Increasing Insulin Pump Use Among 12- to 26-Year-Olds With Type 1 Diabetes: Results From the T1D Exchange Quality Improvement Collaborative

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Insulin pump therapy in pediatric type 1 diabetes has been associated with better glycemic control than multiple daily injections. However, insulin pump use remains limited. This article describes an initiative from the T1D Exchange Quality Improvement Collaborative aimed at increasing insulin pump use in patients aged 12–26 years with type 1 diabetes from a baseline of 45% in May 2018 to >50% by February 2020. Interventions developed by participating centers included increasing in-person and telehealth education about insulin pump technology, creating and distributing tools to assist in informed decision-making, facilitating insulin pump insurance approval and onboarding processes, and improving clinic staff knowledge about insulin pumps. These efforts yielded a 13% improvement in pump use among the five participating centers, from 45 to 58% over 22 months.

Children and adults with type 1 diabetes receive insulin by either multiple daily subcutaneous injections or continuous subcutaneous insulin infusion, commonly called insulin pump therapy (1). Insulin pump therapy in pediatric type 1 diabetes has been associated with improved glycemic control. A 2010 Cochrane systematic review of 23 randomized, controlled trials comparing insulin pump use to multiple daily injections found a significant difference in A1C favoring insulin pump therapy (2). In a more recent meta-analysis, similar findings were seen when comparing insulin pump therapy to multiple daily injections using different types of rapid-acting and basal (i.e., intermediate and long-acting) analog insulins (3). Improved glycemic control for those using insulin pump therapy has also been reported in population-based studies. The SEARCH for Diabetes in Youth study (4), a U.S. population-based study of newly diagnosed diabetes in youths, found that participants with type 1 diabetes using insulin pump therapy had a lower mean A1C than those using other treatment regimens. Furthermore, insulin pump therapy has been associated with lower risks of severe hypoglycemia and diabetic ketoacidosis (5).

Although insulin pump use has increased over time, dramatic uptake of insulin pumps has not been noted globally or even within individual countries. In the SWEET (Better Control in Pediatric and Adolescent Diabetes: Working to Create Centers of Reference) registry, 49% of 6- to 11-year-olds and 42% of 12- to 18-year-olds used insulin pumps in 2016; rates varied from 0 to 90% among 46 participating diabetes centers around the globe (6). In the U.S. T1D Exchange clinic registry, insulin pump use between 2016 and 2018 was 68% for individuals 6–12 years of age, 62% for those 13–17 years of age, and 60% for those 18–25 years of age (7), although these data may not be generalizable to the general U.S. population because of a self-selection bias of participants in this voluntary registry.

In 2016, the T1D Exchange Quality Improvement Collaborative (T1DX-QI), coordinated by the T1D Exchange clinic network, was established to improve care delivery for people with type 1 diabetes (8). The collaborative started with 10 adult and pediatric diabetes centers in the United States and has expanded to 30 centers. The diabetes centers participate in collaborative quality improvement (QI) activities by sharing their clinic population data and best practices. One of the initial focuses of the T1DX-QI was to increase insulin pump use among pediatric member centers, with a subsequently developed SMART (Specific, Measurable, Applicable, Realistic, and Timely) aim of increasing pump use in pediatric and emerging adult patients aged 12–26 years with type 1 diabetes who were receiving medical care at one of five T1DX-QI diabetes centers from a baseline of 45% in May 2018 to >50% by February 2020.

Research Design and Methods

This project was deemed nonhuman subject research by the Western Institutional Review Board, and all participating centers received local institutional review board approval to share aggregate data and participate in this QI project. No protected health information was transmitted outside of each clinic for this project.

