Original Article

Journal of Diabetes Science and Technology
1–11

DOI: 10.1177/1932296818823728
journals.sagepub.com/home/dst
SAGE

Acceptance of the Artificial Pancreas: Comparing the Effect of Technology Readiness, Product Characteristics, and Social Influence Between Invited and Self-Selected Respondents

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Abstract

Background: Psychosocial factors that may affect acceptance of artificial pancreas (AP) systems have been investigated in small sample sizes of highly motivated, self-selected persons with type 1 diabetes (T1DM) with a focus on product characteristics. We aimed to develop a valid survey to investigate the association of technology readiness and social influence with AP acceptance in a larger sample, including both self-selected and invited respondents with T1DM.

Methods: An online survey was developed based on established questionnaires. Intention to use the AP was chosen as measure of AP acceptance. T1DM patients who signed up themselves for scientific research into AP systems represented the self-selected group, while patients treated at a teaching hospital represented the invited group. Questionnaire values were compared using independent *t*-tests and regression analyses.

Results: The developed survey showed reliability and validity. The survey was completed by 425 self-selected and 109 invited persons. Intention to use the AP was high in both groups, but was significantly higher among self-selected respondents. In both groups, intention to use the AP was most strongly related to product compatibility, followed by product complexity, technology readiness, and product usefulness among invited respondents; and followed by product usefulness and technology innovativeness among self-selected respondents.

Conclusions: Product characteristics have a stronger relationship with AP acceptance than technology readiness, while social influence does not seem to be associated with AP acceptance. As the (strength of) factors differ between self-selected and invited persons, researchers and product developers should be cautious when relying on self-selected persons with T1DM in the design, development, and testing of AP systems.

Keywords

acceptance, artificial pancreas, invited and self-selected respondents, psychosocial factors, questionnaire development

The development of artificial pancreas (AP) systems for patients with type 1 diabetes mellitus (T1DM) has progressed substantially over the last decade. AP systems from various research groups have undergone successful testing and the first hybrid-closed loop system has entered the US market.[1,2] Nevertheless, the central role of psychosocial factors tends to be underestimated[3] with the current technological advances in diabetes management. The decision to adopt a new technology is rarely based solely on objective clinical benefits, for example, glycemic, safety, and technical performance metrics.[4] Failure to consider psychosocial factors when AP systems are designed may reduce their eventual acceptance.[5-7] Indeed,

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research has shown that these factors were prominent reasons for reluctance to accept continuous subcutaneous insulin infusion (CSII) therapy[8] and continuous glucose monitoring (CGM).[9] Therefore, it is important to create an understanding of the psychosocial factors that are related to successful technology acceptance.[10-12]

Previous research into psychosocial factors has given relevant insights into the overall likelihood of AP systems' future acceptance.[10,13-17] In addition, it has identified two potential determinants of AP acceptance: product characteristics (ie, ease of use and usefulness)[6,10,13,15,16,18,19] and treatment satisfaction.[10,13] Bevier et al[10] have statistically examined the relationship between AP system acceptance and its determinants. They found that ease of use and usefulness positively affect AP system acceptance, while diabetes treatment satisfaction had no effect. Despite this invaluable understanding, the literature into CGM and CSII therapy success suggests two other unexplored factors that may affect the likelihood of AP systems' future acceptance. First, there is limited attention for the social environment's influence on the decision to use an AP, although perceived social support has been identified as a predictor of CGM[20] and CSII therapy success.[21] Second, little research has considered individuals' attitudes, that is, technology readiness, that are associated with AP acceptance. Technology readiness refers to "people's propensity to embrace and use new technologies for accomplishing goals in home life and at work."[22] Yet it has been shown that patient attitudes are positive or negative prognostic indictors for CSII therapy.[21,23,24] Therefore, our study's first aim was to investigate the relative strength of product characteristics, technology readiness and social influence's relationships with AP system acceptance.

In addition, research into the psychosocial factors that affect AP systems' acceptance is still in its infancy and shows two methodological shortcomings: (1) lack of a robust and standardized questionnaire,[10] and (2) small sample sizes of highly motivated, self-selected and well-controlled persons with T1DM.[5,6,10,13,14] First, measures that adequately capture the factors that play a role in AP systems' acceptance are necessary to allow regulatory authorities and paying stakeholders to consider these aspects in their decision-making process.[9,17] Second, a larger sample of subjects who are not self-selected will be more representative of the general T1DM population and, therefore, provide a more generalizable perspective on AP system reception.[10] Moreover, it can be expected that invited persons may not accept certain products for the very reasons that self-selected adopt them.[25] To address these limitations, the study's second aim was to develop a reliable and valid questionnaire based on existing validated questionnaire items grounded in established theories and use it to addresses our first aim, comparing self-selected and invited respondents with T1DM.

