



Patient Perceptions of Satisfaction and Quality of Life Regarding Use of a Novel Insulin Delivery Device

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Advances in insulin delivery technologies have led to the development of tubeless “patch” systems; however, these devices still involve a level of complexity. We surveyed individuals with type 1 or type 2 diabetes to explore their attitudes and satisfaction after using the CeQur Simplicity insulin patch (SIP) for 2 months. Transition to the SIP yielded significant increases in respondents’ overall treatment satisfaction, less diabetes burden, and improvements in psychological well-being compared with respondents’ prior insulin delivery method.

Achieving recommended glycemic targets using intensive insulin therapy is effective in preventing or slowing the progression of microvascular and macrovascular disease (1–3). In type 2 diabetes, early initiation of intensive treatment with continuous subcutaneous insulin infusion (CSII; pump therapy) or multiple daily injection (MDI) insulin therapy has been shown to significantly improve β -cell function and long-term glycemic control (4–7).

Despite the benefits of intensive insulin therapy, there are also many challenges. Many individuals using MDI therapy often skip insulin injections (8–11). Peyrot et al. (12) reported findings from an telephone survey of 1,530 insulin-treated patients in which 33.2% of respondents reported insulin omission or nonadherence at least 1 day during the past month. In an earlier study of 502 adults with type 1 or type 2 diabetes, 57% of respondents reported intentional omission of insulin, with 20% omitting insulin injections regularly (8).

Among the main barriers to MDI adherence are difficulties of insulin administration, pain, fear of needles, stress/emotional problems, lack of discreetness (public embarrassment), and complexity of the regimen (12–18). Importantly, people with type 2 diabetes who take multiple injections are more likely to omit insulin

injections (10), and the risk of lower adherence increases as the number of injections increases (11). In a randomized trial of 48 young people with type 1 diabetes using an insulin pump, Chase et al. (9) reported that four missed bolus doses per week resulted in a 0.92% increase in A1C.

These data strongly indicate a crucial need for insulin regimens that are less burdensome. CSII can mitigate many of these barriers; however, many patients are resistant to insulin pump therapy because of the complexity, size, and visibility of current devices (19). Although advances in insulin delivery technology have led to the development of tubeless “patch pump” devices (e.g., V-Go and Omnipod DASH) that are more discreet and simpler to use than traditional insulin pumps, these devices still involve some complexity, requiring users to enter settings for basal insulin delivery rates, bolus dose calculations, and user interfaces and to carry multiple devices (e.g., smartphone and controller).

The CeQur Simplicity insulin patch (SIP) (CeQur, Greenville, SC) represents a new category of insulin delivery technology that is designed to simplify insulin administration. Unlike traditional insulin pumps and other patch pumps, the SIP delivers insulin via manual administration of mealtime insulin only (Figure 1). The small wearable device (65 × 35 × 8 mm) can be worn on the abdomen for up to 3 days (20). The SIP holds up to 200 units of mealtime insulin and delivers a 2-unit dose via a subcutaneous cannula with each simultaneous click of the two buttons on either side of the device. For example, if a patient requires 10 units of mealtime insulin before a meal, the patient will click the two buttons simultaneously five times to deliver the full dose. We surveyed individuals with type 1 or type 2 diabetes to explore their attitudes about and satisfaction with the SIP compared with their prior insulin delivery method.

