the time you are mostly on your own. When you look at people who have type 1 diabetes, particularly, then the self-management is fairly intense. We are medicating constantly and our dose changes depending upon what we eat, our exercise level, if we are feeling stressed, and all sort of things that will impact how much insulin we will give ourselves... so getting burnt out, and losing motivation to continually self-manage is a very real thing for most people who live with diabetes."

"Diabetes burn out is something that we talk about a lot these days, but it is really only in the last few years that the psycho-social side of things has been recognised and talked about more and more. It is wonderful that here in Australia we have the Australian Centre for Behavioural Research in Diabetes where we are talking to people about how it feels to actually live with diabetes. We are not talking about how does it feel when you have to give yourself an insulin injection, what we want to know, is what does it feel like to actually live with diabetes? We did a study a number of years ago that surveyed a huge number of people living in Australia called the Diabetes MILES study, which showed significant numbers of people live with diabetes distress on a daily basis. There are a lot of real concerns. Things like diabetes complications, how diabetes impacts upon the rest of the family, the burden of diabetes, the cost of living with diabetes. Those sorts of things we live with every single day."

"Where technology comes into that, is where you are looking at connecting people with each other. There are weekly tweet chats where people connect and fantastic Facebook groups that augment face-to-face peer support. There are so many ways now that people can locate other people to discuss this side of diabetes, and just hearing other people's experiences is incredibly reassuring for people. There are hundreds of diabetes blogs out there, where you can read and hear what people are living through and how they cope with that. Generally, people are not writing about what their blood sugar levels are, they're writing about how they are living on that day-to-day basis of life with a condition that doesn't have a rule book."

Telehealth and telecare are both methods that can also be used to provide some of this support, particularly to those people who are unable to access traditional care and support options.

"We are hearing more and more about people living in rural and isolated areas who are finding telehealth really useful," says Scibilia, "and for some people being able to have a Skype conversation with an endocrinologist in a major city, because they don't have any diabetes specialists near them, and using technology as a communication tool and an access tool, is a real benefit."

"I don't think that we are harnessing this enough. When we are talking about Australia, where the country is huge by comparison to our population, then we really need to be looking at how technology can be better connecting people."

Diabetes Australia is a strong advocate of ensuring that there is equitable access to the wealth of technologies available to help with the management of diabetes. As an organisation social media is also proving to be a significant tool in helping deliver information, advice and support to people living with diabetes.

"As an organisation we use social media to reinforce our messages, and to notify people of our activities, our services, and any events or reports that we have. We have a very strong focus on living well with diabetes, but we want people to also realise that diabetes is serious and for people to understand how they can manage their diabetes in the best possible way." says Scibilia.

The organisation finds that their blogs are extremely well received by members. "That ability to really share your experiences is great as the person writing the blog, but for the people reading it, that feeling of not being alone and reducing those feelings of isolation is absolutely priceless. We constantly hear from people that until you read someone else's story then you can often think that you are the only one dealing with a particular issue."

So what does technology and digital hold for the future of diabetes?

"There are some really exciting things coming through." says Scibilia. "The first of these is called the bionic pancreas. What this does is to provide a closed loop system, between an insulin pump and a continuous blood glucose monitor. This is where we are going and this is where we will be in the future. Everyone wants a cure, and we are constantly told that the cure is 5-years away, but the truth of the matter is the cure is not 5-years away. However, the exciting stuff is all of this technology."

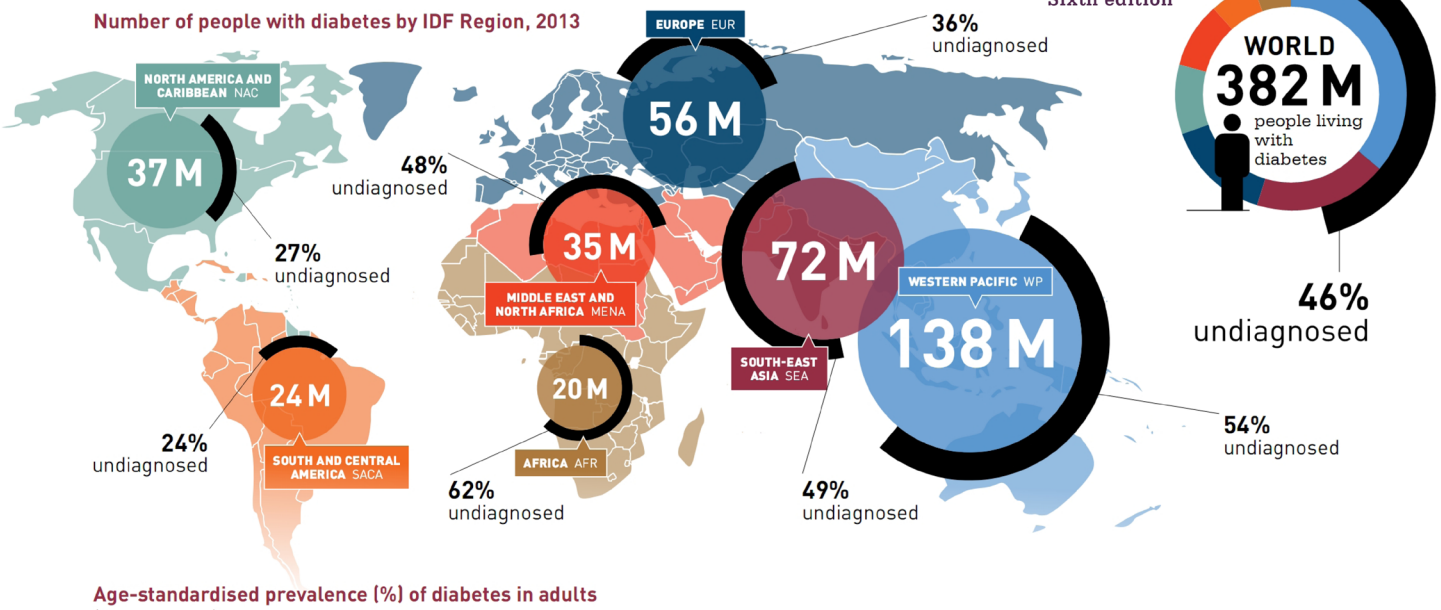
We would like to take this opportunity to thank Renza Scibilia and Diabetes Australia for working with us on this article. To find out more about the work of Diabetes Australia visit www.diabetesvic.org.au. To read more about living with diabetes from Renza visit her blog at www.diabetogenic.wordpress.com.