Methods

Subjects

In June 2014, 601 persons with type 1 diabetes were invited to respond to the survey. This was a convenience sample from >3000 persons who had indicated their wish to participate in scientific research into the AP on Inreda Diabetic BV's (Goor, The Netherlands) website. As the selected persons signed up for scientific research themselves, they represent the self-selected group. In October 2015, 270 persons with type 1 diabetes under treatment at the Rijnstate Hospital (Arnhem, The Netherlands) were invited to respond to the survey. All persons listed as using CSII therapy in the hospital were selected because the needed data, such as contact details, were not readily available for persons with other therapies. As the selected persons from the Rijnstate Hospital did not sign up for scientific research, they represent the invited group. We checked whether the respondents in the invited group had not previously volunteered at Inreda's website and twelve respondents were found to have done so. Their responses were included in the self-selected group.

Survey

A questionnaire was developed to measure AP system acceptance, technology readiness, product characteristics and social influence among persons with T1DM. It contains two items about the *intention to use* an AP system. The Technology Acceptance Model (TAM)[26-28] showed that intention to use has high predictive validity because it is the key indicator of whether a user will accept or reject a new system. In addition, the survey contains 38 items about the (1) technology readiness of the person with T1DM (*optimism, innovativeness, discomfort*, and *insecurity*), (2) perceived product characteristics (*usefulness, complexity*, and *compatibility*), and (3) influence of the social environment (*social influence*). Table 1 lists the variables' definitions, the items' sources, and the associated *multi-item scales* assessed on a 7-point Likert-type scale (1 to 7). To ensure concurrent and content validity as well as scale reliability,[17] the items were based on existing questions (see references in Table 1) used in the Technology Readiness Index (TRI), the TAM, Innovation Diffusion Theory (IDT), and the Theory of Planned Behavior (TRB). These theoretical frameworks were chosen because they explain the critical processes involved in new technology acceptance.[3] To fit the study's purpose, the questions were slightly adapted and translated to Dutch. The questions were thoroughly assessed through a team of scholars, practitioners, and students prior to sending the questionnaire to the respondents to examine face validity. Minor changes to the questions' phrasing were made to clarify ambiguities and avoid unusual word usage. In addition, the questionnaire collected information about the respondents' demographics, current diabetes treatment, and

Table 1. Key Variables, Its Definitions, Questionnaire Items and Cronbach's α.

Variable	Questionnaire items	Cronbach's α
Technology readiness		
Optimism[22]	Technology gives people more control over their daily lives	.866
A positive view of technology and a belief that offers people increased control, flexibility, and efficiency	Products and services that use the newest technologies are much more convenient to use	
	You prefer to use the most advanced technology available	
	Technology makes you more efficient in your occupation	
	Technology gives you more freedom of mobility	
	You feel confident that machines will follow through with what you instructed them to do	
Innovativeness[22]	Other people come to you for advice on new technologies	.886
A tendency to be a technology pioneer and thought leader	In general, you are among the first in your circle of friends to acquire new technology when it appears	
	You can usually figure out new high-tech products and services without help from others	
	You keep up with the latest technological developments in your areas of interest	
	You find you have fewer problems than other people in making technology work for you	
Discomfort[22]	Technical support lines are not helpful because they do not explain things in terms you understand	.792
A perceived lack of control over technology and a feeling of being overwhelmed by it	Sometimes, you think that technology systems are not designed for use by ordinary people	
	There is no such thing as a manual for a high-tech product or service that is written in plain language	
	If you buy a high-tech product or service, you prefer to have the basic model over one with a lot of extra features	
	There should be caution in replacing important people-tasks with technology because new technology can breakdown or get disconnected[a]	
Insecurity[22]	Many new technologies have health or safety risks that are not discovered until after people used them[b]	.814
Distrust of technology and skepticism about its ability to work properly	Technology always seems to fail at the worst possible time[b]	
	Critics lead people to believe that revolutionary new technologies are less safe than they usually are	
	A machine or computer is going to be less reliable in doing a task than a person	
	It can be risky to switch to a revolutionary new technology too quickly	
	If you buy products that are too high-tech, you may get stuck without replacement parts or service	
	Technological innovations always seem to hurt a lot of people by making their skills obsolete	
Product characteristics		
Perceived usefulness[26,27,30,31]	I expect that using the artificial pancreas improves my performance in daily life	.906
The degree to which a person believes that using a system would enhance his or her performance	I expect that using the artificial pancreas in my daily life increases my productivity	
	I expect that using the artificial pancreas enhances my effectiveness in daily life	
	I expect that the artificial pancreas will be useful in my daily life	
	I expect that using the artificial pancreas would enable me to accomplish tasks more quickly	
	I expect that using the artificial pancreas would make it easier to do my job	
Complexity[30,32]	I expect that using the artificial pancreas takes too much time from my normal duties	.854
The degree to which a person believes that using a system would be free of effort	I expect that working with the artificial pancreas is so complicated, it is difficult to understand what is going on	
	I expect that using the artificial pancreas involves too much time doing mechanical operations	
	I expect that it takes too long to learn how to use the artificial pancreas to make it worth the effort	

