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Determining the Perception and Willingness of Primary Care Providers to Prescribe Advanced Diabetes Technologies

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Abstract Advanced diabetes technologies have produced increasingly favorable outcomes compared to older treatments. Disparities in practice resources have led to a treatment disparity by clinical setting, where endocrinologists typically prescribe far more such technologies than primary care providers (PCPs). Fully automated artificial pancreas systems (APS), which combine technologies to deliver and adjust insulin dosing continuously in response to automatic and continuous glucose monitoring, may be more straightforward for PCPs to prescribe and manage, therefore extending their benefit to more patients. We aimed to assess willingness of PCPs to prescribe advanced diabetes technologies through a cross-sectional survey of PCPs from 4 geographically diverse centers. While respondents were uncomfortable initiating (63 of 72, 88%) or adjusting (64 of 72, 89%) traditional insulin pumps, their views on APS were quite different: 71 of 76 (93%) saw advantages to prescribing APS by PCPs rather than only endocrinologists. Most would consider prescribing APS for type 1 diabetes (58 of 76, 76%) and type 2 diabetes (52 of 76, 68%). No differences were seen among attendings, residents, or nurse practitioners. APS were much more acceptable than traditional insulin pumps among this primary care sample. If successful, primary care management of closed-loop APS would greatly increase access to such therapies and reduce disparities among those patients who face more difficulty accessing subspecialty care than they do primary care. (*J Patient Cent Res Rev.* 2021;8:272-276.)

Keywords diabetes mellitus; primary care; endocrinology; continuous glucose monitoring; closed-loop systems; technology; artificial pancreas

Diabetes affects millions of people in the United States; 32.6 million have type 2 diabetes (T2D),[1] 1.6 million have type 1 diabetes (T1D),[1] and gestational diabetes affects 6%–9% of pregnant women.[2] From the point of diagnosis, every patient with T1D requires daily injection of insulin, while patients with T2D or gestational diabetes will usually begin insulin therapy once lifestyle changes and oral medications fail to provide optimal glucose control. Regardless, patients with any type of diabetes will need to couple their therapy regimen with multiple daily blood glucose measurements, either through a standard glucometer or a subcutaneous continuous glucose monitor (CGM) in a perpetual effort to compensate for the loss of physiologic glycemic metabolism. To dose insulin, some people with diabetes opt for using an insulin pump, programmed with individually determined and time-specific basal rates, correction factors, and insulin:carbohydrate ratios over the more common multiple daily injections.[3] Despite multiple benefits,[4,5] these insulin pumps are used by only 20%–30% of those with T1D and substantially fewer with other forms of diabetes.[6]

Treatment of T1D, gestational diabetes, and many cases of insulin-requiring T2D is completely, or nearly completely, managed by the patients or their caregivers themselves, requiring tremendous effort and leaving plenty of room for human factors (eg, varying frequencies of glucose checks, dosage adjustments, and carbohydrate counting accuracy). Failure to navigate these factors can lead to debilitating complications in both the short term, such as severe hypoglycemia or diabetic ketoacidosis,

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or the long term, such as retinopathy, nephropathy, neuropathy, or cardiovascular disease. Many patients managed with insulin must meet with their diabetes care providers to repeatedly adjust insulin dosing ratios and rates to account for changes over time. Because of this, and with advances in technology and computing, several companies have pursued algorithms and technology to automate insulin delivery. This includes the manufacturers of the three most popular existing insulin pumps, who are incorporating CGM technology into and adapting their existing insulin pump products with incremental automation features, resulting in so-called hybrid closed-loop artificial pancreas systems (APS). These systems provide varying degrees of automation and glycemic improvement while still relying on user input and manual determination of insulin dosing rates and ratios.[7-10]

Other examples currently in development — including some in late-stage regulatory testing at the time of this writing — employ fully closed-loop, completely automated APS that mates CGM technology with newer pumping technology and learning-control algorithms to deliver rapid-acting insulin autonomously. One such device only requires user input of weight and generates the necessary basal rates, correction factors, and insulin:carbohydrate ratios for the user. It is also designed to adapt over time and adjust these ratios and rates to the changing daily lifestyles of the user, without the need of intervention from a trained physician, nurse practitioner, physician assistant, or clinical pharmacist. In addition, it does not require carbohydrate counting but gives the user the ability for an optional meal bolus if they would like to prime the device for better blood glucose control. Prior studies have demonstrated that this automated APS significantly decreases the substantial diabetes self-management burden while improving glycemia, thereby reducing time spent in both hypoglycemia and hyperglycemia.[11,12]