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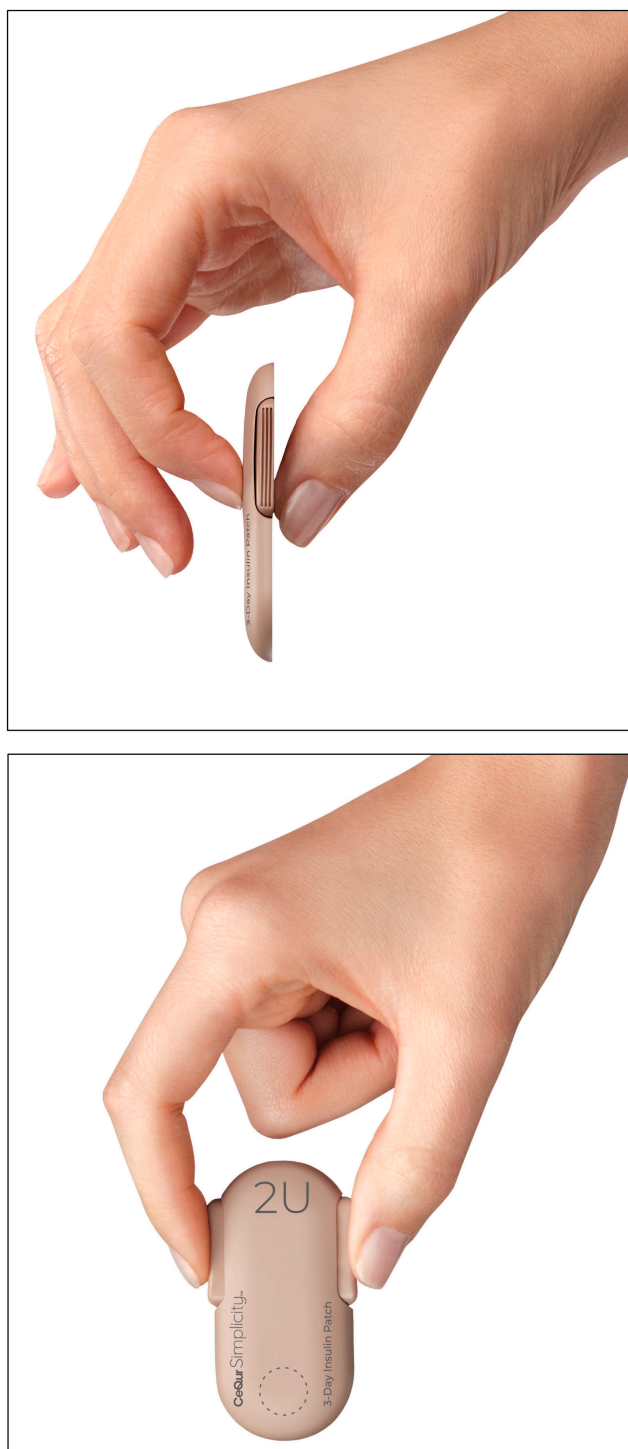


FIGURE 1 CeQur SIP.

Research Design and Methods

Design and Participants

We administered two online surveys using the Insulin Delivery System Rating Questionnaire (IDSRQ) to assess respondents' satisfaction with the SIP compared with their prior insulin delivery method. The first survey assessed

respondents' satisfaction with their previous insulin delivery methods before initiating insulin therapy with the SIP. The second survey was administered after respondents had used the SIP for 2 months. The surveys also included questions about participants' demographic characteristics and diabetes self-care.

All participants were adults with insulin-treated diabetes. Participants were identified by their clinicians, who provided a postcard to patients when SIP therapy was first initiated. Patients who were interested in participating in the survey were asked to complete the postcard and mail it to dQ&A Market Research (San Francisco, CA) to enroll. Eligibility for participation was limited to patients who completed the first survey within 2 weeks of initiating therapy with the SIP. The surveys were conducted from September 2020 to January 2022.

Survey Instrument

The IDSRQ is a validated tool that includes nine subscales focusing primarily on issues specific to respondents' insulin delivery method (21). It includes measures that assess respondents' overall quality of life and issues that are specific to diabetes self-management. The IDSRQ uses 4- and 5-point Likert scales to grade each item. For direct comparisons, we converted the 4-point scales to 5-point scales. Scale scores are computed as the mean of the completed items. For the purpose of this research, we used five different subscales of the IDSRQ: three specifically related to the patient's insulin delivery method (treatment satisfaction, interference with activities, and impact on clinical outcomes) and two with more general questions (diabetes-worry and psychological well-being) (21). The response categories ranged from high to low (Table 1).