(continued)

Table 1. (continued)

Variable	Questionnaire items	Cronbach's α
Compatibility[30,33]	I think that using the artificial pancreas fits well with the way I like to live and work	.893
The degree to which a system is perceived as being consistent with existing values, needs, and past experiences	I expect that using the artificial pancreas is compatible with all aspects of my life, including work as well as free time activities	
	I expect that using the artificial pancreas fits into the way I perform my daily duties	
Social influence		
Social influence[27,28,30]	People who influence my behavior think that I should use the artificial pancreas	.819
The person's perception that most people who are important to him/her think he/she should use a system	People who are important to me think that I should use the artificial pancreas	
Acceptance		
Intention to use[28]	Assuming I have access to an artificial pancreas, I intend to use it.	.895
The intention of a person to use a system in practice	Assuming I have access to the system, I predict that I would use it	

[a]This item was removed from final analysis.
[b]These items loaded originally on the discomfort scale.

satisfaction with the current treatment. The latter was measured with the Diabetes Treatment Satisfaction Questionnaire (DTSQ).[29]

A principal component analysis (PCA) with direct oblimin rotation was run to test for construct validity. This was performed to confirm whether the 38 items belonging to the independent variables measured the same underlying variables as proposed by the theories. PCA suitability was assessed prior to the analysis (ie, Kaiser-Meyer-Olkin = .91; Bartlett's test of sphericity, $\chi^2[666] = 11556.42$, $P < .001$). The analysis revealed eight components with eigenvalues over one, and these combined explained 67.38% of the variance. The components represented the expected eight independent variables. However, the item "there should be caution in replacing important people-tasks with technology because new technology can breakdown or get disconnected" had to be removed from the analysis because it did not have item-to-item correlations above .3. Moreover, the items "many new technologies have health or safety risks that are not discovered until after people used them" and "technology always seems to fail at the worst possible time" loaded on insecurity rather than the discomfort variable. Therefore, the item set to measure these two variables was changed accordingly. The PCA's details and a table with factors loadings are available on request from the authors. In addition, Table 1 shows that the Cronbach's α was above .79 for all variables, reflecting a reliable scale with high internal consistency.

Data Collection

Before respondents were recruited, the questionnaire was submitted to the medical ethics committee Twente (Enschede, The Netherlands). They waived the need for a full ethical assessment because simple questions were used and the burden on the respondents was judged to be small. The self-selected persons with T1DM were invited to participate via email. The email contained a short explanation of the study's purpose and a link to complete the online questionnaire. The invited participants were sent a letter containing information about the study's purpose and an invitation to participate. They could send an email to the researcher to confirm their participation and received a link to access the online questionnaire. Prior to filling in the questionnaire on LimeSurvey—an open source survey tool—the introduction described how Inreda Diabetic's AP system[34] functions. Moreover, they were presented with two pictures to show how the system looks and how someone might wear it (see Figure 1).

Statistical Methods

The statistical analysis was performed using SPSS (version 22; IBM Corp, Armonk, NY, USA). The observed values of each variable were calculated by summing the items and dividing them by the number of items. The variables were calculated per patient and summarized by mean (standard deviation [SD]). There was no missing data because associated items were mandatory and only fully completed questionnaires were included in the analysis. To test for differences between invited and self-selected respondents an independent *t*-test was used for continuous variables and a Pearson's chi-square was used for categorical variables. The relationship between the independent variables (Table 1: from optimism until social influence) and the dependent variable (Table 1: intention to use) was tested using multiple, hierarchical linear regression. To correct for oversampling of self-selected respondents, an adjustment weight to each survey respondent was assigned. Using sampling weights reduced the impact of each self-selected respondent, making the sample more representative of the population.