1. *Insulin Pump Therapy in Australia – The Case for Action.* Report published by Diabetes Australia, 2014.
2. The Diabetes Control and Complications Trial Research Group. *The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus.* N Engl J Med 1993 Sep 30; 329(14): 977-86.
3. Craig M E, Twigg S M, Donoghue K C, Et al. *National Evidence-Based Clinical Care Guidelines for Type 1 Diabetes in Children, Adolescents and Adults.* Canberra: Australian Government Department of Health and Ageing 2011 ■

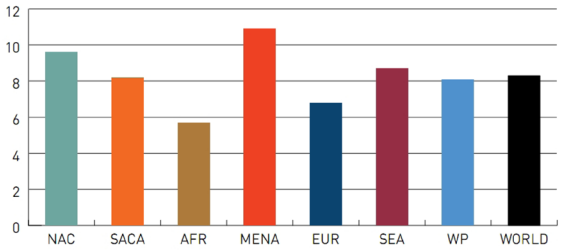
www.idf.org/diabetesatlas

IDF **DIABETES** ATLAS
Sixth edition

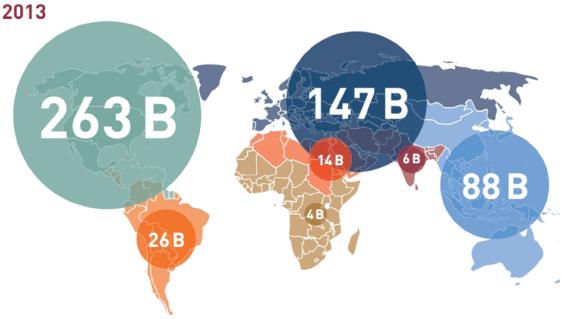
Number of people with diabetes by IDF Region, 2013



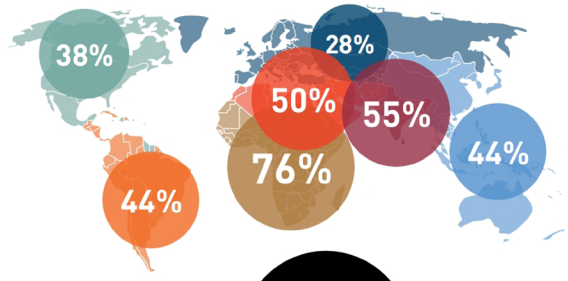
Age-standardised prevalence (%) of diabetes in adults (20-79 years), 2013

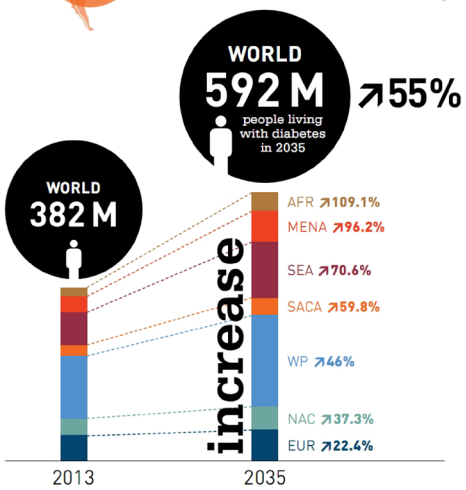


Health expenditure (USD) due to diabetes (20-79 years), 2013



Proportion of people with diabetes-attributable deaths who die before 60 years of age, 2013





Diabetes by the Numbers

Type 1 diabetes, which accounts for between 10 and 15 percent of all people with diabetes, occurs when no insulin is produced at all because the insulin producing cells in the pancreas have been destroyed by the bodies' own immune system.

Type 2 diabetes accounts for between 85 and 90 per cent of all people with diabetes and occurs when the pancreas either does not produce enough insulin, or the insulin it produces does not work as well as it should (insulin resistance). Some of the risk factors associated with Type 2 diabetes are not controllable, e.g. genetic factors, while others, such as being overweight, can be controlled.

There is currently no cure for either Type 1 or Type 2 diabetes.

Treatment

For Type 1 diabetes, treatment means multiple daily insulin injections or infusions to replace the body's natural insulin, finger prick blood testing, eating healthily and taking regular exercise.

For Type 2 diabetes this is likely to involve lifestyle changes, such as diet, weight loss and exercise, which will have enormous health benefits and allow a person to continue their normal day-to-day life. They may also be required to take diabetes medication or insulin, or a combination of the two. ■

Using Game Technology to Help Childhood Diabetes

Applying the concepts and features of video game technology to help improve the way in which users engage and interact with healthcare applications and solutions is proving to be an effective tool. For children and younger users, in particular, these types of gamification techniques are proving to be a good method of helping them to engage and understand their health conditions using platforms that are, at the same time, fun and entertaining.

As with adults, for children and teenagers with diabetes, the daily regimen of managing the condition, and all the necessary monitoring and recording that goes with that, can rapidly become very repetitive, frustrating and overall difficult to live with. Using games and video game concepts is one method of changing the dynamic through which users access information, manage their condition, and monitor and record their health, by making it a more fun and entertaining experience.

The idea of using video game technology in childhood diabetes care is not particularly new. One of the first efforts around diabetes was a 1995 game for Nintendo systems called Packy & Marlon, featuring two diabetic elephants who taught kids the importance of maintaining glucose levels. In the game, players take the role of animated characters who manage their diabetes by monitoring blood glucose, taking insulin injections, and choosing foods, while setting out to save a diabetes summer camp from marauding rats and mice who have stolen the diabetes supplies. Among children who played the game over a six-month period, emergency-room visits dropped by 77%, according to a 1997 paper published in the journal Medical Informatics[1]. Unfortunately, the game failed to live up to commercial expectations, and was discontinued, but the concept was well proven.

The core ideas of gaming technology actually lend themselves extremely well to the management of healthcare conditions. Rewarding positive activity with elements such as points or badges, helps reinforce positive action and to modify behaviours in ways which support improvement. Game user interfaces are designed in ways which allow people to instinctively connect and navigate an application or service. In children and young people who regularly play games, for entertainment, then common user experiences help to create applications that are easily and rapidly understood. This reduces the need for additional training or support on the use of the system. By using features such as incremen-

tal progression and the use of different levels, scores, rewards etc games help users to progress at a pace suited to their individual needs, as well as helping to actively promote and encourage those activities and behaviours that lead to that progression. In a healthcare context this is a valuable method of maintaining patient engagement, and helping people to continue to take an active role in their health or condition management. Video games also help to provide an environment that delivers instant visual feedback via graphical representations which creates an immersive, emotional experience. This in turn helps to encapsulate the normally rather boring elements of managing conditions like diabetes within a fun and interactive setting.

A number of similar trials have demonstrated similar positive results. Video games for diabetes have typically targeted children with type 1 diabetes and used situation problem-solving methods to teach diet, exercise, self-monitored blood glucose, and medication adherence. Evaluations have shown positive outcomes in knowledge, disease management adherence, and clinical outcomes[2].

The present widespread availability of smartphones and tablets has presented an even more accessible medium by which specialist healthcare game developers can produce and distribute health games to a wide audience of users.

There have been a number of recently released App based diabetes games that have proven very successful, and which are beginning to have significant impact on the lives of their users.

Sanofi Diabetes, a subsidiary of Sanofi Aventis, recently launched a health and wellness app called Mission T1D, aimed at improving the understanding of type 1 diabetes among children, parents and caregivers in the school environment.

The app is designed to educate primary school-age children about type 1 diabetes and how to live with it.