Participants were asked to provide information about their insulin bolusing behaviors, as follows:

- In the week before starting on CeQur Simplicity, how many times did you take your rapid-acting (mealtime) insulin later than planned for your meals, snacks, and high glucose corrections?
- In the week before starting on CeQur Simplicity, how many times did you miss taking your rapid-acting insulin for your meals, snacks, and high glucose corrections when you probably should have taken insulin?

Statistical Analysis

All statistical testing of IDSRQ to compare mean values before using the SIP to those after using the SIP was done at the 95% confidence level (t test, $P < 0.05$).

TABLE 1 Survey Instrument

Subscale	Description
Insulin delivery satisfaction	• Response categories: 4 = completely satisfied, 3 = very satisfied, 2 = somewhat satisfied, 1 = not at all satisfied • Subscale points were rescaled such that 5 = completely satisfied and 1 = not at all satisfied to allow for direct comparison with other subscales • Sample items: questions related to ease of use, convenience, perceived pain, and social embarrassment
Interference with activities	• Response categories: 4 = a lot, 3 = some, 2 = a little, 1 = not at all • Subscale points were rescaled such that 5 = a lot and 1 = not at all to allow for direct comparison with other subscales • Sample items: questions related to daily activities such as quality of sleep, flexibility in exercising, and inconveniences when traveling
Impact on clinical outcomes	• Response categories: 5 = excellent, 4 = very good, 3 = good, 2 = fair, 1 = poor • Sample items: include questions related to blood glucose control, weight gain, and avoiding hospitalizations
Diabetes-related worry	• Response categories: 5 = all the time, 4 = frequently, 3 = sometimes, 2 = rarely, 1 = never • Sample items: questions related to getting complications, being home alone, and unpredictable blood glucose
Psychological well-being	• Response categories: 5 = all the time, 4 = frequently, 3 = sometimes, 2 = rarely, 1 = never • The subscale points for Overwhelmed, Stressed, Self-Conscious, and That Diabetes Limits You were rescaled such that 1 = all of the time and 5 = never. This was done to allow for direct comparisons to the other subscales of the IDSRQ.

Results

Study Population

A total of 239 individuals with type 1 or type 2 diabetes were invited to participate in the survey. Responses to the first survey were received from 114 participants. Responses from the 106 participants who completed both surveys are included in this analysis—a 93% response rate. Participants who completed both surveys were mostly older adults (mean age 54.8 years), 63% were ≥ 50 years of age, 61% were female, and 56% were treated with one or more oral medication before starting the SIP. Among these respondents, 60% were taking metformin only, 54% took a sodium–glucose cotransporter 2 inhibitor, 11% took a sulfonylurea, 5% took a dipeptidyl peptidase 4 inhibitor, and 4% took an oral glucagon-like peptide 1 (GLP-1) receptor agonist. In addition, 37% of respondents reported taking an injectable GLP-1 receptor agonist. The large majority (98%) reported using long-acting insulin; however, 21% also reported treatment with premixed insulin. The majority (90%) reported treatment with a rapid-acting insulin; of this group, 46% had been treated with rapid-acting insulin for < 5 years. Of those taking rapid-acting insulin before using the SIP, most (82%) reported using an insulin pen for administering rapid-acting insulin, followed by an insulin pump (14%) and a syringe (9%), and one respondent reported treatment with inhaled insulin.