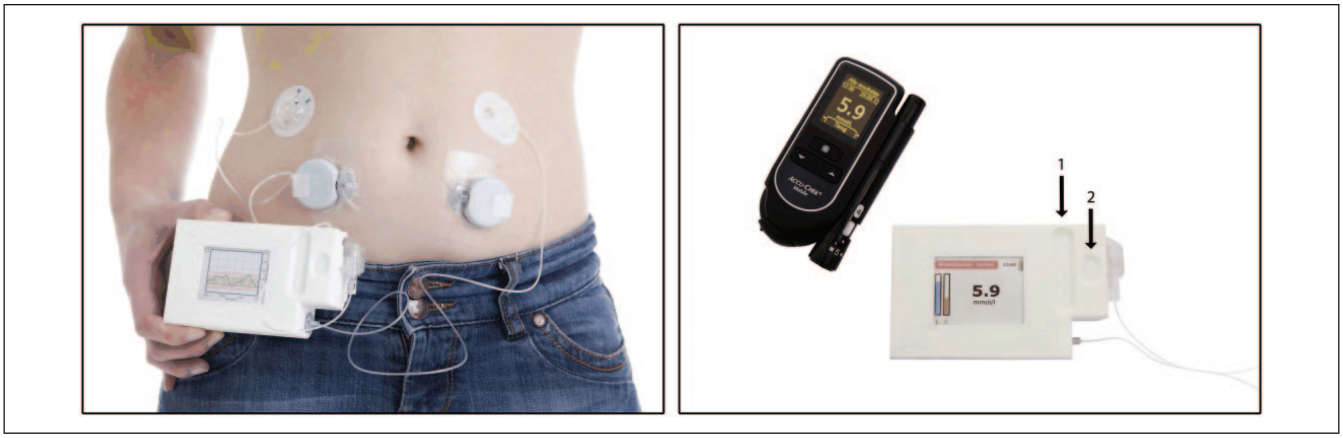

Figure 1. Pictures shown in the introduction to the survey.

Yet they could also increase a statistical analysis' sampling variance, standard deviation and standard errors. This was not a major concern because our sample is sufficiently large. In addition, a Chow test was performed to test whether the coefficients in the regression model were different between the self-selected and invited group. Furthermore, interaction variables were created to assess whether the effect size estimates between the subgroups were significantly different. Furthermore, six covariates—age, gender, educational level, treatment method, diabetes duration, and diabetes treatment satisfaction—were included in the regression analysis. Two-tailed values of $P \leq .05$ were considered statistically significant.

Table 2. Age and Diabetes Duration Among the Invited and Self-Selected Respondents.

	Self-selected respondents		Invited respondents		*P* value[a]
Age	39.1	(16.0)	45.8	(13.5)	<.001
Diabetes duration	18.1	(13.9)	21.6	(11.0)	.006
Treatment satisfaction	29.8	(5.74)	33.3	(4.03)	<.001
Perceived hyperglycemia	5.0	(1.46)	4.5	(1.74)	.025
Perceived hypoglycemia	4.3	(1.64)	4.1	(1.51)	.219

Data are mean (SD). n = 425 self-selected respondents, n = 109 invited respondents. [a]Independent *t*-tests, two-tailed.

Results

Sample Characteristics

The survey was completed by 425 self-selected persons (response rate: 69.7%) and 109 invited persons (response rate: 42.2%) with T1DM. It was impossible to identify the main reasons why people refused to participate in a separate study or obtain this information from other sources. Therefore, we estimated nonresponse bias by comparing the 25% early respondents to the 25% late respondents (as proxy for nonresponses)[35] on age, diabetes duration, treatment satisfaction, perceived hyperglycemia and hypoglycemia, gender, education, and treatment method. No significant differences were found between early and late respondents, indicating that nonresponse bias is not a concern in our study. Table 2 and 3 describe the invited and self-selected respondents' sample characteristics.

Mean Comparison Between Self-Selected and Invited Respondents

Table 4 shows that self-selected and invited respondents had a high intention to use the AP system once it would become available. However, this intention to use was significantly higher among self-selected respondents than among invited respondents. In addition, the mean values show that the technology readiness among both respondent groups was relatively high: the means for optimism and innovativeness were high, while the means for discomfort and insecurity were low. On average, invited respondents had a less optimistic and innovative attitude toward new technology than self-selected respondents. Furthermore, self-selected and invited respondents perceived that the AP would be useful, compatible, and easy to use on a scale of 1 to 7. Invited respondents perceived the AP to be less useful and compatible than self-selected respondents. Last, the extent to which the respondent groups were influenced by their social environment was moderate.

Linear Regression

In the appendix, we present the correlations among all variables for the complete sample as well as each respondent group separately. A multiple hierarchical regression for each respondent group was run. The Chow test, $F(9,631) = 3.241$, $P = .001$, confirmed that separate analysis of these two groups was suitable: the regression coefficients for the self-selected and invited respondents were significantly different.

Table 3. Treatment Method, Gender, and Educational Level Among the Invited and Self-Selected Respondents.

		Self-selected		Invited		
Variable	Category	#	%	#	%	*P* value[a]
Gender	Female	237	55.8	64	58.7	.590
	Male	188	44.2	45	41.3	
Education	Primary education	24	5.6	3	2.8	.124
	Secondary education	96	22.6	17	15.6	
	Secondary vocational education	118	27.8	42	38.5	
	Higher vocational education	140	32.9	33	30.3	
	University or higher education	47	11.1	14	12.8	
Treatment	MDI	162	38.8	9	8.6	<.001
	CSII	198	47.5	87	82.9	
	CSII + CGM	57	13.7	9	8.6	

[a]Pearson's chi-square test, two-tailed.

Table 4. Mean (SD) of Key Variables Among the Invited and Self-Selected Respondents.