The five participating T1DX-QI centers were Texas Children's Hospital in Houston; C.S. Mott Children's Hospital in Ann Arbor, MI; Nationwide Children's Hospital in Columbus, OH; the Barbara Davis Center in Aurora, CO; and the University of Pennsylvania in Philadelphia, PA. Four are pediatric endocrinology practices, and one is an adult endocrinology practice. The centers used QI methodology, including Plan-Do-Study-Act (PDSA) cycles (9,10), to develop, implement, and evaluate the impact of initiatives to increase and sustain insulin pump use among their patients aged 12–26 years with diabetes duration ≥12 months. The age range of 12–26 years was selected because it represents the time of life with poorest glycemic control, as measured by A1C (7), and overlaps pediatric and adult health care, thereby promoting the cross-sharing of ideas between T1DX-QI pediatric and adult centers.

The project began in May 2018, and centers began testing change ideas by July 2018. Data are presented through February 2020. Centers created PDSA cycles based on their clinic priorities and patient population needs and implemented them according to their local practice procedures and policies. PDSA interventions were recommended to clinics through change package

examples and case studies. A change package is a practical guide that provides strategies and change ideas for care teams to test. The T1DX-QI has designed a series of change packages, all developed in collaboration with participating clinics. PDSA cycles were implemented and communicated to the T1D Exchange coordinating office through regular conference calls. Centers also reported on a monthly basis the number of their patients who had at least two A1C values in the preceding 12 months, of which the most recent A1C value was from that month, and the percentage of those patients who were using insulin pumps. A1C is usually obtained in proximity to a clinic appointment. (The project finished before the rapid increase in telehealth appointments the five centers experienced as a result of the coronavirus disease 2019 pandemic.)

The monthly data were shared with the T1D Exchange coordinating office using a secure collaborative spreadsheet (www.smartsheet.com). The coordinating office collected, analyzed, and communicated back to the five participating sites all of the active PDSA cycles and aggregate data to foster the cross-sharing of best practices and collaborative improvement for the project's 22-month duration.

Data were analyzed by using control chart rules to determine shifts and evaluate project effectiveness. Eight data points above the mean or four out of five consecutive data points outside the first σ control limits were used to determine the shifts. The t test was used to evaluate statistical significance between pre- and post-intervention means; the pre-intervention period was from May to July 2018, the interventions took place between August 2018 and November 2019, and the post-intervention period was from December 2019 to February 2020. Control charts were created using the SPC for Excel plugin (https://www.spcforexcel.com), whereas the t test was completed using R version 4.0.1 statistical software (11).

Given that the T1DX-QI strives to prevent competitive comparisons that would threaten its cooperative culture (8), only aggregated data are presented, and individual centers are listed by randomly selected numbers and not referred to by name in the results and discussion sections.

Results

In the 6 months before initiating the project, the rate of insulin pump use was stable across the five participating sites, ranging from 43 to 47%, with an average of 45%.

The centers developed a key driver diagram to identify novel and practical change ideas to increase and sustain insulin pump use (Figure 1). Identified key drivers that directly contribute to achieving the SMART aim were to *1)* support patients in starting and continuing insulin pump therapy, *2)* educate patients on effective insulin management, and *3)* support patients in active problem-solving for glucose monitoring, insulin management, and nutrition education. Secondary drivers that guided the development of change ideas included addressing patient barriers to insulin pump use, redesigning workflow to increase patient education on pumps and effective management, and offering mobile technology classes for patients and families.

The centers then independently developed and implemented change ideas and PDSA cycles to increase insulin pump use among patients receiving care at their individual centers. Successful interventions implemented through PDSA cycles included developing and distributing educational materials, offering in-person and telehealth patient and family education, creating and distributing tools to assist in informed decision-making, facilitating insulin pump insurance approval and onboarding processes, and engaging clinic staff in introducing and educating patients and families about insulin pump use (Table 1). Supplementary Figure S1 is a sample patient education tool developed for a PDSA cycle at a participating center.

After the series of rapid tests of change over 22 months, the collaborative average of insulin pump uptake increased to 58%, a 13% increase from baseline across the centers ($P < 0.0001$) (Supplementary Figure S2). Three out of the five participating sites also had statistically significant control chart shifts in their site-specific data.

