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From Wary Wearers to d-Embracers: Personas of Readiness to Use Diabetes Devices

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Abstract

Background: Diabetes devices such as insulin pumps and continuous glucose monitoring (CGM) are associated with improved health and quality of life in adults with type 1 diabetes (T1D). However, uptake remains low. The aim of this study was to develop different "personas" of adults with T1D in relation to readiness to adopt new diabetes technology.

Methods: Participants were 1498 T1D Exchange participants who completed surveys on barriers to uptake, technology attitudes, and other psychosocial variables. HbA1c data was available from the T1D Exchange for 30% of the sample. K-means cluster analyses grouped the sample by device barriers and attitudes. The authors assigned descriptive labels based on cluster characteristics. ANOVAs and chi-square tests assessed group differences by demographic and psychosocial variables (eg, diabetes duration, diabetes distress).

Results: Analyses yielded five distinct personas. The *d-Embracers* (54% of participants) endorsed few barriers to device use and had the highest rates of device use, lowest HbA1c, and were the least distressed. The *Free Rangers* (23%) had the most negative technology attitudes. The *Data Minimalists* (10%) used pumps but had lower CGM use and did not want more diabetes information. The *Wary Wearers* (11%) had lower overall device use, were younger, more distressed, endorsed many barriers, and had higher HbA1c. The *High Distress* (3%) group members were the youngest, had the shortest diabetes duration, reported the most barriers, and were the most distressed.

Conclusion: These clinically meaningful personas of device readiness can inform tailored interventions targeting barriers and psychosocial needs to increase device uptake.

Keywords

continuous glucose monitoring, device uptake, technology attitudes, type 1 diabetes

Diabetes devices are increasingly critical components of type 1 diabetes (T1D) management. Devices such as insulin pumps and continuous glucose monitoring (CGM) have been shown to result in improvements in glycemic control and other encouraging outcomes such as reduced glucose variability and increased time in target range.[1-5] These devices can also improve quality of life for people with T1D as they may provide greater flexibility and decrease or eliminate the need for injections.[6,7] Unfortunately, despite these known benefits, current uptake rates of these critical devices continue to lag, particularly for CGM. As of 2014, around 60% of adults in the T1D Exchange Clinic Network were using insulin pumps, and a lower proportion, 15%, were using CGM.[8] These rates differ somewhat by age group, with young adults having the lowest rates of uptake.[8,9] In addition to reaping benefits from these individual devices, device users are likely more prepared for the next stage in diabetes technology. Artificial pancreas, or closed loop, systems require wearing an insulin pump and CGM. These systems show evidence of the ability to improve key glycemic outcomes;[10-14] one system has already received FDA approval and more are currently being tested. By automating aspects of diabetes management, closed loop systems will be able to

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decrease the user's mental burden and improve quality of life as a result.[15,16] Given these potential benefits, it is important that we prepare more adults with T1D to adopt these systems while recognizing a "one-size-fits-all" approach will not work. One avenue to increasing readiness for more advanced systems is through uptake of each individual component of closed loop.

However, several key barriers—including some that may be addressed through behavioral intervention—may be slowing more widespread device adoption. In our recent survey of 1,503 adults in the T1D Exchange Clinic Network, many reported cost and insurance as major barriers to using insulin pumps and CGMs.[9] However, respondents also commonly endorsed the hassle of wearing devices, and not liking how devices look and feel on their bodies. Other respondents noted feeling nervous that the devices would not work, and not wanting more information about their diabetes.[9] Furthermore, those who had previously used insulin pumps or CGM and stopped using them noted several reasons for discontinuation such as being bothered by alarms, discomfort and pain, and being concerned about inaccuracy.[9] For CGM in particular, 27% of adults who start CGM discontinue use within the first year, compared to 3% for insulin pumps.[17] Examining response patterns reveals that uptake rates, perceived barriers, and attitudes toward technology differ by age group. Young adults expressed less positive attitudes toward diabetes technology, more barriers to using devices, and also higher levels of diabetes distress compared with adults over 25.[9] As behavioral specialists and diabetes care clinicians, we are interested in understanding how to reduce barriers that are modifiable through intervention. Different people will experience different sets of barriers, and therefore it will be necessary to tailor interventions to target the most salient barriers for each individual.