	Self-selected respondents		Invited respondents		*P* value[a]
Optimism	5.90	(0.86)	5.61	(1.00)	.007
Innovativeness	4.99	(1.24)	4.66	(1.40)	.025
Discomfort	2.97	(1.21)	2.86	(1.16)	.397
Insecurity	3.13	(0.97)	3.18	(0.89)	.671
Usefulness	6.06	(0.84)	5.66	(1.04)	<.001
Compatibility	6.21	(0.85)	5.88	(1.14)	.006
Complexity	2.13	(1.04)	2.31	(1.06)	.129
Social influence	4.95	(1.66)	4.66	(1.65)	.105
Intention to use	6.49	(0.82)	6.10	(0.99)	<.001

n = 425 self-selected respondents, n = 109 invited respondents. Scale = 1 to 7.
[a]Independent *t*-tests, two-tailed.

The regression results can be found in Table 5 and are illustrated in Figure 2. First, the figure shows that optimism was negatively and significantly related to the intention to use the AP among the invited respondents. Nevertheless, the interaction effects show that the estimated effect size was not significantly different. Second, Figure 2 shows that innovativeness was positively and significantly related to the intention to use the AP among invited and self-selected respondents. Third, the interaction effects show that the estimated effect size of discomfort was significantly different in the two respondent groups. This effect was, however, almost negligible and insignificant in both groups. Fourth, insecurity was positively and significantly related to the intention to use the AP in the invited respondent group. Fifth, Figure 2 shows that perceived usefulness and compatibility were positively and significantly related to the intention to use the AP in both respondent groups. Sixth, perceived complexity had a significant negative association with the intention to use the AP among invited respondents. The interaction effects confirm that the estimated effect size was significantly different in the two respondent groups. Last, social influence's relationship with intention to use was negligible and insignificant in both respondent groups.

Regarding the variables' importance, Figure 2 reveals that product characteristics were generally more strongly related to intention to use than technology readiness and social influence.

Discussion

This study's first aim was to investigate the relative strength of technology readiness, product characteristics and social influence's relationships with AP system acceptance among self-selected and invited respondents with T1DM. The results show that product characteristics are generally more strongly related to AP system acceptance than technology readiness. Furthermore, the results show that social influence does not seem to be associated with AP system acceptance in both groups. This stresses the importance of studying product characteristics in AP system acceptance research identified in previous literature.[6,10,13,15,16,18,19] Moreover, it contributes to this literature by providing insight into two additional factors: technology readiness and social influence.

AP system acceptance was most strongly correlated with product compatibility in both groups. Among invited respondents, this was followed by (1) complexity, optimism, innovativeness, product usefulness, and insecurity; and among self-selected respondents by (2) product usefulness and innovativeness. The reason that fewer variables are related with intention to use among self-selected respondents than among the invited ones may be that self-selected persons with T1DM have a more positive approach toward new technology in general and the artificial pancreas in specific than invited persons. They are shown to have a more optimistic and innovative attitude toward new

Table 5. Multiple, Hierarchical Regression With Intention to Use as Dependent Variable, the Covariates, the Independent Variables, and Their Interactions With Self-Selection.

	Model 1				Model 2				Model 3			
	B	SE	β	*P* value[a]	B	SE	β	*P* value[a]	B	SE	β	*P* value[a]
(Constant)	6.18	0.40			2.55	0.42			2.70	0.43		
Age	0.00	0.00	0.04	.218	0.00	0.00	0.04	.176	0.00	0.00	0.04	.149
Diabetes duration	0.00	0.00	−0.03	.267	0.00	0.00	−0.01	.439	0.00	0.00	0.00	.471
Diabetes treatment satisfaction	−0.02	0.01	−0.09	.039	−0.01	0.01	−0.05	.088	−0.01	0.01	−0.04	.133
Perceived hyperglycemia	0.08	0.03	0.14	.001	0.07	0.02	0.12	.000	0.06	0.02	0.11	.000
Perceived hypoglycemia	0.00	0.03	0.00	.494	−0.04	0.02	−0.07	.020	−0.04	0.02	−0.06	.022
Gender	0.12	0.08	0.06	.076	0.05	0.06	0.03	.188	0.06	0.06	0.03	.179
Education	−0.05	0.04	−0.05	.105	−0.01	0.03	−0.02	.303	−0.02	0.03	−0.02	.229
MDI	−0.19	0.11	−0.08	.043	−0.17	0.08	−0.08	.015	−0.19	0.08	−0.08	.008
CSII + CGM	0.13	0.13	0.04	.161	0.02	0.10	0.01	.423	0.00	0.10	0.00	.498
Self-selection	0.36	0.09	0.19	.000	0.17	0.06	0.09	.004	−0.04	0.25	−0.02	.434
Optimism					−0.09	0.04	−0.09	.008	−0.14	0.05	−0.14	.002
Innovativeness					0.10	0.03	0.14	.000	0.13	0.03	0.18	.000
Discomfort					−0.02	0.03	−0.02	.308	0.06	0.05	0.07	.119
Insecurity					0.06	0.04	0.06	.052	0.09	0.05	0.09	.040
Usefulness					0.11	0.04	0.12	.002	0.07	0.05	0.08	.066
Compatibility					0.50	0.04	0.55	.000	0.52	0.04	0.57	.000
Complexity					−0.09	0.04	−0.10	.006	−0.19	0.05	−0.22	.000
Social influence					0.02	0.02	0.04	.132	0.02	0.03	0.04	.220
Optimism × Self-selection									0.11	0.07	0.35	.073
Innovativeness × Self-selection									−0.06	0.05	−0.16	.129
Discomfort × Self-selection									−0.12	0.06	−0.22	.025
Insecurity × Self-selection									−0.08	0.07	−0.15	.127
Usefulness × Self-selection									0.11	0.08	0.36	.083
Compatibility × Self-selection									−0.10	0.07	−0.35	.086
Complexity × Self-selection									0.19	0.07	0.26	.003
Social influence × Self-selection									0.01	0.04	0.03	.382
R^2				.089				.554				.567

