

The role of diabetes tech youth: **getting connected**

Francine R. Kaufman



nology in children and for better control

The use of diabetes technology by people with type 1 and type 2 diabetes is becoming increasingly widespread. Examples of the types of technology include devices that monitor glucose and deliver insulin, cell phone-based text messaging, applications (apps) on smart phones, and internet-enabled education and support programs. While some programs and devices are highly technical and expensive in terms of investment by the patient, family, and health care system, others are less complex and designed for popular usage. Perhaps the most exciting aspect of the use of technology for diabetes treatment, education, motivation, and support is how children and youth may particularly benefit from these interventions. As children and youth around the world grow up using a variety of technologies to learn, play and communicate, they will also be able to use the ever-increasing array of diabetes devices, on-line programs and engagement tools to improve their diabetes outcomes. This article describes the broad categories of diabetes technologies and suggests how they may positively impact paediatric and teenage diabetes populations.

Self-monitoring of blood glucose (SMBG)

Technologies that enable the measurement of blood glucose levels with a finger stick, referred to as SMBG, have been available on a widespread basis for over three decades and have been viewed as one of the greatest advances in the field of diabetes. SMBG is part of the Global Guideline¹ for diabetes in childhood and adolescence, although those living in the most poorly resourced

regions often do not have full access to medically necessary supplies. Beginning with the Diabetes Complications and Control Trial, referred to as the DCCT,² there have been many articles in the world's diabetes literature attesting to the value of measuring blood glucose levels throughout the day and night to improve glucose control in people with type 1 diabetes in all age groups, including children and youth. While the use of SMBG by the general type 2

population is still controversial, for youth with type 2 diabetes the value of SMBG has been highlighted by the results of the TODAY Trial.³ Youth with type 2 diabetes in this US study were shown to have high rates of co-morbidities and difficulty controlling their diabetes making it important for youth with type 2 diabetes to monitor glucose levels at home.

Improvements may give additional motivation to children and teens when it comes to the drudgery of accounting for daily blood glucose values in order to adequately manage their diabetes.

Over the years, manufacturers have developed improvements to glucose meters, glucose strips and lancing devices for the benefit of the paediatric diabetes population. Examples include: smaller lancets and meters; decreased time to get results; very low blood volume requirements; linkages to more intuitive retrospective data management displays via computer, internet and smartphone; and

connections to games and reward systems. These improvements have helped make SMBG easier to use and may also give additional motivation to children and teenagers when it comes to the drudgery of accounting for daily blood glucose values in order to adequately manage their diabetes.

Continuous glucose monitoring (CGM)
Continuous glucose monitoring (CGM), first implemented in the early 1990s, provides up to 288 glucose values in a 24-hour period through a sensor placed under the skin. The real-time CGM system displays data on a monitor or pump screen, and shows the latest glucose value, the glucose trend graph, and arrows indicating the direction and rate of change of glucose levels. Alerts are given when glucose levels reach, or are predicted to reach, pre-set high and low thresholds determined by the patient in collaboration with his or her diabetes health care team. There is also a CGM device worn for three to six days with the relevant blood glucose data only available for review once the sensor is removed.

CGM data can be uploaded into systems that display the data in a variety of ways (e.g., pie charts, graphs and tables), and in association with the patient's simultaneous finger stick blood glucose values. If the CGM system is integrated with an insulin pump, the data in the pump concerning insulin delivery and carbohydrate intake can also be part of the CGM display. For

CGM to be valuable, all this information should be used in the moment, or in retrospective analysis, to better balance insulin dosages, food/carbohydrate ingestion, activity levels and stress/illness when it occurs. To succeed, children and youth with diabetes and their caregivers must not only be taught CGM functionality, but also motivated to use it. The first big study using CGM in children, done with the support of the Juvenile Diabetes Research Foundation (JDRF), did not show a marked benefit from the use of CGM in improving HbA_{1c}, mainly because the children in the study did not wear CGM enough of the time.⁴ However, in subsequent studies^{5,6} when CGM was utilised the majority of the time, children benefitted by improving their diabetes outcomes and parents benefitted by reducing their worry about hypoglycaemia.

In contrast to SMBG, the use of CGM remains less widespread globally for a variety of reasons including: cost; concern about patient acceptance, motivation and usage; limited places to put sensors on small children's bodies; and limited numbers of global health care providers with experience in using CGM. While CGM is rarely available in low-resourced countries, some high-resourced countries and health care systems allow for almost unlimited use by paediatric patients living with type 1 diabetes while others have restricted its use to only those with specific indications, such as prior severe hypoglycaemic events, recurrent DKA, and high

HbA_{1c} results. The newer generations of CGM systems use smaller more accurate sensors for improved patient comfort and acceptance. Newer CGM systems are now driving the primary elements of the artificial pancreas through their linkage with insulin pumps. Second generation CGM systems may soon be able to move data in real-time for shared access from the child wearing the CGM to a remote caregiver thus helping to reduce patient burden and improve glucose outcomes. It is hoped that, as these systems evolve, access to CGM technology will be increased for all children and youth living with diabetes worldwide.