The free game aims to improve health outcomes in children with diabetes by improving the level of understanding about the disease. Set in a school environment, players must earn points to advance through various levels. At each level, a wise old man—"the sensei"—provides short, practical, and illustrated messages about living with the condition.

As well as the app, there are supporting educational packs, which include games, videos and quizzes.

Type 1 diabetes affects 400,000 people in the UK and more than 29,000 are children but figures show 94.2 per cent of infants; children and young people with diabetes do not receive all of the diabetes health checks recommended by the National Institute of Health and Care Excellence (NICE).

Dr Sheridan Waldron, Specialist Diabetes Dietician, comments: "Children with diabetes and their families face many challenges in their daily lives as they care for a very complex life-long condition.

"It is essential that children, parents and carers have the knowledge and skills to manage diabetes but they also need their friends, teachers and other people in the school environment to understand and support them, to care for their diabetes effectively.

"Sharing information and fostering a caring environment at school will help children with diabetes to feel normal, happy and ensure that they reach their full potential in a safe environment."

The game is designed to allow children living with diabetes to share basic knowledge about the condition in their school in order to dispel any misconceptions.

Rebecca Reeve, Head of Professional Relations at Sanofi Diabetes, says: "As a company, we have entered the diabetes gaming arena to improve health outcomes for children with type 1 diabetes."

"We are committed to making a difference to the lives of children who are struggling with the challenge of managing diabetes, especially in an environment where they can easily be made to feel different."

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"We hope that the teachers, parents and carers for whom this game was developed will make it their mission to make this game a success."

Karen Addington, Chief Executive of JDRF, said: "Type 1 diabetes is a complex and serious condition. Furthermore, when the facts about type 1 diabetes are not appreciated and understood, extra pressure is placed upon those living with it. Thankfully, technology can play a big role in broadening awareness and understanding among people of all ages."

The Mission T1D app is the second game from Sanofi Diabetes that targets younger people with the condition. The previous release, developed as a joint project between healthcare game application Development Company Ayogo Health working with Diabetes UK and Sanofi Diabetes, was called Monster Manor and was designed to encourage children to test and record their blood glucose levels on a more regular basis.

Children between the ages of 6 and 13 with type 1 diabetes are expected to take on increasing responsibility for testing and logging their own blood glucose. By incorporating a casual play collecting game, Monster Manor provides a fun and rewarding experience for those children who struggle with this growing responsibility.

Testing and logging blood glucose within the game's built-in tracker generates positive feedback to keep children engaged in this crucial aspect of their self-care with the aim of generating better outcomes. Research shows that just one extra test a day in teenagers leads to a 0.4 reduction in blood glucose concentration or HbA1c, which could be very significant[3].

Michael Fergusson, CEO at Ayogo Health comments, "As game designers, watching children play Monster Manor has been very satisfying, as the kids tell us that it's fun and they want to keep playing. But for us, fun is only a means to an end; the goal ultimately is to improve health outcomes for the children we work for."

Simon O'Neill, Director of Health Intelligence and Professional Liaison at Diabetes UK, speaking at the launch of the app in 2013, said: "Parents tell us that their children often find regular blood glucose monitoring very hard to accept and it can often become a source of tension in families. By turning the testing into a game we hope it will encourage young children with diabetes to manage their condition more effectively and help them succeed in achieving tighter blood glucose control in their early years. In turn this would help them reduce the risk of developing the serious complications associated with diabetes in later life."

Ayogo Health is one of the companies pioneering this type of game based intervention, and they have been involved with a number of projects that apply gaming experiences to diabetes care. They have worked with a range of organisations like the American non-profit DiabetesSisters, the Diabetes Hands Foundation, and the College Diabetes Network on game projects that help engage and support people with diabetes.

Another diabetes management solution that has successfully incorporated game technologies into an application aimed at children is from developer mySugr. Their product mySugr Junior not only makes it possible for children to be more independent in their day-to-day lives, but it also teaches them in a playful way how to deal with their diabetes.

Targeted at 6 to 10 year-olds, the app features a simple, child-friendly user-interface which enables and motivates children to document their diabetes data. They take photos of their blood glucose meters and meals with their smart phones and send them to their parents or show them to other supervisors, who then do the maths for them. This makes it possible for parents to control their child's therapy even when they are not with them and to take action if needed.

The Junior solution engages younger patients to document their data by employing elements of gamification: Every time they use it, they collect points to feed a diabetes-monster that changes as they get from one level to the next. Following the diabetes therapy becomes a fun and rewarding activity and a habit.

At the launch of the app in 2013 Co-founder Fredrik Debong described, "The main goal of the app is to positively influence the communication within the family. In families with diabetes patients there are a lot of 'have-tos' and a lot of complaining. 'You have to do this, you have to do that' – we want to help to turn this communication into something positive with our app."

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Type 2 Diabetes Clinical Study Shows Lower Blood Glucose when Using Remote Diabetes Care System with Patient App

Professor Kerstin Brismar from Karolinska Institutet in Stockholm has reported that using the Triabetes smartphone app and TriabetesClinic online decision support service in type 2 diabetes treatment helps reduce long-term blood glucose levels.

Triabetes, from Swedish medical technology company Diabetes Tools, is a smartphone app and online decision support service for people living with and caring for all forms of diabetes. It can be used by individuals, doctors and treatment clinics, and can be integrated with large-scale Electronic Medical Record (EMR) systems.

Results from the first six months of a two-year randomized, multi-centre clinical study show that the blood glucose marker HbA1c is significantly lower in patients being managed by the TriabetesClinic system compared with the control group who is not using the system.

The research, which was presented during a seminar for delegates at a meeting of the Swedish Society for Diabetology, aims to detect a minimum 5.5 mmol/mol decrease in HbA1c in the patients who self-report to the healthcare provider's remote care system using a smartphone app across four different treatment clinics over 24 months. Intention-to-treat analysis was applied to the interim results which show a significant median difference of 5.3 mmol/mol between the smartphone app and control groups during just six months.

"We found that it is clinically worthwhile to use the Triabetes app combined with the TriabetesClinic service to support patients to improve metabolic control and lower their HbA1c values," said Kerstin Brismar, Professor of diabetes research at Karolinska Institutet. "Our analysis after six months showed that apps are a viable way to help control type 2 diabetes when the patient shares live data with their doctor or nurse, who in turn use a web-based triage service to monitor, coach and suggest treatment strategies."

"I welcome today's interim results since there are few rigorous studies that report on the clinical use of telemedicine systems in diabetes management," said Diabetes Tools' Chief Executive Officer Anders Weilandt.

There are 226 patients with Type 2 diabetes taking part in the study. They are spread across nine different primary care clinics in Poland run by the managed care group Medicover. The study uses Diabetes Tools' Triabetes smartphone app for patients and TriabetesClinic, a web-based diabetes decision support service, for healthcare providers. The research is backed by academics from the Medical University of Warsaw and Karolinska Institutet in Stockholm, Sweden.