N = 533. Self-selection: invited respondents = 0, self-selected respondents = 1. Sampling weights of 2.45 (invited respondents) and 0.63 (self-selected respondents) were applied. [a]One-tailed *P* value.

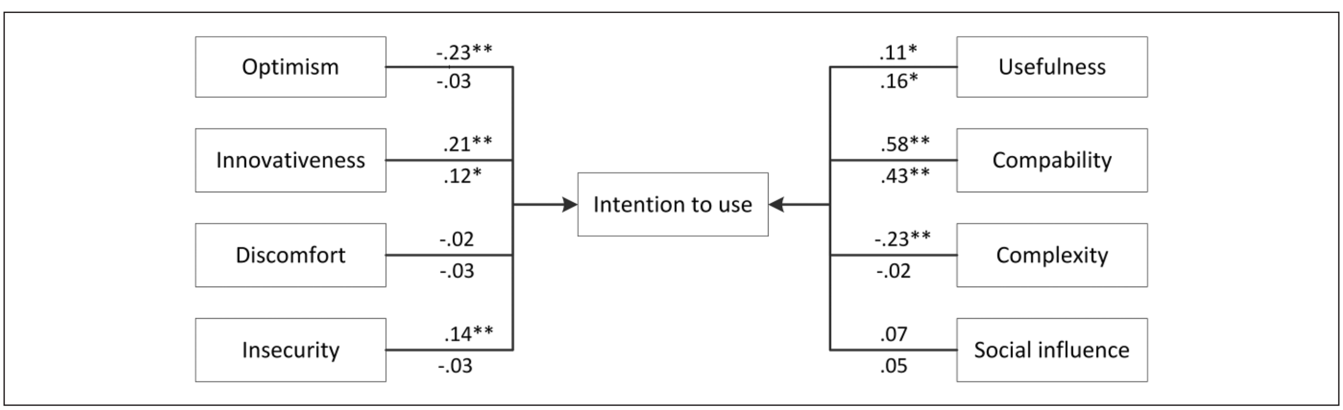

Figure 2. Multiple regression with intention to use as dependent variable for invited (above the line) and self-selected (below the line) respondents separately (regression tables including the covariates are available on request of the authors). As the data represent standardized β from the separate respondent groups rather than the complete sample, they can deviate slightly from Table 5. **P* < .05. ***P* < .001. Invited respondents: n = 267, self-selected respondents: n = 266, sampling weights of 2.45 (invited respondents) and 0.63 (self-selected respondents) were applied. Invited respondents: R^2 = .670; self-selected respondents: R^2 = .423.

technology, perceive the AP system to be more useful and compatible, and have a higher intention to use it than invited respondents. Another reason may be that the studied variables are a better explanation of intention to use among invited respondents than self-selected respondents. The combined variables explain 67% of the variance in intention to use among invited respondents, while only 42% of its variance is explained among self-selected respondents. This implies that there are probably other variables that relate to the intention to use an AP system, especially among self-selected respondents. Therefore, we argue that future research should explore which other psychosocial factors, for example, self-efficacy and emotional distress,[36] affect AP system acceptance among self-selected respondents.

Unexpectedly, the AP system's perceived complexity was not associated with AP acceptance among self-selected respondents. A reason for this finding might be that in comparison to invited persons, self-selected persons probably put more effort into searching for information about new diabetes treatments. If an AP system can alleviate their disease burden and fits with their daily life, they will be motivated to put in the effort to learn how a new system works.

Concerning technology readiness, an unoptimistic attitude, and an insecure feeling toward new technology increased with the intention to use the AP system, but only among invited respondents. This contradicts contemporary literature which predicts a positive effect of optimism and a negative effect of insecurity.[22] Further analysis showed that the inclusion of compatibility and complexity suppressed the association of optimism and insecurity with intention to use. Before compatibility and complexity were included in the analysis, they had the expected relationship with intention to use. Yet the effects' direction was reversed once they were included. This might be because unoptimistic people with an insecure feeling may especially be encouraged to use an AP system because of its promise to decrease the burden of the technical actions they need to do themselves; the device does the work. Thus, unoptimistic and insecure people may consider an AP system as more compatible and less complex than optimistic and secure people. In turn, they may be more inclined to use an AP system. Previous research[22] also has shown that the attitude toward new technology may influence the perception of the product characteristics. Therefore, it may be worthwhile to investigate how technology readiness influences the perceived complexity and compatibility of AP systems by persons with T1DM, and in turn their intention to use it.