Currently, diabetes technology like insulin pumps and CGMs are prescribed more frequently by endocrinologists.[13,14] These devices are associated with better outcomes[4] but require special training and/or office resources for providers to manage them for their patients. Generally speaking, such training and resources are available to most endocrinology practices but to very few primary care practices. This disparity in access exists despite CGM recommendations in the American Diabetes Association's current and prior *Standards of Medical Care in Diabetes*.[15,16] People with T2D and gestational diabetes treated with insulin also may be placed on insulin pumps in some circumstances to tailor their insulin delivery as an alternative to other treatments or to multiple daily insulin injections. These are usually managed by endocrinology, not by primary care providers (PCPs),[13,14] due to practice resource and training differences. However, in contrast to PCPs, endocrinologists are not broadly dispersed geographically. A recent study found that more than 75% of U.S. counties have no endocrinologists at all, while 96% of U.S. counties have at least one PCP, and while all people live in or adjacent to a county with a PCP, the nearest endocrinologist can be hundreds of miles and many counties away.[17]

With emerging advanced artificial pancreas technology, and especially fully automated closed-loop systems and their ability to autonomously manage insulin dosing and glycemia with only an initial input of the user's weight, it is quite likely that much of the advanced provider training and extended practice resources may no longer be necessary to support such systems. This is especially the case for systems that can also autonomously determine and perpetually update patient-specific ratios, correction factors, and basal rates. As each person with diabetes has a PCP within their own or neighboring county,[17] having advanced artificial pancreas technology prescribed by PCPs would greatly increase the access to this important technology beyond through endocrinologists alone, addressing potential disparities deriving from lack of access to endocrinologists. This would allow the benefits of improved glycemia, including reduced time spent in hyperglycemia and hypoglycemia, to reach not only more patients but also more geographically distributed patients.

Before moving toward such a model, it is important to assess provider perceptions and awareness of such technologies. There is a paucity of literature on these topics, some of which this study aimed to address by investigating PCPs' perceived barriers and willingness to prescribe advanced diabetes technologies to patients with T1D, T2D, and gestational diabetes.

METHODS

This cross-sectional study was approved by the Penn State College of Medicine institutional review board.

Population

Eligible participants were PCPs, including physicians, nurse practitioners, and physician assistants practicing family medicine, general internal medicine, general pediatrics, or obstetrics/gynecology. Targeted recruitment was conducted through academic, residency, and health system-based U.S. centers that responded to an email inviting interest to participate. In turn, interested centers sent an email announcement to their providers, with a link to study information, including an explanation of the study and opportunity to consent to participate. Participants

could not continue to the survey unless they agreed that they had read the summary and consent and would like to participate. They were then presented with an eligibility screener; if eligible based on the aforementioned criteria, the survey followed immediately. Participants who completed the survey could optionally enter a drawing for one of two $100 electronic gift cards.

Measures

The instrument included questions about experience with diabetes, advanced diabetes technology, patient population, and provider demographics, including age, gender, position, and specialty (Online Appendix A). It was pilot tested prior to distribution among a group of PCPs, who reviewed it for clarity and what they perceived to be the meanings and intent of each item. Minor adjustments to language were made based on pilot results. After arriving at a final instrument, estimated completion time among another sample of PCP testers was 10–15 minutes. The survey and data were hosted in REDCap,[18,19] a secure electronic data collection instrument supported by the Penn State Clinical and Translational Science Institute.

Statistical Analyses

Descriptive statistics and inferential comparisons were conducted with R software (The R Foundation). Comparisons between groups employed 2-sided *t*-tests for continuous items and chi-squared tests for categorical items, at the 5% level of significance. To limit the number of comparisons made, comparisons were predetermined and made across groups where possible.