Discussion

Five diabetes centers in the T1DX-QI collaborated to address barriers to insulin pump initiation and sustainment through sharing of standardized metrics and best practices. Over 22 months, insulin pump use rates increased from 45 to 58%, a significant improvement.

Use of diabetes technology, including insulin pumps, has been associated with improved glycemic control, particularly in youths with type 1 diabetes (7). Despite this, the rate of insulin pump technology use in individuals with type 1 diabetes is not optimized. Patient barriers to uptake include financial issues (i.e., insurance coverage and costs of device and supplies) and personal preference (i.e., not liking to have a device on one's body and the hassle of wearing a device) (12,13), and barriers to sustained use include wearability issues, disliking the pump, and problems with glycemic control (14). Additionally, providers' familiarity and comfort with technology may vary, at least while in training (15). Furthermore, adolescents and young adults have the poorest glycemic control compared with other age-groups, as well as the highest rate of pump discontinuation (7,14).

The T1DX-QI created interventions to target these barriers to insulin pump therapy among 12- to 26-year-olds receiving care at five U.S. diabetes centers (Table 1). By working together in a collaborative, these centers cross-shared change ideas and PDSAs, which facilitated in disseminating to all T1DX-QI clinics successful change ideas that centers could then adapt and implement in

FIGURE 1 Insulin pump therapy key driver diagram.
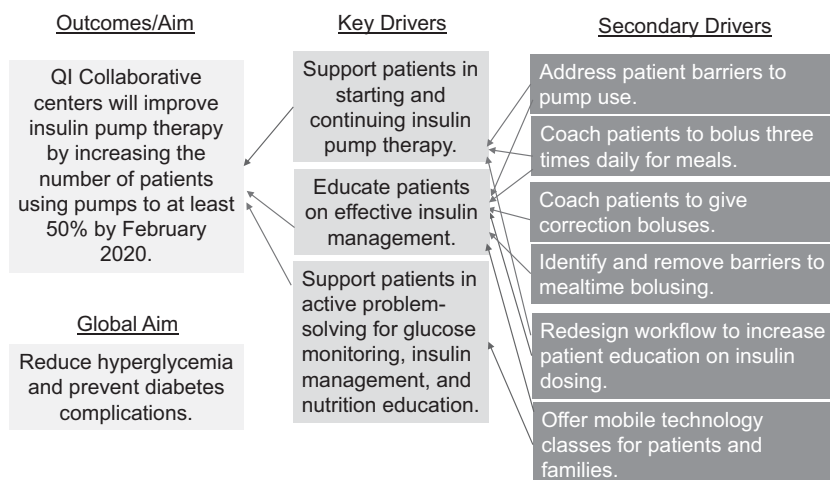
TABLE 1 Interventions to Increase Insulin Pump Use and Examples From the Diabetes Centers