The results show that the social environment of respondents with T1DM was unrelated with the intention to use the AP system. This confirms previous research,[15] which found that the patients make the ultimate decision to use an AP system themselves, although they might consult people in their social environment.

To achieve this study's second aim, a questionnaire to measure AP system acceptance and potentially explanatory factors among persons with T1DM was developed. The developed questionnaire consists of 39 preexisting items grounded in well-established theories. The results show that this questionnaire is valid and reliable. Therefore, the questionnaire can assist researchers and product developers who want to evaluate the perceptions of persons with T1DM regarding their intention to use AP systems meaningfully and accurately.

A limitation of this study is that the invited respondent group appeared to be less representative of the general T1DM population because they consisted of persons with CSII treatment for the most part. The respondent groups also showed differences in terms of age, diabetes duration and treatment satisfaction. To protect against the cofounding of these variables with the observed associations, we included these variables as covariates in the regression analysis. Additional analysis showed that this did not change the relationships between the variables of interest and the intention to use an AP system. Furthermore, the questionnaire was used to measure Inreda Diabetic's AP system's acceptance. Thus, the conclusions drawn here may not be generalized to other AP systems. However, the questionnaire was designed in such a way that it can measure the acceptance of any AP system.

Conclusion

This study contributes to the current literature about AP systems' acceptance by persons with T1DM through (1) the development of a valid and reliable questionnaire based on existing scales grounded in well-established theories to meaningfully and adequately capture the factors that play a role in AP systems' acceptance; (2) the inclusion of a large sample of invited and self-selected respondents to assess resemblances and differences in AP systems' acceptance and potentially relating factors among these groups; and (3) assessment of technology readiness and social influence beside the widely researched relationship of product characteristics with the intention to use an AP system.

We encourage other researchers—who want to evaluate the perceptions of persons with T1DM regarding their intention to use their AP systems—to use the questionnaire developed for this study. As AP system acceptance and its relationship with technology readiness and product characteristics differs between self-selected and invited persons with T1DM, it is recommended that researchers and product developers should not only involve self-selected persons in AP systems' design, development, and testing. They should also include invited persons to avoid that their needs remain unrecognized and are therefore not adequately addressed as an AP system is developed.

Appendix

Correlation Tables.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Age	1.00																		
2	Diabetes duration	.49	1.00																	
3	Diabetes treatment satisfaction	.12	.11	1.00																
4	Perceived hyperglycemia	−.06	−.15	−.34	1.00															
5	Perceived hypoglycemia	.07	.05	−.15	.25	1.00														
6	Gender	.14	.04	.03	−.06	.05	1.00													
7	Education	.07	−.01	.07	−.03	−.03	.08	1.00												
8	MDI	.00	−.12	−.38	.10	−.01	.10	−.11	1.00											
9	CSII + CGM	−.02	.02	.00	.07	.19	−.10	.17	−.19	1.00										
10	Self-selection	−.22	−.14	−.33	.13	.06	.03	−.07	.35	.08	1.00									
11	Optimism	.12	.04	.02	.00	.02	.19	−.05	.12	−.07	.15	1.00								
12	Innovativeness	−.05	−.01	−.01	.00	.03	.28	.05	.05	−.02	.13	.48	1.00							
13	Discomfort	.27	.14	.00	−.01	.00	−.04	−.19	.10	−.09	.05	−.14	−.31	1.00						
14	Insecurity	−.05	.01	.02	−.03	.00	−.12	−.15	.01	−.12	−.02	−.24	−.30	.52	1.00					
15	Usefulness	−.01	−.02	−.21	.12	.17	.04	−.15	.08	−.01	.21	.43	.30	−.12	−.17	1.00				
16	Compatibility	.02	−.03	−.10	.08	.13	.00	−.08	.07	.07	.16	.41	.30	−.19	−.27	.60	1.00			
17	Complexity	.11	.13	.05	−.10	−.01	−.10	−.14	.02	−.13	−.08	−.30	−.28	.50	.48	−.37	−.48	1.00		
18	Social influence	−.06	−.07	−.12	.11	.06	−.06	.01	.08	.04	.09	.23	.10	.00	−.05	.36	.30	−.15	1.00	
19	Intention to use	−.03	−.05	−.17	.19	.08	.04	−.06	.03	.07	.21	.29	.33	−.19	−.20	.53	.69	−.43	.26	1.00