Among the 83 participants who provided information about the use of continuous glucose monitoring (CGM), 71 (85.5%) were regular CGM users and 5 (6.0%) identified as occasional users in that they used CGM but tended to take long breaks of nonuse. Among all CGM users, 53 (69.7%) reported using the Dexcom G6 (Dexcom, San Diego, CA), 21 (27.6%) reported using one of the FreeStyle Libre devices (Abbott Diabetes Care, Alameda, CA), and one respondent (1.3%) reported using the Medtronic Guardian Connect device (Medtronic, Minneapolis, MN). The majority (75%) of respondents using CGM reported using CGM before initiating therapy with the SIP, 20% started CGM concurrently with initiating SIP therapy, and 5% started CGM after initiating SIP therapy. Demographic characteristics of the respondents are presented in Table 2.

Total Subscale Scores

Respondents reported a significant positive change in each of the five subscales when using the SIP, with significant increases in insulin delivery method satisfaction, clinical outcomes, and psychological well-being compared with their previous insulin delivery method (Table 3). Significant decreases in interference with activities and diabetes-related worry were also reported. Similar findings were reported by respondents who started the SIP before initiating CGM. Similar improvements in total subscale scores were also reported by prior insulin pump users.

TABLE 2 Demographic Characteristics

Characteristics at Baseline	Participants (N = 106)
Sex	
Male	41 (39)
Female	65 (61)
Age, years	54.8
Type of diabetes	
Type 1	27 (25.5)
Type 2	74 (69.8)
Not sure	2 (1.9)
Other	3 (2.8)
Diabetes duration, years	16.8
Diabetes medications	
Metformin	45 (42.4)
Sulfonylurea/meglitinide	7 (6.6)
DPP-4 inhibitor	3 (2.8)
TZD	1 (0.9)
SGLT2 inhibitor	33 (31.1)
Oral GLP-1 receptor agonist	2 (1.9)
Injected GLP-1 receptor agonist	39 (36.8)
Insulin	
Rapid-acting	95 (89.6)
Long-acting	102 (96.2)
Premixed	22 (20.7)
Duration of rapid-acting insulin use, years	
<1	12 (11.3)
1–4	31 (29.2)
5–9	12 (11.3)
10–14	17 (16.0)
15–19	10 (9.4)
≥20	13 (12.2)
Rapid-acting insulin delivery method	
Syringe	9 (8.5)
Pen	78 (73.6)
Pump	13 (12.2)
Inhaler	1 (0.9)

Data are n (%) or mean. DPP-4, dipeptidyl peptidase 4; SGLT2, sodium–glucose cotransporter 2; TZD, thiazolidinedione.

Insulin Delivery Method Satisfaction

Significant increases in insulin delivery method satisfaction were reported for all 12 subscale measures (Table 4).

Interference With Activities

Respondents reported significant reductions in interference with eating (what and when), when exercising, and when traveling. Slight improvements in the other subscale items were also reported but were not statistically significant (Table 5).

TABLE 3 Mean Changes in Total Subscale Scores

Subscale	Before SIP Use	With SIP Use
<i>All respondents (n = 106)</i>		
Insulin delivery method satisfaction*	2.93	4.25†
Interference with activities‡	2.50	1.79†
Clinical outcomes*	2.69	4.07†
Diabetes-related worry‡	2.97	2.06†
Psychological well-being*	3.12	3.72†
<i>Prior CGM use (n = 57)</i>		
Insulin delivery method satisfaction*	2.99	4.29†
Interference with activities‡	2.47	1.56†
Clinical outcomes*	2.83	4.06†
Diabetes-related worry‡	2.93	2.08†
Psychological well-being*	3.19	3.73†

Scoring: minimum 1 to maximum 5. *Higher scores indicate improvement. †All changes from baseline were statistically significant at the 95% confidence level (*t* test, *P* < 0.05). ‡Lower scores indicate improvement.

Impact on Clinical Outcomes

In each of the three subscales for clinical outcomes, the SIP received better ratings than patients' prior insulin delivery method, including for good glucose control, avoiding low glucose without extra snacks, and avoiding low glucose at night (Table 6). A significantly higher percentage of respondents rated the SIP as very good or excellent in improving glycemic control, avoiding hypoglycemia without extra snacks, and avoiding nocturnal hypoglycemia compared with their prior insulin delivery method (Figure 2).