For more information on the study visit *www.diabetestools.se* ■

New Glucose Monitoring System Eliminates the Need for Routine Finger Pricks

The new FreeStyle Libre Flash Glucose Monitoring System from Abbott uses revolutionary new glucose sensing technology. The system reads glucose levels through a sensor that can be worn on the back of the upper arm for up to 14 days. In addition, no finger prick calibration is needed—a key differentiator from current continuous glucose monitoring systems.

The new system consists of a small, round sensor – approximately the size of a two Euro coin – worn on the back of the upper arm, which measures glucose every minute in interstitial fluid through a small (5mm long, 0.4mm wide) filament inserted just under the skin and held in place with a small adhesive pad.

A reader is scanned over the sensor to get a glucose result painlessly in less than one second. Scanning can take place while the sensor is under clothing, making testing more discreet and convenient. Each scan displays a real-time glucose result, a historical trend and the direction the glucose is heading. The reader holds up to 90 days of data, providing a histor-

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ical snapshot of glucose levels over time.

Robert Ford, senior vice president, Diabetes Care, Abbott, said: "The FreeStyle Libre System fulfills a major need for people living with diabetes. Our customers told us that the pain, inconvenience and indiscretion of finger pricking were the key reasons they weren't managing their diabetes as well as they should.

"Addressing these concerns has guided the development of FreeStyle Libre – a transformational product designed to not only remove the pain of finger pricking but also seamlessly integrate into their daily lives."

The system's software has also been developed to enable the collected data to be presented in a user-friendly, visual chart for both healthcare professionals and patients, driving a more productive discussion around treatment and any necessary modification.

The disposable, water-resistant sensor can be worn on the back of the upper arm for up to 14 days allowing glucose readings to be taken as many times per day as needed or desired. Each scan provides a current glucose reading, 8-hour history and the direction glucose is heading with the data generated by the system is designed to provide actionable trends and patterns that may help people determine how to modify food and other behaviours to better manage their diabetes in consultation with their healthcare professionals

Cliff Bailey, Professor of Clinical Science and Director of Biomedical Sciences Research at Aston University in Birmingham, said: "For decades, people with diabetes have had to prick their fingers routinely to check their glucose levels. The pain and inconvenience of finger pricks has contributed to less frequent testing and suboptimal diabetes management.

"By eliminating the need for routine finger pricks, the FreeStyle Libre System will significantly advance the field of glucose monitoring. It offers a convenient and painless way to get more frequent glucose readings, which should help to improve diabetes management."

The majority of people with diabetes are not at their target glucose levels often because the data generated by their glucose meters does not provide a clear historical picture of where their glucose has been or how their actions impact their levels. The new system provides users and their physicians with the Ambulatory Glucose Profile (AGP), a report providing a visual snapshot of a person's typical day by utilizing dense glucose data revealing hypoglycemic and hyperglycemic trends to facilitate better patient therapy and education. ■

Technology Improving the Understanding of Nutrition in Diabetes

Diabetics with type 1 diabetes must control their increased blood glucose values with medications and plan their meals so that the blood glucose level does not sharply increase after eating. The amount of carbohydrates in a meal – such as starch and various sugars – is the most important parameter for an increase in blood glucose after eating. In the course of insulin therapy, the increase in blood glucose after the intake of carbohydrates is lowered again through the injection of the hormone insulin – so called "prandial insulin". The correct dose of prandial insulin has to be calculated on the basis of the amount of carbohydrates. But, often it is difficult even for the well-trained diabetic to estimate the carbohydrate content of a meal accurately enough.

GoCARB is an app for smartphones, developed at the ARTORG Institute of the University of Bern (in close cooperation with Bern University Hospital) which automatically calculates the carbohydrate content of a meal. The programme enables diabetics to better plan their meals and subsequently makes controlling their blood glucose easier.

The mobile application supports diabetics by determining the carbohydrates in meals and specifying the appropriate dose of prandial insulin. In doing so, the smartphone-based system recognises food items on a plate by means of photos from a smartphone camera and estimates their carbohydrate content. In turn, the app automatically calculates the prandial insulin dose.

GoCARB is a four-year international research project directed by Dr.-Ing. Stavroula Mougiakakou from the ARTORG Centre for Biomedical Engineering Research of the University of Bern and Prof. Dr. med. Peter Diem from the University Department of Endocrinology, Diabetes and Clinical Nutrition. The project has been undertaken in close cooperation with Roche Diagnostics and has been financed under the European Commission's 7th Research Programme.

"We want to improve the personalised treatment of patients with diabetes mellitus", says Stavroula Mougiakakou. "There are already apps which help to estimate the carbohydrate content of a meal. But with those the foodstuffs must be manually recorded and the programmes do not offer any calculation of prandial insulin."

The estimation of the prandial dose is a complex and time-consuming task, dependant on many factors, with carbohydrate (CHO) counting being a key element[1]. Clinical studies have shown that, in children and adolescents on intensive insulin therapy, an inaccuracy of ±10g in CHO counting does not impair postprandial control[2], while a ±20g variation significantly impacts postprandial glycaemia[3]. There is also evidence that even well-trained patients suffering from type 1 diabetes find it difficult to estimate CHO precisely. In one clinical study, of 184 adult patients on intensive insulin, researchers found that on average 8.5% of those studied overestimated the CHO contained in their breakfast and 28% underestimated the CHO contained in lunch. Furthermore, 23% of those in the study underestimated the levels found in dinner, and 5% did the same with snacks[4]. In another recent study researchers found that for children with type 1 diabetes and their caregivers, 27% of meal estimations are inaccurate in the ranges greater than ±10g[5].

The GoCARB prototype offers a very simple method for helping overcome this problem.

The user initially places a reference object next to the meal and records two photos with a smartphone camera. The various foodstuffs – such as meat, vegetables and noodles – are segmented and recognised by the programme, while their form is reconstructed in 3D. Based on the 3D model, the results of segmentation and the reference object, the volume of the individual foodstuff is estimated. Knowledge of the nature and volume of the foodstuff enables the calculation of carbohydrate content with the aid of a nutritional value database.

Tests on real meals revealed that the system errs by only ±6-7 grams on average. Based on this carbohydrate content and additional information the included bolus calculator module works out the optimal insulin dose for the meal.

"With this prototype we satisfy the need of diabetics for a more effective, automated and precise determination of carbohydrates in foodstuffs – this shall allow them [to have] better diabetes control and indirectly bring them an enhanced quality of life", says Mougiakakou.

The researchers hope that the prototype solution can be refined and made available on a wider scale. Over time, as the underlying database increases, the system will be able to recognise more and more different food types, making it a valuable assistive tool for anyone living with type 1 diabetes, and needing to accurately determine carbohydrate intake.

There are a number of additional different technologies that are both currently available or which are in development that also have the potential to help in this matter.

Smartphone applications like mySugr allow users to take photographs of meals and log the relevant data relating to carbohydrates, overtime this builds into a comprehensive database of the types of meals an individual may have, with the related nutritional and carbohydrate value attached. This type of process helps to reduce some of the daily burden on people with diabetes.