RESULTS

A total of 76 completed responses were obtained from programs located in Connecticut, Hawaii, North Carolina, and Pennsylvania. Due to the nature of survey distribution, response rate could not be calculated. Of 72 respondents who provided their position/role, there were 45 (63%) attending physicians, 22 (31%) residents, 4 (6%) nurse practitioners, and 1 (1%) clinical pharmacist. Of 42 who provided their specialty, 22 (52%) reported family medicine, 10 (24%) obstetrics/gynecology, 7 (17%) general pediatrics, and 3 (7%) general internal medicine.

Respondents reported being uncomfortable initiating (63 of 72, 88%) or adjusting (64 of 72, 89%) traditional insulin pump therapy for patients with T2D. In all, 71 of 76 (93%) respondents — and 35 of 35 [100%] respondents who shared their specialty and treated adult patients — saw advantages to prescription of APS by PCPs rather than only by subspecialists. Of 76 respondents, 58 (76%) PCPs would consider prescribing APS for T1D, 52 (68%) would consider prescribing APS for T2D, and 28 (37%) would consider prescribing APS for gestational diabetes, with no differences between attendings, residents, and nurse practitioners.

Table 1. Participant Responses Regarding APS Prescribing Beliefs and Intentions, by Position, Age, Years Since Training, and Specialty

Participant characteristics		n	Sees advantages to PCP prescription of APS devices		Would consider ordering APS for T1D		Would consider ordering APS for T2D		Would consider ordering APS for GD	
			Positive response, n (%)	*P*	Positive response, n (%)	*P*	Positive response, n (%)	*P*	Positive response, n (%)	*P*
Position	Attending	45	40 (89)		30 (67)		28 (62)		16 (36)	
	Resident	22	22 (100)	0.333	20 (91)	0.074	18 (82)	0.072	9 (41)	0.862
	Nurse practitioner	4	4 (100)		4 (100)		4 (100)		2 (50)	
Age	< mean of 38 years	32	28 (88)	0.180	20 (63)	0.023	17 (53)	0.015	8 (25)	0.155
	≥ mean of 38 years	36	35 (97)		32 (89)		30 (83)		16 (44)	
Years since training	Still in training	21	21 (100)		19 (91)		17 (81)		8 (38)	
	0–10	23	20 (87)	0.263	17 (74)	0.181	17 (74)	0.172	11 (48)	0.368
	10+	28	26 (93)		19 (68)		16 (57)		8 (29)	
Medical specialty	General pediatrics	7	2 (29)		0 (0)		0 (0)		0 (0)	
	General internal medicine	3	3 (100)	<0.001	3 (100)	<0.001	3 (100)	<0.001	2 (67)	0.121
	Family medicine	22	22 (100)		22 (100)		20 (91)		6 (27)	
	Obstetrics/Gynecology	10	10 (100)		4 (40)		3 (30)		4 (40)	

APS, artificial pancreas system; GD, gestational diabetes; PCP, primary care provider; T1D, type 1 diabetes; T2D, type 2 diabetes.

Those younger than the mean respondent age of 38 years were less likely than those at or above the mean age to consider prescribing APS for T1D (20 of 32 [63%] vs 32 of 36 [89%]; P=0.023) and T2D (17 of 32 [53%] vs 30 of 36 [83%]; P=0.015). There was no association between time since training and willingness to prescribe APS for either T1D or T2D. General pediatricians were not willing to consider prescribing APS for T1D (P<0.001) or T2D (P<0.001) and were less likely to see benefits of PCPs prescribing APS (P<0.001) than their colleagues in general internal medicine, family medicine, and obstetrics/gynecology.

Additional results are detailed in Table 1.

DISCUSSION

While PCPs were overwhelmingly uncomfortable initiating or adjusting traditional insulin pumps, they largely agreed that there are advantages to prescribing automated APS through primary care rather than only through specialists. PCPs were generally willing to consider prescribing automated APS for T1D and T2D but not for gestational diabetes. When considering only PCPs who treat adult patients, this willingness was even more evident. Respondents with greater familiarity with CGM were more likely to report advantages of prescribing APS through primary care and to consider doing so. However, a significant majority of even those unfamiliar with CGM saw advantages and would consider prescribing APS. Automated APS appear to be much more acceptable to this sample of PCPs than traditional insulin pumps.