Diabetes-Related Worry

Respondents reported significant reductions in diabetes-related worry overall and in all subscale items with use of the SIP compared with their prior insulin delivery method (Table 7).

Psychological Well-Being

Respondents reported significant improvements overall and in all subscale measures of psychological well-being after 2 months of SIP use (Table 8).

TABLE 4 Mean Changes in Insulin Delivery Method Satisfaction

Item	Before SIP Use	With SIP Use
Total insulin delivery method satisfaction subscales	2.93	4.25*
<i>Subscale items</i>		
How easy it is to take insulin†	3.03	4.65*
How easy it is to learn to use it†	3.90	4.51*
How convenient it is†	2.57	4.39*
How much time it takes†	2.92	4.24*
Embarrassment having it with you†	2.77	4.36*
Embarrassment when using it†	2.75	4.32*
Difficulty in taking all insulin prescribed†	2.78	4.21*
Unsure about getting the amount of insulin intended†	3.17	4.03*
How complicated it is to use†	3.58	4.22*
How painful it is†	2.74	4.14*
How much it costs to use it†	2.57	3.63*
Difficulty in having all of your supplies with you†	2.39	4.27*

Scoring: minimum 1 to maximum 5. *All changes from baseline were statistically significant at the 95% confidence level (t test, $P < 0.05$). †Higher scores indicate improvement.

Overall Satisfaction With Insulin Delivery Method

The majority of respondents (94%) reported that they were completely (56%) or very (39%) satisfied with the SIP after 2 months of use compared with 37% of respondents who reported being completely (5%) or very (27%) satisfied with their prior insulin delivery method. After 2 months of SIP use, 93% of respondents reported that the SIP was “much better” (76%) or “a bit better” (17%) than their prior insulin delivery method.

Adherence to Prescribed Insulin Bolusing

Significant improvements in adherence to insulin bolusing (late and missed boluses for meals, missed boluses for snacks, missed boluses when glucose is elevated) were reported (Table 9). Only slight improvements were seen in late boluses for snacks, and no change was reported in late boluses when glucose is elevated.

Discussion

Despite advances in diabetes technology, a significant proportion of adults with diabetes use insulin pens or

TABLE 5 Mean Changes in Interference With Activities

Item	Before SIP Use	With SIP Use
Total interference with daily activities subscales	2.51	1.79*
<i>Subscale items</i>		
Wearing the clothes you want to†	2.22	1.98
Getting a good night's sleep†	2.02	1.78
Eating when you want†	2.95	1.68*
Eating what you want†	3.02	1.68*
Exercising when you want†	2.18	1.77
Engaging in sexual activities†	1.99	1.82
Taking care of yourself when traveling†	3.12	1.82*

Scoring: minimum 1 to maximum 5. *Changes from baseline were statistically significant at the 95% confidence level (t test, $P < 0.05$). †Lower scores indicate improvement.

needles/syringes for insulin delivery (22,23). Some people simply do not know that there are other options for insulin delivery. This lack of awareness is common among intensive insulin users with type 2 diabetes. Very few of these individuals are offered or use an insulin pump compared with people with type 1 diabetes. Moreover, many individuals use incorrect techniques when injecting insulin (24).

Although insulin delivery via pumps or patch devices eliminates many of the issues associated with insulin injection technique, some individuals treated with intensive insulin therapy may find these delivery methods too complex or intrusive in their daily lives. SIP use was

TABLE 6 Mean Changes in Diabetes Control

Item	Before SIP Use	With SIP Use
Total impact on clinical outcomes subscales	2.69	4.07*
<i>Subscale items</i>		
Getting good blood glucose control†	2.75	4.22*
Avoiding low blood glucose without extra snacks†	2.66	3.99*
Avoiding low blood glucose at night†	2.67	3.99*

Scoring: minimum 1 to maximum 5. *Changes from baseline were statistically significant at the 95% confidence level (t test, $P < 0.05$). †Higher scores indicate improvement.