A number of companies are also developing smartphone augmenting sensors that they suggest could be capable of analysing food material at the molecular level. Devices like the SCiO - from start up company Consumer Physics, which is a tiny, low-cost spectrometer that will fit in the palm of your hand - allow you to get instant relevant information about the chemical make-up of just about anything around you, sent directly to your smartphone. At present the application of these types of device are fairly limited, but with time it is conceivable that they could become an accurate method of analysing foodstuff at a molecular level, and subsequently providing valuable insight into the relevant carbohydrate content[6].

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2. Smart C.E, Ross K, Edge J. A, Collins C.E, Colyvas K, & King B.R. *Children and adolescents on intensive insulin therapy maintain postprandial glycaemic control without precise carbohydrate counting.* Diabetic Med, Vol. 26, No. 3, pp 279-285, 2009.

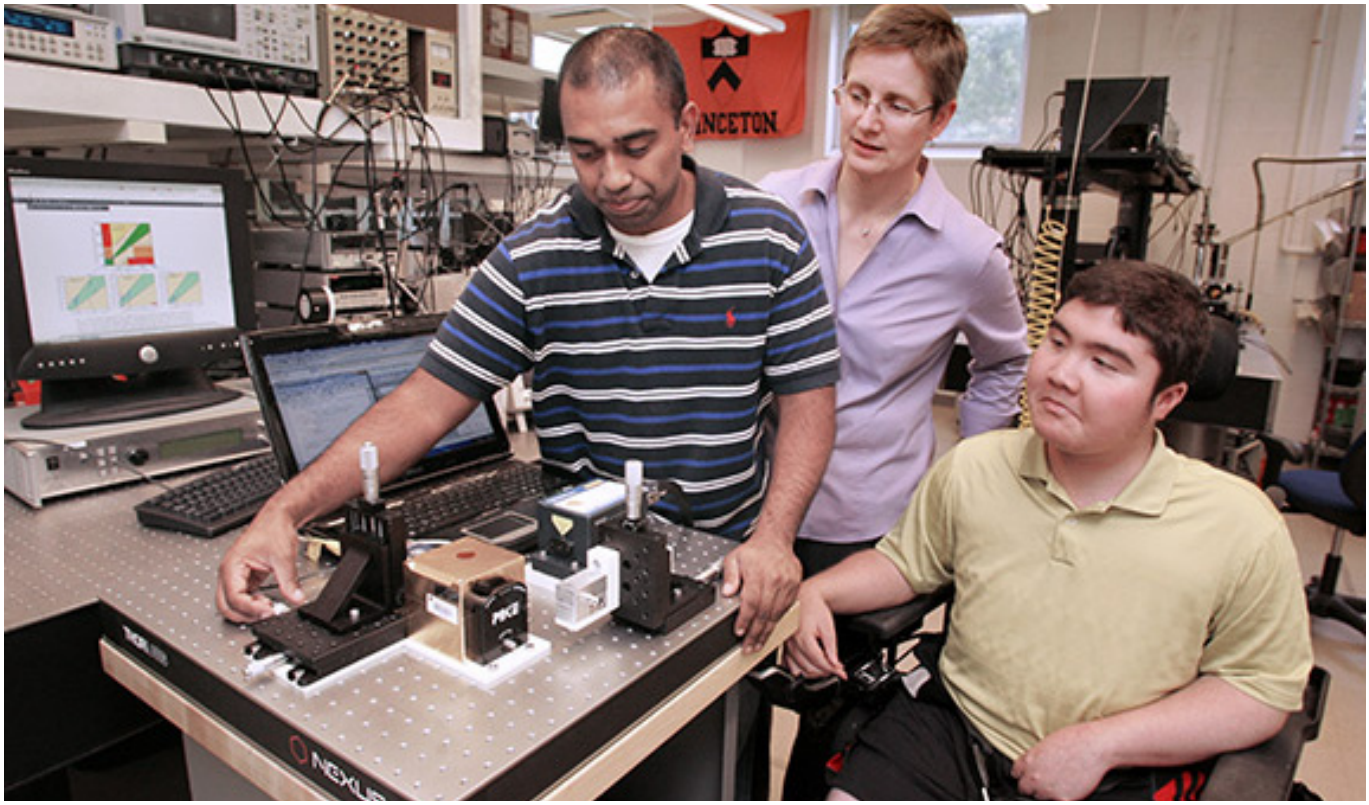
3. Smart C.E, King B.R, McElduff P, & Collins C.E. *In Children using intensive insulin therapy, a 20g variation in carbohydrate amount significantly impacts on postprandial glycaemia.* Diabetic Med, Vol 29, No. 7, pp e21-e24, 2012.

4. Graff M, Gross T, Juth S, & Charlson. *How well are individuals on intensive insulin therapy counting carbohydrates?* Diabetes Res. Clinical Practice, Vol 50, Suppl. 1, pp 238-239, 2000.

5. Smart C.E, Ross K, Edge J. A, King B.R, McElduff P, & Collins C.E. *Can children with type 1 diabetes and their caregivers estimate the carbohydrate content of meals and snacks?* Diabetic Med, Vol 27, pp 348-353, 2010.

6. *www.consumerphysics.com* accessed 03/11/2014.

More information on the GoCARB project can be found at *www.gocarb.eu* ■



Laser Device Could Mean an End to Daily Diabetes Blood Tests

Princeton University researchers have developed a way to use a laser to measure people's blood sugar, and, with more work to shrink the laser system to a portable size, the technique could allow diabetics to check their condition without pricking themselves to draw blood.

In an article published in the journal Biomedical Optics Express, the researchers describe how they measured blood sugar by directing their specialised laser at a person's palm. The laser passes through the skin cells, without causing damage, and is partially absorbed by the sugar molecules in the patient's body. The researchers use the amount of absorption to measure the level of blood sugar.

Sabbir Liakat, the paper's lead author, said the team was pleasantly surprised at the accuracy of the method. Glucose monitors are required to produce a blood-sugar reading within 20 percent of the patient's actual level; even an early version of the system met that standard. The current version is 84 percent accurate, Liakat said.

"It works now but we are still trying to improve it," said Liakat, a graduate student in electrical engineering.

When the team first started, the laser was an experimental setup that filled up a moderate-sized workbench. It also needed an elaborate cooling system to work. The researchers have since solved the cooling problem, so that the laser works at room temperature. The next step will be to reduce the size of the equipment involved.

The key to the system is the infrared laser's frequency. What our eyes perceive as colour is created by light's frequency (the number of light waves that pass a point in a certain time). Red is the lowest frequency of light that humans normally can see, and infrared's frequency is below that level. Current medical devices often use the "near-infrared," which is just beyond what the eye can see. This frequency is not blocked by water, so it can be used in the body, which is largely made up of water. But it does interact with many acids and chemicals in the skin, so it makes it impractical to use for detecting blood sugar.

Mid-infrared light, however, is not as much affected by these other chemicals, so it works well for blood sugar. But mid-infrared light is difficult to harness with standard lasers. It also requires relatively high power and stability to penetrate the skin and scatter off bodily fluid. (The target is not the blood but fluid called dermal interstitial fluid, which has a strong correlation with blood sugar.)