In order to better understand these barriers and the people who endorse them, this project set out to categorize current and potential users of diabetes devices into *personas* based on modifiable characteristics that facilitate or impede uptake of insulin pumps or CGM. The purpose of these personas is to provide insight into each individual's level of readiness to start on a new diabetes device as well as entry points for addressing the main barriers. Identifying personas enables application of a precision medicine framework[18] to individualize interventions to help increase device uptake among those who are likely to benefit from this technology. A tailored approach would provide the appropriate content for each person to work through their individual barriers rather than delivering a standard comprehensive education package to everyone. We developed device readiness personas using K-means cluster analysis, a statistical approach often used in market research to segment the population into groups that may behave or make decisions differently. For example, cluster analysis has been used to identify individuals based on different levels of health risks;[19,20] and patterns of engaging in various health behaviors.[21-23] We expected that, when we clustered individuals based on their attitudes toward diabetes technology and perceived barriers to using the devices, we would see other key differences emerge between the groups such as rates of device uptake and demographic and behavioral characteristics. Developing these personas is the next incremental step toward designing modular intervention tools that can be combined in different ways to individualize approaches to targeting technology attitudes and barriers. These tools may also help facilitate conversations between clinicians and patients regarding starting on diabetes devices and working through key barriers.

Methods

Survey data used in this study were collected via an online survey through the T1D Exchange Clinic Registry. A description of the original sample (n = 1,503), recruitment and measures was published previously.[9] Table 1 summarizes measures used. Five participants were excluded from the present study due to missing data from the diabetes technology attitudes scale that precluded inclusion in cluster analyses. K-means cluster analysis was used to segment adults (n = 1,498) with type 1 diabetes with regard to their attitudes toward diabetes technology and perceived barriers to using insulin pumps and CGM. We clustered based on the following variables: (1) diabetes technology attitudes, (2) nervousness to rely on diabetes technology, (3) not wanting attention from others due to wearing devices, (4) not liking wearing devices on the body and dealing with them every day, and (5) not wanting to have more information about diabetes or learn about a new device. We initially included a sixth barrier variable, cost- and insurance-related barriers to device use, but this variable did not significantly distinguish between personas so we omitted it from clustering analyses. The aforementioned five composite technology attitude and barrier variables were used to create clusters which we then evaluated for validity using demographic, clinical and behavioral variables. In K-means cluster analysis, the similarity measure used is simple Euclidean distance.[24,25]

Our goal was to generate clinically meaningful and interpretable personas, so we chose to examine 3-, 4-, and 5-cluster solutions. For ease of interpretation, all clustering variables were mean-centered prior to analyses. Based on initial interpretability of the three solutions, we selected the 5-cluster solution to examine validity evidence. We selected this solution because it distinguished between subgroups of young adults to offer additional clinical utility. We used ANOVA, chi-square and post hoc tests to assess validity, or differences between personas, based on the following variables: age, HbA1c, current device use, diabetes distress, and worry about hypoglycemia. Given that the personas contained different numbers of participants, ANOVA post hoc testing was done using the Gabriel procedure, and Games-Howell procedure was used with unequal variances.

Table 1. Clustering and Validating Variables.

Clustering variables	Description
Diabetes technology attitudes[9]	5 items on a 5-point Likert scale. Example items: "Diabetes technology has made my life easier"; "Diabetes technology has made managing my health easier"; and "I am lucky to live in a time with so much diabetes technology." Higher scores indicate positive attitudes. Items are summed to create a total score and mean-centered for clustering. Internal consistency was .91.
Barriers to using diabetes devices[9]	Four categories of barriers to using diabetes devices were nervousness to rely on technology (2 items; example: "nervous that the device might not work"); not wanting attention from others (2 items; example: "do not like diabetes devices because people notice them and ask questions about them"); burden of wearing devices on the body (4 items; example: "do not like having devices on my body"); and not wanting more diabetes information (3 items; example: "do not want to have more information about my diabetes). Items are summed within each category and mean-centered for clustering.
Validating variables	
Current device use	A single item asked participants to identify their current device use: CGM and insulin pump together; glucose meter and pump; CGM and injections; or glucose meter and injections.
Age and diabetes duration	From T1D Exchange clinic registry data
Hemoglobin A1c (HbA1c)	From T1D Exchange clinic registry data, which includes HbA1c values available in the medical chart. Values came from laboratory collection at the clinic or through point-of-care testing. Values were included in this study if the HbA1c test date was within 3 months of survey completion. HbA1c data were available in 452 participants.
Diabetes Distress	28-item Diabetes Distress Scale for adults with T1D (DDS-T1).[26] Items are on a 6-point Likert scale. Example items: "feeling like I have to hide my diabetes from other people"; "feeling that I am not as skilled at managing diabetes as I should be." Items are averaged to create a total score. Internal consistency was .94.
Worry about hypoglycemia	18-item Worry subscale from Hypoglycemia Fear Scale (HFS-Worry).[27,28] Items are on a 5-point Likert scale in which the respondent rates how worried they are about each item happening due to low blood sugar. Example items: "passing out in public"; "embarrassing myself or my friends in a social situation." Items are summed to create a total score. Internal consistency was .94.