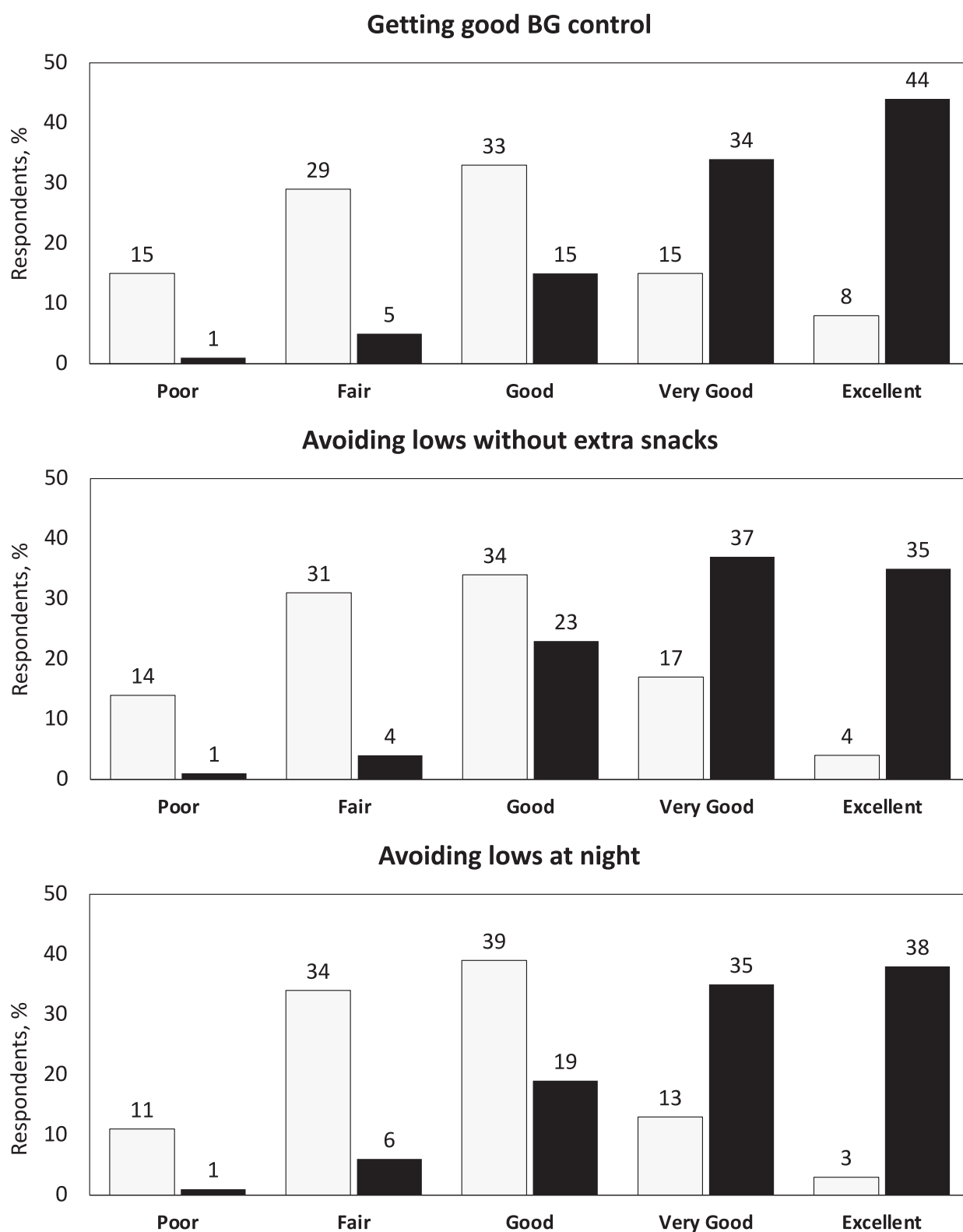


FIGURE 2 Distribution of IDSRQ clinical outcomes subscale scores with prior insulin delivery method and SIP use. BG, blood glucose.