Insulin pump therapy

An insulin pump is a small mechanical device worn by a person with diabetes to deliver basal and bolus insulin through a small tube or needle placed under the skin. Basal insulin can be programmed to change throughout the day and night, and bolus insulin is given for food and to correct a high glucose level. Insulin pumps have been in use for over thirty years, have been studied extensively in children and have been shown to have benefit in improving glucose control and reducing hypoglycaemia when someone is switched from multiple daily injection therapy. In many high-resourced countries, pumps are used routinely in children and teenagers who are motivated to wear the device, willing to do frequent SMBGs or wear a CGM, and who may not be at glucose goal or have had a diabetes management problem. Insulin pump therapy is part of the basic care package in many regions, although main barriers for uptake are cost of the device and the need to have a well-trained and experienced diabetes education team. In addition to the cost of the pump and other durables, the routine recommendation that insulin pump therapy is best served by rapid-acting insulin analogues further increases

Children benefitted by improving their diabetes outcomes and parents benefitted by reducing their worry about hypoglycaemia.



overall pump therapy cost. Many insulin pump innovations were developed expressly for use in children, such as: lock out mechanisms so young children cannot give insulin themselves; bolus calculators to figure out the amount of bolus insulin taking into account previously infused insulin still active in the body; very low dose insulin delivery down to 0.025 units; tubeless patch pumps; computer data reports; and more.

The artificial pancreas

The artificial pancreas is the term used to describe an insulin pump coupled with real-time CGM providing automatic delivery of insulin through closed-loop mathematical algorithms. The artificial pancreas delivers insulin based on sensor glucose levels. If the glucose level is high, more insulin is given, and if it is low, insulin can be automatically stopped. The accepted concept for the development of the artificial pancreas is that it will be accomplished through a series of steps, until all insulin delivery is done automatically, without input from the person or caregiver. The first step has the 'threshold suspend' feature that automatically stops insulin delivery at a pre-set sensor glucose level to minimize hypoglycaemia. The next step is to use a 'predicted suspend' feature so that insulin stops before hypoglycaemia occurs, which may help prevent hypoglycaemia from occurring altogether. There have been many research studies demonstrating promising results from the use of the artificial pancreas, including studies in older children and youth. It is hoped that when the full

artificial pancreas is approved and released for medical use, it will prove to be a near 'cure' for type 1 diabetes.

On-line programs, applications (apps) and games

There are a variety of programs available on the internet and through mobile applications on tablets, smartphones and cell phones which can aid in type 1 and type 2 diabetes management and address obesity as a risk factor for type 2 diabetes. These programs range from simple text messages reminding the child or caregiver to perform various diabetes tasks, review educational and motivational online videos, utilise programs that track and analyse multiple data obtained manually or through connections with other devices, like pedometers, scales, and more. Glucose values, insulin doses, carbohydrate and calorie intake, physical activity levels and weight can be tracked and analysed, with supplemental treatment and behavioural suggestions and encouragement. In some instances, these applications have been linked to games and a broader on-line community to increase engagement and motivation so children will improve their behaviours and overcome their barriers to good care. The use of mobile applications, internet programs and games are potentially available for little cost with worldwide access. How much these programs will change the face of diabetes education, care and outcomes has yet to be determined.

Conclusion

There have been many advances in technology which have helped change how individuals manage diabetes, particularly benefitting children and youth. From glucose meters, to insulin pumps and CGM devices, to the soon-to-be-available early steps of the artificial pancreas, advanced technologies hold tremendous promise

but remain restricted to high-resourced countries. The newer systems are expensive and require patient and health care provider education and commitment. On-line programs and cell phone applications have greater potential to be used by a broader range of patients, including those in low-resourced countries because they are often inexpensive and relatively easy to use. It is hoped that newer technologies will continue to motivate and help children and youth with type 1 and type 2 diabetes improve their health.

Francine R. Kaufman

Francine R. Kaufman is member of the IDF's Life for a Child Programme Medical and Scientific Advisory Group 2012-2014; Chief Medical Officer and Vice-President of Global Clinical, Medical and Health Affairs, Medtronic Diabetes; Distinguished Professor Emerita of Pediatrics, the Keck School of Medicine of USC and Children's Hospital Los Angeles.

References

1. *Global IDF/ISPAD guideline for diabetes in childhood and adolescence*. Brussels, 2011. <http://www.idf.org/sites/default/files/Diabetes-in-Childhood-and-Adolescence-Guidelines.pdf>
2. The Diabetes Control and Complications Trial Study Group. The effect of intensive management of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N Engl J Med* 1993; 329: 977-86.
3. The TODAY Study Group. A clinical trial to maintain glycemic control in youth with type 2 diabetes. *N Engl J Med* 2012; 366: 2247-56.
4. Tamborlane WV, Beck RW, Bode BW, et al. The Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group: Continuous glucose monitoring and intensive treatment of type 1 diabetes. *N Engl J Med* 2008; 359: 1464-76.
5. Mauras N, Beck R, Xing D, et al. The Diabetes Research in Children Network (DirecNet) Study Group: A randomized clinical trial to assess the efficacy and safety of real-time continuous glucose monitoring in the management of type 1 diabetes in young children aged 4 to <10 years. *Diabetes Care* 2012; 35: 204-10.
6. Bergenstal RM, Tamborlane WV, Ahmann A, et al. The STAR 3 Study Group: Effectiveness of sensor-augmented insulin-pump therapy in type 1 diabetes. *N Engl J Med* 2010; 363: 311-20.