Significance tests were at the .05 level. Statistical analyses were conducted using SPSS version 23 software (IBM Corporation, Chicago, IL). Meaningful, significant differences between groups on these key variables are interpreted as evidence of validity of differences between the personas. We then developed descriptive names for each device readiness persona. To generate these names, we convened an expert panel of T1D/technology researchers and individuals with T1D to brainstorm ideas based on clustering and validation analyses. We sought additional stakeholder input through meetings with T1D experts to arrive at the persona labels for ease of interpretation.

Results

Selection of the 5-cluster Solution

Figure 1 depicts the overall makeup of each solution. In the 3- and 4-cluster solutions, a large group (67%; 65% of the sample, respectively) had more positive attitudes toward diabetes technology and lower barriers to using diabetes devices on average. Each solution had a smaller group (21-22%) endorsing more negative technology attitudes and elevated barriers regarding unwanted attention, burden of wearing the devices, and feeling nervous to trust them. In the 3-cluster solution, the last group (11%) endorsed significantly higher barriers to diabetes devices regarding not wanting more information about diabetes, and average attitudes toward diabetes technology and other barriers. In the 4-cluster solution, this latter group divided into two groups: one (10%) that specifically did not want more information about diabetes but otherwise had average scores on other variables and a small group (3%) that endorsed the most negative attitudes toward technology and highest endorsement of barrier variables including not wanting attention from others and not wanting more information about diabetes.

The 5-cluster solution introduced additional distinctions; we selected this solution due to its ability to distinguish between groups that endorsed different specific barriers and technology attitudes, which would lend itself to greater interpretability and clinical utility. This solution retained a large proportion expressing more positive technology attitudes and low barriers, as well as a smaller group with negative technology attitudes and lower barriers to using devices. A third group did not want more diabetes information. Two additional groups endorsed high barriers to using devices compared to the other groups, particularly not wanting attention from others and burden of wearing devices; one of these groups was smaller and endorsed the most barriers across the board. Names developed for these groups were d-Embracers, Free Rangers, Data Minimalists, Wary Wearers, and High Distress.