TABLE 7 Mean Changes in Frequency of Worrying

Item	Before SIP Use	With SIP Use
Total diabetes-related worry subscales	2.97	2.06*
<i>Subscale Items</i>		
Getting complications†	2.80	2.00*
High blood glucose†	3.52	2.51*
Low blood glucose†	3.13	2.43*
Unpredictable blood glucose†	3.42	2.34*
Being home alone†	2.20	1.49*
Travel away from home†	2.74	1.57*

Scoring: minimum 1 to maximum 5. *All changes from baseline were statistically significant at the 95% confidence level (t test, $P < 0.05$).

†Lower scores indicate improvement.

designed to address many of these complexities while simplifying insulin administration.

In this quantitative study, we administered two online surveys to 115 adults with insulin-treated diabetes; 106 individuals responded to both surveys. Respondents

TABLE 8 Mean Changes in Psychological Well-Being

Item	Before SIP Use	With SIP Use
Total psychological well-being subscales	3.12	3.72*
<i>Subscale Items</i>		
In a good mood†	3.79	4.18*
In control of your body†	3.34	3.99*
That you can do what you want†	3.48	4.18*
That it is easy to forget about diabetes†	2.66	3.15*
That your life is normal†	3.02	3.72*
Overwhelmed‡	2.91	2.36*
Stressed‡	3.22	2.59*
Self-conscious‡	2.83	2.31*
That diabetes limits you‡	3.22	2.41*

Scoring: minimum 1 to maximum 5. *All changes from baseline were statistically significant at the 95% confidence level (t test, $P < 0.05$).

†Higher scores indicate improvement. ‡Lower scores indicate improvement (e.g., a significant decrease in frequency of the feeling from before SIP delivery method).

TABLE 9 Mean Changes in Insulin Bolusing Adherence

Item	Before SIP Use ($n = 92$)	With SIP Use ($n = 106$)
Late for meals*	4.7	2.9†
Late for snacks*	1.9	1.7
Late when glucose is elevated*	2.8	2.8
Missed for meal*	3.0	1.0†
Missed for snacks*	2.0	0.6†
Missed when glucose is elevated*	1.7	0.8†

*Lower scores indicate improvement. †Changes from baseline were statistically significant at the 95% confidence level (t test, $P < 0.05$).

reported significantly greater overall satisfaction with SIP use for mealtime and correction insulin administration compared with their previous insulin delivery device. After 2 months, respondents felt that using the SIP for mealtime and correction insulin administration was more convenient, less painful, less complex, and more discreet than insulin injections or insulin pump therapy. Our results also showed that SIP use resulted in less diabetes-related worry and improvements in psychological well-being.

Overall, respondents felt less burdened by their diabetes. After using the SIP, patients, on average, indicated that they were in a better mood, felt more in control of their body, could do what they wanted more often, found it easier to forget about their diabetes, and felt that their life was more normal compared with life with their prior insulin delivery method. Respondents also reported feeling less overwhelmed, less stressed, less self-conscious, and less limited by diabetes than when using their prior insulin delivery method. It is notable that participants who had initiated CGM before SIP use reported similar significant improvements in all IDSRQ subscales, suggesting that using the SIP conferred additional benefits independent of CGM.