(a) Complete sample. N = 535, sampling weights of 2.45 (invited respondents) and 0.63 (self-selected respondents) were applied. Self-selection: invited respondents = 0, self-selected respondents = 1.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Age	1.00																	
2	Diabetes duration	.28	1.00																
3	Diabetes treatment satisfaction	.20	.15	1.00															
4	Perceived hyperglycemia	−.06	−.23	−.31	1.00														
5	Perceived hypoglycemia	.11	.01	−.14	.21	1.00													
6	Gender	.17	.00	.11	−.06	.11	1.00												
7	Education	−.05	−.12	.00	.02	.02	.04	1.00											
8	MDI	−.08	−.22	−.27	.14	.06	−.05	−.07	1.00										
9	CSII + CGM	−.06	−.06	−.11	.06	.15	−.12	.20	−.09	1.00									
10	Optimism	.17	.07	.23	−.03	−.02	.21	−.13	.06	−.25	1.00								
11	Innovativeness	−.10	−.02	.02	−.03	.00	.26	.01	−.03	−.16	.50	1.00							
12	Discomfort	.31	.16	.15	−.04	.06	.03	−.15	.08	−.17	−.15	−.38	1.00						
13	Insecurity	−.04	.02	.03	−.01	.08	−.03	−.09	.05	−.19	−.14	−.27	.53	1.00					
14	Usefulness	−.03	.01	−.16	.10	.11	.09	−.19	−.02	−.08	.40	.31	−.16	−.13	1.00				
15	Compatibility	.00	−.06	−.06	.09	.08	.01	−.11	.07	.05	.36	.33	−.25	−.22	.56	1.00			
16	Complexity	.19	.23	.14	−.14	.09	−.02	−.13	.02	−.20	−.28	−.31	.58	.40	−.39	−.52	1.00		
17	Social influence	−.02	−.08	−.15	.10	−.02	−.02	.04	.08	.01	.23	.07	.04	−.01	.34	.26	−.12	1.00	
18	Intention to use	.03	−.03	−.06	.21	.03	.06	−.10	.02	.05	.24	.35	−.22	−.14	.51	.75	−.51	.24	1.00

(b) Invited respondents. n = 266, sampling weights of 2.45 (invited respondents) and 0.63 (self-selected respondents) were applied.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Age	1.00																	
2	Diabetes duration	.60	1.00																
3	Diabetes treatment satisfaction	−.05	.02	1.00															
4	Perceived hyperglycemia	.00	−.05	−.34	1.00														
5	Perceived hypoglycemia	.06	.09	−.14	.28	1.00													
6	Gender	.13	.08	.00	−.08	−.01	1.00												
7	Education	.13	.05	.09	−.07	−.05	.11	1.00											

(continued)

Appendix (continued)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
8	MDI	.17	−.02	−.31	.02	−.09	.18	−.10	1.00										
9	CSII + CGM	.03	.08	.11	.06	.20	−.09	.15	−.31	1.00									
10	Optimism	.15	.06	−.04	.01	.05	.16	.04	.09	.07	1.00								
11	Innovativeness	.05	.03	.04	.01	.04	.31	.10	.02	.09	.44	1.00							
12	Discomfort	.27	.14	−.07	.02	−.07	−.11	−.21	.10	−.05	−.15	−.26	1.00						
13	Insecurity	−.07	.00	.00	−.04	−.06	−.20	−.21	.00	−.07	−.34	−.33	.52	1.00					
14	Usefulness	.10	.01	−.15	.09	.22	−.04	−.09	.04	.03	.43	.24	−.10	−.22	1.00				
15	Compatibility	.12	.06	−.04	.03	.17	−.04	−.03	−.02	.08	.46	.22	−.13	−.34	.64	1.00			
16	Complexity	.00	.03	−.05	−.03	−.08	−.18	−.17	.07	−.07	−.32	−.22	.44	.56	−.33	−.43	1.00		
17	Social influence	−.05	−.05	−.06	.09	.13	−.11	.00	.04	.06	.21	.12	−.06	−.09	.37	.35	−.18	1.00	
18	Intention to use	.00	−.03	−.15	.09	.11	.00	.02	−.10	.06	.30	.26	−.19	−.27	.49	.58	−.32	.27	1.00

(c) Self-selected respondents. n = 267, sampling weights of 2.45 (invited respondents) and 0.63 (self-selected respondents) were applied.

Abbreviations

AP, artificial pancreas; CGM, continuous glucose monitoring; CSII, continuous subcutaneous insulin infusion; DTSQ, Diabetes Treatment Satisfaction Questionnaire; IDT, Innovation Diffusion Theory; MDI, multiple daily injections; PCA, principal component analysis; SD, standard deviation; SE, standard error; T1DM, type 1 diabetes; TAM, Technology Acceptance Model; TRB, Theory of Planned Behavior; TRI, Technology Readiness Index.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: HB is an employee of Inreda Diabetic BV. No other (potential) competing financial interests exist.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was funded through FP7 grant number 305654 from the European Commission to the PCDIAB Consortium.

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