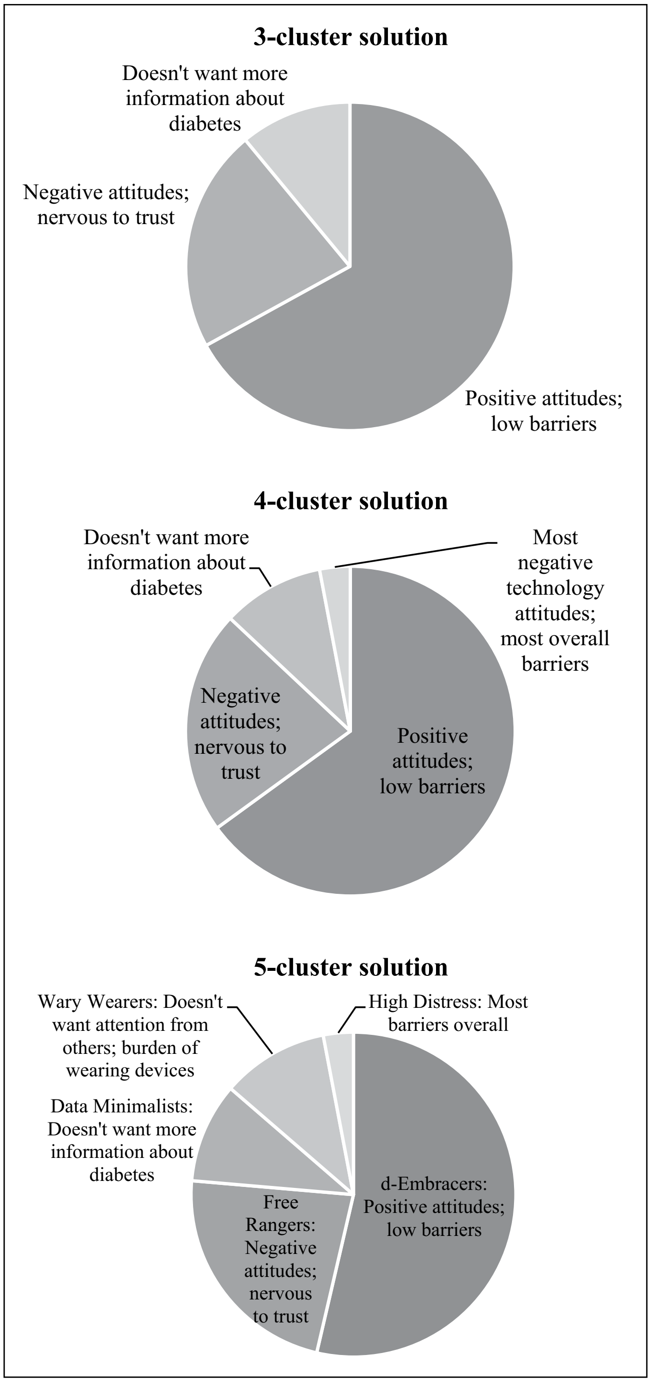

Figure 1. Breakdown of the 3-, 4-, and 5-cluster solutions.

Validation Analyses

Results from ANOVA and chi-square tests are presented in Table 2. We found significant differences between personas by age, $F(4, 1{,}493) = 17.68, p < .001$, HbA1c, $F(4, 444) = 4.24$, $p = .002$, diabetes duration, $F(4, 1{,}375) = 9.48$, $p < .001$, diabetes distress, $F(4, 1{,}493) = 62.8$, $p < .001$, and worry about hypoglycemia, $F(4, 1{,}492) = 25.79$, $p < .001$. Table 3 presents an overview of differences between personas.

Persona Descriptions

d-Embracers (53.8% of Sample). The d-Embracers had the most positive attitudes toward diabetes technology and endorsed few barriers to using devices. They were significantly older than all groups except the Data Minimalists and had the longest duration of diabetes. They also had the lowest HbA1c (post hoc analyses showed that this difference was only significant when compared to the Wary Wearers). They had significantly less diabetes distress than all other groups. They also had the least worry about hypoglycemia, and this difference was significant compared to all other groups except the Data Minimalists. They also had the highest rates of insulin pump (78%) and CGM uptake (47%).

Free Rangers (22.8% of Sample). This persona had the most negative attitudes toward diabetes technology and endorsed nervousness to rely on devices but otherwise endorsed few barriers to using diabetes technology. They were significantly younger and had diabetes for significantly less time than the d-Embracers. Their diabetes distress and worry about hypoglycemia fell in the middle (significantly higher than d-Embracers; significantly lower than Wary Wearers and High Distress). They had lower pump (67%) and CGM (36%) uptake than d-Embracers, but higher uptake than Wary Wearers and High Distress.

Data Minimalists (10% of Sample). This persona had average attitudes toward diabetes technology and endorsed few barriers to using devices with the exception of not wanting more information about diabetes. They were the second oldest group with the second longest duration of diabetes after the d-Embracers. Their glycemic control fell between the d-Embracers and the other personas. They had slightly more distress than the d-Embracers and less distress than all other groups except the Free Rangers. They had less worry about hypoglycemia compared to the Wary Wearers and High Distress groups and were not significantly different from the other two groups. In terms of device uptake, they had comparable levels of insulin pump uptake as the d-Embracers (75%) but lower CGM uptake (30%).