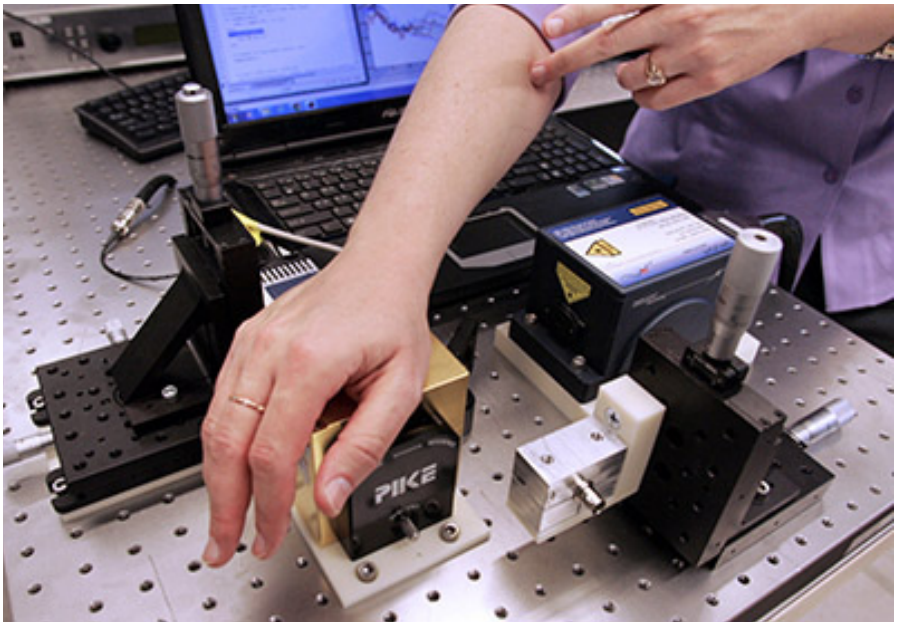
The breakthrough came from the use of a new type of device that is particularly adept at producing mid-infrared frequencies — a quantum cascade laser.

In many lasers, the frequency of the beam depends on the material that makes up the laser — a helium-neon laser, for example, produces a certain frequency band of light. But in a quantum cascade laser, in which electrons pass through a "cascade" of semiconductor layers, the beam can be set to one of a number of different frequencies. The ability to specify the frequency allowed the researchers to produce a laser in the mid-

infrared region. Recent improvements in quantum cascade lasers also provided for increased power and stability needed to penetrate the skin.

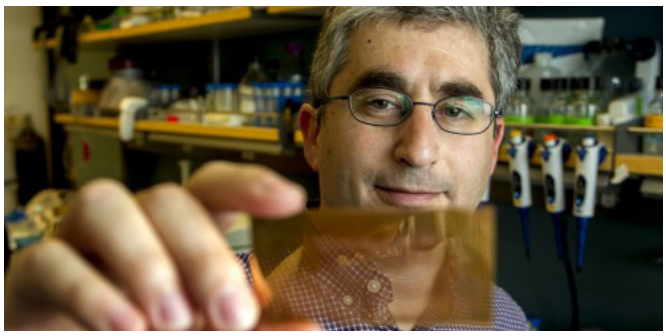
To conduct their experiment, the researchers used the laser to measure the blood sugar of three healthy people before and after they each ate 20 jelly-beans, which raise blood sugar levels. The researchers also checked the measurements with a finger-prick test. They conducted the measurements repeatedly over several weeks.

The researchers said their results indicated that the laser measurements readings produced average errors somewhat larger than the standard blood sugar monitors, but remained within the clinical requirement for accuracy.



"Because the quantum cascade laser can be designed to emit light across a very wide wavelength range, its usability is not just for glucose detection, but could conceivably be used for other medical sensing and monitoring applications," said Claire Gmachl, a professor of electrical engineering at Princeton and the project's senior researcher. ■

Microchip Test to Diagnose Type 1 Diabetes



Researchers funded by JDRF have designed a cheap, microchip-based test that can diagnose Type 1 diabetes in the quickest time yet.

The test detects the presence of islet auto-antibodies in a drop of blood. These proteins indicate that the immune system is primed to attack the insulin-producing cells of the pancreas – and are present in Type 1 but not Type 2.

Because of this, the test could be used after a diagnosis of diabetes, to distinguish whether a person has Type 1 or Type 2, potentially saving them from being misdiagnosed and receiving the wrong treatment.

The portability and low cost of the chip mean it could also be used more widely than current tests, so healthcare providers would no longer have to choose between a slower lab-based test and assuming which type of diabetes their patient has, based on their age and lifestyle.

Professor Brian Feldman, of Stanford University, who led the research, said: "With the new test, not only do we anticipate being able to diagnose diabetes more efficiently and more broadly, we will also understand diabetes better."

Because the chip tests for auto-antibodies, which are present even before a person develops the symptoms of Type 1, it could allow healthcare providers to monitor people at risk and give them treatment much sooner than is currently possible.

This could become even more important in future with the development of preventative treatments, as these would be most effective before a person loses their ability to produce insulin. Such treatments are a priority area of JDRF research, which funded the project, as part of its strategy to cure, treat and prevent Type 1.

Feldman added: 'The auto-antibodies truly are a crystal ball. Even if you don't have diabetes yet, if you have one autoantibody linked to diabetes in your blood, you are at significant risk; with multiple auto-antibodies, it's more than 90 per cent risk.

"There is great potential to capture people before they develop the disease, and prevent diabetes or prevent its complications by starting therapy early."

The research was published in the journal Nature Medicine. ■

New Treatment Option Launched to Simplify Insulin Pump Therapy

Novo Nordisk has launched NovoRapid PumpCart, the first pre-filled pump cartridge with an insulin analogue that has been specifically designed for insulin pumps. This new treatment solution, which contains NovoRapid, a rapid-acting insulin, is expected to make insulin pump therapy more convenient for people with diabetes and their care staff.

The cartridge which has been developed as a partnership between Roche Diabetes Care and Novo Nordisk has been designed to be compatible with the new Accu-Chek Insight insulin pump therapy system from Roche Diabetes Care.

"One of the challenges in operating a traditional pump lies in the manual filling of the insulin reservoir, a procedure with multiple steps, which can often be perceived as a complex and time-consuming process by patients and healthcare professionals alike," commented Dr Parth Narendran, clinical senior lecturer and honorary consultant in medicine at the University of Birmingham.

He continued: "This can be a difficult hurdle to overcome when starting on insulin pump therapy, and is exacerbated by the extensive amount of time needed by healthcare staff to provide the necessary support during pump initiation. A simpler process could address this issue and deliver tangible benefits for those patients who rely on insulin pump therapy every day to manage their diabetes."

Compared to multiple daily injections, insulin pumps can provide greater flexibility of lifestyle and potentially tighter blood glucose control without an increased risk of hypoglycaemia[1-2].