Interventions	Examples
Increase patient and family education and informed decision-making.	Center 1: Creation of a comprehensive handout of available pump options to assist with informed decision-making (Supplementary Figure S1). Center 2: Creation of an introductory pump handout discussing advantages and considerations with insulin pumps (available in English and Spanish) that was shared with patients and families. Based on feedback, the handout was reviewed to include more pictures and less text. Centers 2 and 4: Demonstrations of different insulin pumps for interested patients. Center 3: Use of a center-created insulin pump booklet and electronic presentation. Centers 3 and 4: Use of home telemedicine.
Facilitate insulin pump approval and onboarding processes.	Center 2: Creation of electronic versions of Certificate of Medical Necessity (required forms to start insulin pump insurance approval process) in the electronic medical record with auto-populated elements, which underwent multiple iterations based on stakeholder feedback. Center 5: Creation of a technology on-boarding process improvement with a Pump 101 program.
Improve staff knowledge about insulin pumps.	Center 2: Quarterly technology sessions for providers and clinic staff to improve pump knowledge. Format changed over time based on provider and staff feedback. Center 2: Certification of the clinic's diabetes educators in all commonly used pumps.
Determine barriers to insulin bolusing and tailor recommendations in accordance to the barriers (i.e., if forgetting is the problem, help the patient set reminders).	Center 1: Creation and implementation of an Insulin Delivery Barriers Assessment, which facilitates a patient-centered discussion and goal-setting for those struggling with insulin administration. Center 2: Use of bolus reminders on pumps. Center 3: Use of *Understanding Diabetes: A Handbook for People Who Are Living With Diabetes* by H. Peter Chase, MD, of the Barbara Davis Center. Center 4: Assessment of psychosocial barriers and encouragement of patients to use technology (e.g., cell phone alarms/reminders) and support systems (e.g., parents and friends) to help them stay accountable.
Use technology to improve insulin pump management.	Center 1: Creation of an education program focusing on using technology to support diabetes management (e.g., teaching patients and families how to interpret diabetes data and recognize patterns, how to understand insulin dosing and how behaviors can affect blood glucose, and how to adjust insulin doses). Center 4: Provision to patients of their pump manufacturer's guidelines for downloading and sharing data electronically with clinic.
Increase frequency of touchpoints between visits to optimize insulin adjustments for patients to sustain pump use.	Center 4: Use of telehealth, including providing patients written instructions and a check-in call before telehealth visits.
Test mobile apps or books that lead to better dose calculations for patients and higher patient satisfaction.	Center 1: Promotion of insulin calculation apps. Centers 1–4: Promotion of nutrition and exercise tracking apps. Center 4: Creation of an insulin adjustment tool.
Ensure patients have access to affordable diabetes resources.	Center 1: Links to resources on the center's website. Center 4: Sharing of information with patients at clinic visits about affordability resources for diabetes prescriptions, including insulinhelp.org.

their patient populations. Common themes for interventions included improving patient education and support, easing the onboarding process, and engaging and educating clinic staff about the aim. Subsequent interventions focused on sustainment, including increasing the frequency of touchpoints with patients between visits, determining barriers to insulin bolusing and tailoring recommendations to address those barriers, and integrating technology to facilitate bolus calculations.

Building on the success of this aim, future directions include efforts to *1*) increase insulin pump use in a high-risk diabetes subpopulation (defined by the T1DX-QI as individuals with two A1C values >9% within the previous year); *2*) track and improve the number of individuals administering insulin boluses at least three times daily, as more frequent insulin boluses have been associated with improved A1C (16); and *3*) increase the use of automated insulin delivery systems. Future interventions include *1*) identifying barriers and sharing tools to support insulin pump adoption in the high-risk subpopulation, *2*) developing and implementing an evidence-based curriculum to educate patients on administering at least three boluses daily, *3*) incorporating an

evidence-based insulin dose adjustment algorithm to assist clinicians in their recommendations to patients for dose adjustment between clinic visits, and *4*) ensuring that patients have access to affordable insulin so that cost is not a barrier to taking insulin.

Diabetes technology is quickly advancing. The combined use of insulin pumps with continuous glucose monitoring can provide additional benefit in this age-group compared with insulin pump use with intermittent blood glucose checks (17). T1DX-QI initiatives to increase CGM use are discussed elsewhere in this special article collection (18).

In summary, this collaboration rapidly improved the rate of insulin pump use, which directly supports the T1DX-QI global aim of reducing hyperglycemia and preventing diabetes complications. Furthermore, it has promoted a cooperative culture among diabetes centers in the sharing of best practices and population data.

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DUALITY OF INTEREST

O.E. is a compensated Health Equity Advisory Board member for Medtronic Diabetes and serves as the principal investigator for investigator-led projects sponsored by Abbott, Dexcom, Eli Lilly, Insulet, and Medtronic. J.M.L. is on the medical advisory board for GoodRx. No other potential conflicts of interest relevant to this article were reported.

AUTHOR CONTRIBUTIONS

S.K.L. wrote the first draft of the manuscript. All authors reviewed and edited the manuscript. O.E. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

PRIOR PRESENTATION

Parts of this study were presented at the American Diabetes Association's virtual 80th Scientific Sessions, 12–16 June 2020.

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