Wary Wearers (10.7% of Sample) and High Distress (3% of Sample). These groups shared some similarities. Together, they represented the youngest group who had diabetes for the shortest duration and had the highest HbA1c. They also had the highest levels of diabetes distress and worry about hypoglycemia compared to all other groups. However, the High Distress group—a small minority of the overall sample—also had significantly more distress and worry than the Wary Wearers. This group was the only group whose mean diabetes distress score exceeded the scale's cutoff for high distress (>3.0). The Wary Wearers' mean score (2.59) fell into the moderate distress range (2.0-2.9). In terms of device uptake, both personas had lower uptake than the other groups, but the

Table 2. Differences Between Groups on Device Use, Age, HbA1c, Diabetes Duration, Diabetes Distress, and Worry About Hypoglycemia.

	d-Embracers (n = 806)	Free Rangers (n = 342)	Data Minimalists (n = 145)	Wary Wearers (n = 160)	High Distress (n = 45)	*P* value
% of total sample	53.8	22.8	10	10.7	3	
Current device use (%)						
CGM+pump	40.2	32.05	29	23	17.78	<.001
Meter+pump	38	34.8	45.5	36.9	24.4	
Meter+injections	15.4	40.6	24.14	33.75	53.3	
CGM only	6.45	4.4	1.38	6.25	4.4	
Pump total	78	67	75	60	42	
CGM total	47	36	30	29	22	
Age	37.74 (15.35)	33.15 (13.23)	36.13 (15.52)	29.48 (12.24)	27.29 (9.66)	<.001
HbA1c	7.32 (1.12)	7.65 (1.5)	7.74 (1.7)	8.08 (1.68)	8.14 (1.12)	.002
Diabetes duration	22.05 (13.47)	18.7 (11.4)	20.81 (10.92)	16.57 (10.31)	16.28 (9.83)	<.001
DDS-T1	1.83 (.63)	2.08 (.74)	2.1 (.7)	2.59 (.88)	3.01 (1.06)	<.001
HFS-Worry	15.29 (12.2)	19.07 (12.98)	17.96 (10.47)	23.11 (14.05)	29.42 (15.19)	<.001

Data are mean (SD) unless otherwise indicated. HbA1c n = 449.

Table 3. Summary of Differences between Device Readiness Personas.

Dimensions	d-Embracers	Free Rangers	Data Minimalists	Wary Wearers	High Distress
Barriers to uptake	Low	Low	High—information	High—all barriers except Information	Highest—all barriers
Diabetes distress	Lowest	Middle	Middle	High	Highest
Tech attitudes	Higher	Lowest	Middle	Middle	Low-middle
Hypoglycemia worry	Lowest	Low	Low	High	Highest
Age and T1D duration	Highest	Middle	Middle	Low	Lowest
HbA1c	Lowest	Middle	Middle	Higher	Higher

High Distress group had the lowest uptake of all groups (Wary Wearers: 60% on pumps and 29% on CGM; High Distress: 42% on pumps and 22% on CGM). Both of these groups had average attitudes toward diabetes technology and were more likely to endorse not wanting to wear devices because of the attention they could draw from other people. The High Distress members, in contrast to the Wary Wearers, also endorsed the most barriers across all other categories compared to all other personas.

Therefore, while High Distress was similar to the Wary Wearers on age, diabetes duration, and HbA1c, they had clinically significant levels of diabetes distress and significantly different levels of device use. While this group may not represent its own persona per se, it appears to indicate a small clinically meaningful subpopulation in need of intensive and comprehensive psychosocial intervention.

Discussion

The main purpose of this study was to identify personas of people with T1D with regard to their attitudes and barriers concerning diabetes devices. We found five personas (which we labeled as the d-Embracers, Free Rangers, Data Minimalists, Wary Wearers, and High Distress). The validity of these personas was supported by the different patterns of demographic, medical, and behavioral characteristics between the groups. For instance, d-Embracers were more likely to use diabetes devices and had lower HbA1c values and less fear of hypoglycemia on average than other groups, as we would expect based on their positive attitudes and minimal perceived barriers regarding these technologies. Cost- and insurance-related barriers, while frequently endorsed in our sample[9] and clearly important barriers that should be considered as top priorities to address for many individuals with T1D, did not significantly distinguish between personas. Therefore, we omitted these variables from the final analyses. Instead, these personas highlight attitudinal differences toward diabetes devices and may provide guidance as to how to approach introducing devices to each persona and what behavioral supports could help encourage technology uptake for those who may benefit from it.