"This can provide benefits to certain patients," explained Dr Mark Evans, lecturer and honorary consultant in medicine at the University of Cambridge. "In Europe, we've seen a slow but steady increase in insulin pump therapy uptake in recent years, but there is still room for improvement; in the United Kingdom pumps are currently used by 19% of children and 6% of adults with type 1 diabetes."

An insulin pump delivers insulin from a reservoir inside the pump to a patient's body using an infusion set and a tiny cannula. The insulin is delivered using continuous infusion and is often used by people with type 1 diabetes who receive intensified insulin therapy and test their blood glucose levels on a regular basis. An insulin pump is suitable for certain patients and provides more flexibility, with the potential to improve glycaemic control and quality of life[1-2]. In Europe, use of insulin pumps among people with type 1 diabetes varies with less than 5% using a pump in some countries to more than 15% in other countries. In the US, 40% are treated with insulin from a pump[3].

1. Cohen ND, et al. Diabetes Technol Ther. 2013;15:544-9.
2. Pickup J. Nat Rev Endocrinol. 2012;8:425-33.
3. Pickup J. Insulin pumps. Int J Clin Pract. 2011;65(Suppl.170):16-19. ■

Online Diabetes Risk Calculator Developed

A new online tool will help doctors predict which patients are most likely to develop Type 2 diabetes.

The calculator will enable doctors to identify high-risk patients so that they can be tested for the disease and offered lifestyle advice. The test is targeted at people who have been admitted to hospital for emergency care.

Experts say it could offer a cost-effective way to identify people with diabetes in Scotland as it avoids the need for significant investment in screening.

The test, developed by a team from the University of Edinburgh, University of Glasgow and Scottish Diabetes Research Network, calculates a person's risk of developing diabetes over the next three years based on their age, sex and the level of sugar in their blood, which is routinely measured on admission to A&E.

Blood sugar levels often rise during serious illness but usually drop back to normal when patients get better. This can make it difficult for doctors to identify patients who are at risk of diabetes, which is also associated with high levels

of sugar in the blood.

Dr David McAllister, Clinical Lecturer in Epidemiology and Public Health, said: "This tool will enable us to identify people at risk of diabetes and give them the opportunity to make positive lifestyle changes to improve their health, without the cost of running a national screening programme."

The calculator will help doctors determine which patients should be referred for diabetes testing when they recover. It was developed by a team led by the University of Edinburgh's Centre for Population Health Sciences, the University of Glasgow and members of the Scottish Diabetes Research Network.

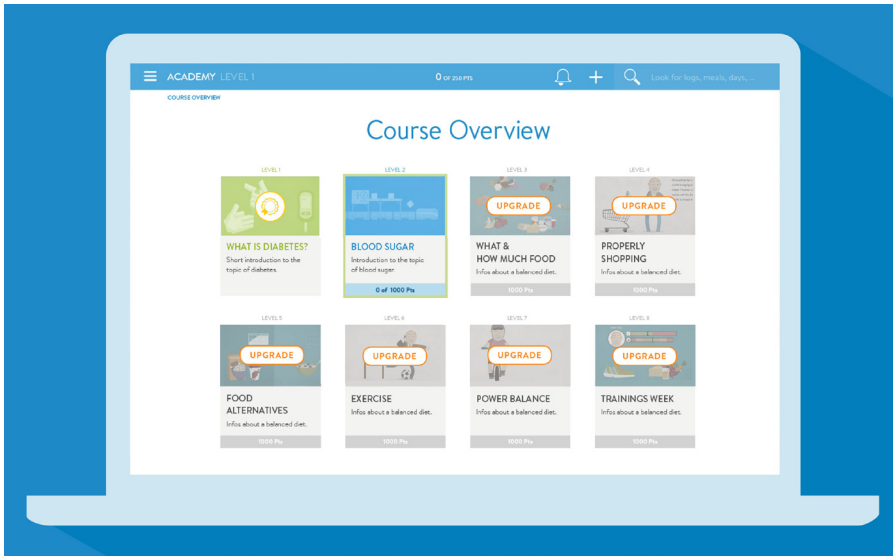
The team linked records from more than 100,000 hospital patients to a national diabetes register to get the information needed to create the calculator.

The researchers used the databases to identify more than 100,000 patients aged 30 years or older who were admitted to a hospital for an acute illness between 2004 and 2008 in Scotland, to obtain information on blood glucose levels on admission for nearly three-quarters of these patients, and to identify which patients subsequently developed diabetes. They then used statistical models to estimate the patients' risk of developing type 2 diabetes during the 3 years following hospital discharge. Among patients aged 40 years or older, the overall 3-year risk of developing diabetes was 2.3%. The risk of developing diabetes increased linearly with increasing blood glucose level at admission. Specifically, the 3-year risks at blood glucose levels of 7 mmol/l and 11.1 mmol/l were 2.6% and 9.9%, respectively; because glucose levels fluctuate according to when an individual last ate, fasting blood glucose levels of 7 mmol/l and non-fasting blood glucose levels of 11.1 mmol/l are used as thresholds for the diagnosis of diabetes. The diabetes risk associated with blood glucose levels on admission among 30–39-year-old patients followed a similar pattern but was less marked. Finally, high glucose levels on admission were associated with increased mortality.

These findings indicate that blood glucose measured during an emergency hospital admission predicts the subsequent risk of type 2 diabetes among patients aged 40 years or older (the analysis specified in the researchers' original protocol). Importantly, however, they also suggest that a high blood glucose reading in these circumstances usually indicates stress hyperglycemia rather than type 2 diabetes. The accuracy and generic nature of these findings may be limited by the lack of data on ethnicity or body mass index (a measure of obesity), both of which affect diabetes risk, and by other aspects of the study design. Nevertheless, given their findings, the researchers recommend that any patient with a blood glucose level above 11.1 mmol/l on hospital admission for an acute illness (one in 40 patients in this study) should be offered follow-up testing. In addition, the researchers constructed a risk calculator using their findings that should help clinicians to inform their patients about their long-term risk of diabetes following hyperglycemia during an acute hospital admission and to target lifestyle advice to those patients at the highest risk of type 2 diabetes.

The research was funded by the Chief Scientist Office of the Scottish Government, and published in the journal PLOS Medicine. Read the full article at: *http://www.plosmedicine.org/article/info:doi/10.1371/journal.pmed.1001708* ■

mySugr Revolutionises Diabetes Education with New Platform for People with Diabetes



Startup mySugr has already gained favour with people living with diabetes through their range of innovative smartphone apps, gaining more than 160,000 users. The company has now launched mySugr Academy, an online training program for people with diabetes that has been developed by doctors, dieticians, nurses, and people with diabetes. The first course for people with Type 2 diabetes answers many questions that come during the shock of diagnosis: What does this mean? What can I eat? Will diet & exercise help? Will I need insulin?