The finding that younger respondents were less likely to consider prescribing APS while no association was found between time since training and willingness to prescribe APS seems counterintuitive. This might be explained on the basis of the differences in the comparisons — 2 groups (above or below the median) compared by age versus 3 groups (with fewer in each group) compared by years from training — making it less likely to find a significant difference among the smaller years from training groups.

If these results are true more generally, PCP receptivity to using APS could increase access to greater numbers of patients with diabetes. Distance from the nearest endocrinologist would not need to be a limiting factor in determining which patients with diabetes can have access to the newest and most effective technology to manage their disease. In the case of patients with gestational diabetes, the effect of diabetes on pregnancy could be lightened by giving an obstetrician the option to place their patient on closed-loop APS for the duration of their disease, but more education must be provided to help clear up misconceptions clearly seen in this study that PCPs currently have against this emerging technology in gestational diabetes.

Study limitations include the relatively small number of respondents, in addition to underrepresentation of general internal medicine and pediatrics, and the unexplained finding that just 55% of respondents reported their specialty, limiting generalizability. The survey described the hypothetical diabetes management system based on the known evidence and did not speculate or inquire about potential PCP management or liability responsibilities. While this approach kept focus on the facts, omission of hypothetical impact on clinical practice may have influenced survey responses. Another concern may be that including in the survey instrument a description of a closed-loop APS could have influenced respondents to report favorably about it. While there is no way to refute this, it may be helpful to consider that pediatrician respondents were not influenced in this way, remaining unwilling to consider prescribing such a system. We leave to the reader how to interpret this when observing that family medicine and internal medicine respondents were so likely to consider prescribing closed-loop APS. Finally, the observational design makes it impossible to evaluate directionality of associations; clinical trials would overcome this.

Future trials should assess outcomes in artificial pancreas system prescription and management by primary care providers compared to endocrinologists. If successful, primary care management of such advanced diabetes technologies would greatly increase access to automated therapies and reduce disparities among those who have a harder time (if able to at all) accessing subspecialty care than they do primary care.

Patient-Friendly Recap

- Primary care providers (PCPs) frequently treat patients with diabetes; however, it is reported that PCPs do not order traditional insulin pumps as frequently as diabetes specialists, aka endocrinologists.
- Newer artificial pancreas systems that automate the dosing of insulin have been shown to safely control blood glucose levels.
- 76 PCPs practicing in 4 geographically different U.S. states completed surveys regarding their comfort level in prescribing automated technologies.
- Most PCPs surveyed reported they would consider ordering artificial pancreas systems for type 1 and type 2 diabetes but were resistant to do so for gestational diabetes or for pediatric patients.

Author Contributions

Study design: O'Donovan, S.M. Oser, Parascando, T.K. Oser. Data acquisition or analysis: O'Donovan, S.M. Oser, Parascando, Berg, T.K. Oser. Manuscript drafting: O'Donovan, S.M. Oser, Parascando, T.K. Oser. Critical revision: O'Donovan, S.M. Oser, Nease, T.K. Oser.

Conflicts of Interest

Tamara Oser has received research support from the National Institute of Diabetes and Digestive and Kidney Diseases, The Leona M. and Harry B. Helmsley Charitable Trust, The Beryl Institute, and Abbott Laboratories, and has served on primary care advisory boards for The Leona M. and Harry B. Helmsley Charitable Trust, the Association of Diabetes Care & Education Specialists, Xeris Pharmaceuticals, MannKind Corporation, and Cecelia Health. Sean Oser has received research support from the National Institute of Diabetes and Digestive and Kidney Diseases, The Leona M. and Harry B. Helmsley Charitable Trust, The Beryl Institute, and Abbott Laboratories, and has served on primary care advisory boards for The Leona M. and Harry B. Helmsley Charitable Trust, Bayer Pharmaceuticals, Xeris Pharmaceuticals, and Cecelia Health. Donald Nease has received research support from the Agency for Healthcare Research and Quality, the National Center for Advancing Translational Sciences, the National Cancer Institute, the Patient-Centered Outcomes Research Institute, and the Colorado Health Foundation, and has served on advisory boards for the Foundation for Psychosomatic and Social Medicine, the Colon Cancer Alliance, and the International Balint Federation

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