These personas inform future research and clinical practice to increase device readiness. Specifically, people with varying levels of readiness to start on new devices and different barriers may require tailored introductions to devices. Given that some aspect of technology attitudes or barriers to device use distinguished each persona from the others, the personas provide direction for tailoring these discussions.

Because of their interest and openness to new technology, d-Embracers could be introduced to new devices and provided with education whenever updates to technology occur. D-Embracers may appreciate access to self-guided resources for learning about advances that could improve upon their current technology. The Data Minimalists' biggest barrier was not wanting more diabetes-related information in their daily lives. This barrier has been previously described in the literature: Some CGM users report experiencing alarm fatigue, spending too much time interpreting their data, not understanding how to interpret the data, and becoming too aware of their glucose levels, which can be anxiety-provoking for some.[29] Thus, emphasizing the benefits of data may not convince Data Minimalists to adopt CGM. Instead, a brief, CGM-focused intervention to increase problem-solving skills to interpret and respond to CGM data may be useful in demonstrating how to experience benefit from the technology (eg, urgent hypoglycemia alerts) without substantially increasing burden. The Free Rangers tend to view diabetes technology more negatively; therefore, an appropriate starting point may be a patient-centered approach to exploring feelings about technology and openness to learning about diabetes technology options. Simulated experiences, slower device starts, and problem-solving skills for adjusting to new technology may also benefit this group. The Wary Wearers may benefit from the above-mentioned interventions and resources with added tailored interventions for social and physical barriers to device use while also incorporating elements to target diabetes distress and worry about hypoglycemia. Last, the small High Distress group may need the most comprehensive psychosocial intervention with support from a behavioral health professional with diabetes expertise to reduce clinically significant diabetes distress prior to or alongside discussions about new diabetes technology. This work could include teaching problem-solving skills for when challenges with diabetes arise.[30]

Additional research is needed to develop and test tailored interventions with the goal of meeting each individual with T1D where they are at in terms of diabetes management and device readiness. Ideally, these interventions could be embedded in clinical settings and provide clinicians and people with T1D with entry points for conversations about diabetes devices. In the context of this work, it is also important to recognize that these devices come with tradeoffs and hassles as well as benefits and that they may not be appropriate for every individual at every time. Tailored interventions should also present these tradeoffs in a transparent, flexible way that empowers each individual with T1D to make their own device-related decisions.

Limitations

Limitations and additional future directions for research should be noted. First, the sample was primarily Caucasian and participants were all from the United States. In addition, participants were all recruited from the T1D Exchange clinic network registry and opted to be contacted for research studies. Thus, our sample is likely skewed with greater access to care and greater device uptake than the general population (eg, a higher proportion of d-Embracers). To enhance generalizability, future studies should consider additional recruitment approaches, such as recruiting people with T1D who receive their diabetes care from a primary care provider rather than an endocrinology practice. Further, we suspect that the personas will be the same in other samples, but the proportions will be different (eg, much lower proportion of d-Embracers). Second, the cross-sectional study design allowed us to describe differences between the personas regarding medical and behavioral characteristics, but we could not examine whether persona membership predicts these characteristics over time. An interesting direction for future research includes a longitudinal study to examine whether persona membership predicts medical and behavioral outcomes, such as device uptake, sustained use, glycemic outcomes including time in target range and HgA1c, and diabetes distress. Evidence that persona membership predicts these outcomes would provide additional support for tailoring interventions to meet the needs of each group.

Conclusion

In summary, despite the benefits of diabetes devices, adoption is below expectation due to many reported barriers. Apart from cost- and insurance-related factors which were commonly reported barriers among our sample, many barriers can be addressed via behavioral interventions. The personas identified in this study provide a starting point for guiding tailored interventions. Informed by the results of this study, next steps are to develop tools to group people in terms of their device readiness persona and to develop tailored interventions that more effectively address their unique barriers. These interventions may be key to improving device uptake and improving diabetes and quality of life outcomes.

Abbreviations

CGM, continuous glucose monitoring; DDS-T1, Diabetes Distress Scale–Type 1 Diabetes; HbA1c, hemoglobin A1c; HFS-Worry, Hypoglycemia Fear Scale–Worry subscale; T1D, type 1 diabetes.

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Declaration of Conflicting Interests

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