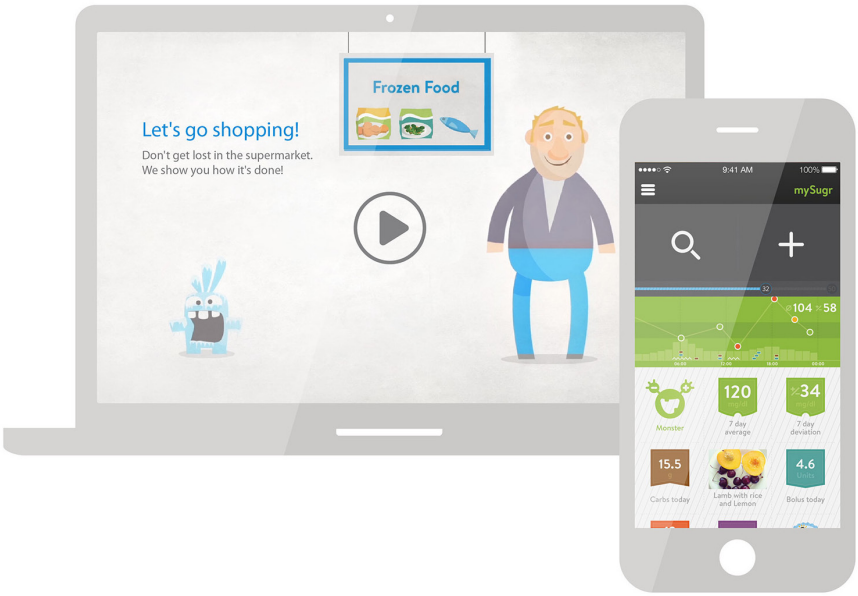
The content is delivered through fun

Continued on page 16

Continued from page 15

animated videos along with playful elements of gamification – without any of the typical guilt or shame so often associated with diabetes diagnosis.

"Many patients with type 2 diabetes feel so confused, overwhelmed and discouraged at the time of diagnosis, and traditional approaches to diabetes education often do not address these critical problems." said Dr. William H. Polonsky, President of the Behavioural Diabetes Institute in San Diego, CA. "mySugr Academy is a series of online videos that aim to breathe a sense of fun and whimsy into diabetes education. People with diabetes need to feel engaged and encouraged, and Academy's approach is sure to help!"



According to the CDC's 2014 National Diabetes Statistics Report, 9.3% of the U.S. population (29.1 million people) have diabetes. As of 2012 the estimated direct and indirect costs (disability, work loss, premature death) of diabetes were $245 billion.

Payers, both public and private, are working with mySugr to determine how best to integrate mySugr's impactful method of educating. The Austrian Social Insurance Authority for Commerce and Industry (SVA) is the first national health insurer to cover the costs of mySugr Academy for its members in Austria. ■

The Bionic Future

Finding a cure for Type 1 diabetes will always be the hope, but in reality this is still likely a number of years away. In the more immediate future, there is considerable work underway to develop what is often referred to as the 'bionic pancreas' - a closed loop insulin delivery system, which it is hoped will offer significant benefits for people living with type 1 diabetes.

Type 1 diabetes is an autoimmune condition where the body starts to produce antibodies that attack and destroy the insulin-producing cells in the pancreas. The body can therefore not make insulin, so the person relies on lifelong insulin injections to control their blood sugar. It can be a challenge for people with type 1 diabetes to keep insulin delivery at the right level, which is necessary to keep blood sugar levels within the normal range. Avoiding periods of hypoglycaemia can be a challenge, particularly overnight. A further challenge is that the symptoms of type 1 diabetes usually develop during childhood. This means that children, especially teenagers, can often find the need to stick to a particular treatment "regime" and regularly monitor their blood sugar quite restrictive. However, without such treatment recommendations, they can be at risk of complications, such as hypoglycaemia.

Because of this difficulty, a device to help simplify the treatment of type 1 diabetes would be welcomed.

The premise of a "closed-loop" insulin delivery system – in other words, an artificial pancreas - is to combine a small device that is connected to the body through a standard insulin pump, to deliver insulin under the skin without the need for continuous injections, with a real-time sensor that will continuously monitor a person's sugar level (by measuring the level in the interstitial fluid that surrounds body cells). This system would then automatically make fine adjustments to insulin delivery in response to the glucose level being continuously measured, as would normally happen in the human body with a healthy pancreas.

One endeavour that has been established to help develop and test this type of technology is the Bionic Pancreas Project, which consists of a collaborative group from Boston University and Massachusetts General Hospital working together to make automated blood glucose control a reality. The aim of the project is to develop a system that automatically makes decisions about insulin and glucagon dosing every five minutes. The project has conducted a number of studies, to date, using three system components to implement this automated control of blood glucose.

A Dexcom G4 Platinum Continuous Glucose Monitor (CGM) is used to measure interstitial fluid glucose every 5 minutes as an estimation of blood glucose, taking readings from a glucose sensor inserted into the body using an automated injector. A transmitter is then attached to enable transmission of glucose data wirelessly to the Dexcom receiver. Using a custom iPhone app the system then acts upon the glucose data by computing how much insulin or glucagon to deliver during each 5 minute episode. Once calculated, the app sends these dosing instructions via Bluetooth to two pumps, one filled with insulin and the other with glucagon (the doses of these two hormones are used

to regulate blood glucose). The pumps then deliver the insulin and glucagon doses subcutaneously through separate infusion sets.

A number of studies, to date, have used different variations of this type of system and the results suggest that this may be an extremely promising method of blood glucose control, that in the future has the potential to decrease the risk of hypoglycaemia.

In one recent study researchers found that when compared with an insulin pump, a wearable, automated, bi-hormonal, bionic pancreas improved mean glycaemic levels, with less frequent hypoglycaemic episodes, among both adults and adolescents with type 1 diabetes mellitus[1].

In another study, that considered the use of a closed-loop insulin delivery system for overnight glucose control in adults with type 1 diabetes, the results showed the time that participants spent in the target optimum sugar range during a seven-hour overnight period was higher when using the closed-loop system (52.6% of the time) compared to when they used the control pump (39.1%), with a significant difference of 13.5%. The research, published in The Lancet medical journal, is also said to be the first to monitor safety and effectiveness of the closed-loop system when used unsupervised in the person's own home over a four-week period. The study found that there were no severe adverse effects associated with using the closed-loop system, over the period[2].

Despite the promise of the artificial pancreas, there is some way to go. All of the trials conducted so far have been fairly limited in their application, and the technology has not yet been proven to be able to operate completely autonomously, and without the need for a person to monitor their blood sugar or adjust their own insulin. However, the concept of the treatment has certainly been proven, and it is hoped that the practicalities of a complete closed-loop autonomous system, will be available in the not-so distant future.

1. Russell S J, El-Khatib F H, Sinha M, Magyar K, McKeon K, Goergen L G, Et al. *Outpatient Glycemic Control with a Bionic Pancreas in Type 1 Diabetes*. N Engl J Med, 317: 313-325, 2014.

2. Thabit H, Lubina-Solomon A, Stadler M, Leelarathna L, Walkinshaw E, Pernet A, Et al. Home use of closed-looop insulin delivery for overnight glucose control in adults with type 1 diabetes: a 4-week, multicentre randomised crossover study. The Lancet: Diabetes and Endocrinology. Published online June 16 2014. ■