Diabetes is a condition that requires constant decision-making to keep glucose in range and limit time spent in hypoglycemia and hyperglycemia. This process can contribute to worry, distress, and burnout. The SIP removes some decision-making by making it easier to deliver bolus doses. SIP users do not have to remember to carry extra equipment (e.g., insulin pens or vials and syringes) or decide if it is a convenient time to gather the equipment to deliver an insulin dose. Additionally,

in summer and winter, extreme temperatures can affect insulin stability. People who wear the SIP do not have to worry about where to store their current insulin supplies.

Our findings are consistent with earlier studies that used the IDSRQ to assess changes in treatment satisfaction with the SIP compared with insulin pen therapy (13,25). In a randomized, 48-week crossover study of 278 adults with type 2 diabetes, investigators reported significantly higher patient satisfaction with the SIP compared with insulin pen injections at 24 weeks and a significantly higher preference for the SIP and improvements in quality of life measures at 44 weeks (25). Patients who crossed over from insulin pens preferred the SIP after only 4 weeks of use. Peyrot et al. (13) also reported high levels of satisfaction with and preference for the SIP compared with insulin pens in adults with type 1 or type 2 diabetes.

These findings suggest that using the SIP may have substantial implications for long-term clinical outcomes by addressing many of the barriers to insulin therapy adherence (26,27). Given the respondents' strong preference for the SIP over insulin pens and pumps, use of the SIP may lead to even greater and more persistent treatment adherence. As reported by Barbosa et al. (27), less complex insulin regimens are significantly associated with higher treatment satisfaction, improved adherence, and greater persistence, factors that are, in turn, significantly associated with improved overall diabetes control (28).

Importantly, studies have consistently demonstrated a strong link between suboptimal adherence to prescribed therapy, poor health outcomes, and associated costs (12,29–31). In a retrospective claims database analysis of 23,365 insulin-treated patients (7,508 adherent and 15,857 nonadherent), patients who were adherent to their prescribed basal-bolus insulin regimen had significantly lower adjusted all-cause total costs than nonadherent patients (\$36,603 vs. \$44,702) (32). These results demonstrate both the clinical and economic impacts of optimal adherence to prescribed insulin therapy.

A key strength of the survey was use of the IDSRQ, a reliable, validated instrument that has been used in numerous studies. Another strength was the diversity of our study population in terms of use of concomitant oral and noninsulin injectable medications as well as its inclusion of people who had or had not used CGM.

Moreover, given the relatively short time frame between the first and second surveys (2 months), respondents were more likely to recall their experiences and issues with their previous insulin delivery method than if more time had elapsed between surveys.

However, there are notable limitations, such as an imbalance between sexes within the cohort, with 61% of respondents being female. Additionally, we did not collect information on respondents' race/ethnicity, insurance type, income, or education level. All of these factors limit the generalizability of our findings. We also did not obtain clinical information such as respondents' prior and current A1C values or time in range, which prevented us from determining whether transition to the SIP resulted in any changes in glycemic status. We also could not determine whether transition to the SIP affected respondents' actual adherence to their prescribed regimen in terms of dosing accuracy and glucose monitoring. However, there was perceived improvement among respondents.

Conclusion

Adherence to the prescribed insulin regimen is crucial to achieving optimal glycemic management. Studies have shown that suboptimal adherence is closely linked to depression, diabetes-related distress, low treatment satisfaction, side effects, poor self-efficacy, and the overall burden of daily self-management with insulin therapy (33,34). Findings from our survey showed that transition to the CeQur Simplicity SIP resulted in significant increases in respondents' overall treatment satisfaction, less diabetes burden, and improvement in psychological well-being compared with respondents' prior insulin delivery method.

The SIP offers an additional choice for insulin delivery that may provide benefits compared with other insulin delivery options, especially in its simplicity of use. Further studies are needed to assess glycemic outcomes with the use of the SIP, as well as outcomes in a broader, more diverse population over an extended period of time.

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DUALITY OF INTEREST

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AUTHOR CONTRIBUTIONS

E.S. designed the survey. All authors wrote, edited, and reviewed the manuscript. D.I. 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.

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