

Predicting Noninsulin Antidiabetic Drug Adherence Using a Theoretical Framework Based on the Theory of Planned Behavior in Adults With Type 2 Diabetes

A Prospective Study

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Abstract: Understanding the process behind noninsulin antidiabetic drug (NIAD) nonadherence is necessary for designing effective interventions to resolve this problem. This study aimed to explore the ability of the theory of planned behavior (TPB), which is known as a good predictor of behaviors, to predict the future NIAD adherence in adults with type 2 diabetes.

We conducted a prospective study of adults with type 2 diabetes. They completed a questionnaire on TPB variables and external variables. Linear regression was used to explore the TPB's ability to predict future NIAD adherence, which was prospectively measured as the proportion of days covered by at least 1 NIAD using pharmacy claims data. The interaction between past NIAD adherence and intention was tested.

The sample included 340 people. There was an interaction between past NIAD adherence and intention to adhere to the NIAD ($P = 0.032$). Intention did not predict future NIAD adherence in the past adherers and nonadherers groups, but its association measure was high among past nonadherers ($\beta = 5.686$, 95% confidence interval [CI] $-10.174, 21.546$). In contrast, intention was mainly predicted by perceived behavioral control both in the past adherers ($\beta = 0.900$, 95% CI $0.796, 1.004$) and nonadherers groups ($\beta = 0.760$, 95% CI $0.555, 0.966$).

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The present study suggests that TPB is a good tool to predict intention to adhere and future NIAD adherence. However, there was a gap between intention to adhere and actual adherence to the NIAD, which is partly explained by the past adherence level in adults with type 2 diabetes.

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Abbreviations: β = regression coefficient, CI = confidence interval, NIAD = noninsulin antidiabetic drugs, PDC = proportion of days covered, TPB = theory of planned behavior.

INTRODUCTION

Nearly 6 out of 10 adults with type 2 diabetes report that they use a noninsulin antidiabetic drug (NIAD) as their main pharmacologic treatment.^{1,2} A systematic review of studies in which NIAD adherence was measured as the proportion of days covered with NIAD showed that the proportion of NIAD adherers ranged from 30.4%³ to 70.6,⁴ and was less than 62.7% in half of the consulted studies.³⁻⁷ In these studies, a participant was considered adherent when his proportion of days covered was equal to or greater than 80%. This shows that NIAD adherence is often suboptimal in adults with type 2 diabetes. This suboptimal NIAD adherence leads to negative consequences, such as suboptimal metabolic control,^{8,9} increased risk of diabetes complications and hospitalizations,^{10,11} and additional healthcare expenditures, for adults with type 2 diabetes.¹²

Understanding why many people with type 2 diabetes do not take their NIAD as prescribed is very important for designing effective interventions to resolve this problem. According to the World Health Organization, there are multiple determinants of medication adherence, and these determinants can be categorized into 5 groups: economic and socio-demographic, healthcare team and system-related, disease-related, therapy-related, and patient-related factors.¹³ Some of these determinants are nonmodifiable (eg, sex, age) or difficult to modify (eg, education level), whereas others are modifiable (eg, intention, perceived behavioral control) using behavioral methods. Although all these determinants could be useful for optimizing medication adherence-enhancing interventions, many authors recommend implementing behavioral interventions based on patient-related determinants, especially those identified using behavioral theories.^{14,15}

Among the many behavioral theories, the theory of planned behavior (TPB) has been shown to effectively predict many behaviors (eg, physical activity, smoking cessation, alcohol consumption reduction).¹⁶⁻¹⁸ Moreover, this theory (Cohen $d = 0.36$, 95% confidence interval [CI] $0.15, 0.56$) seemed to be more effective than other theories such as the transtheoretical

model (Cohen $d = 0.20$, 95% CI 0.08, 0.33) and social cognitive theory (Cohen $d = 0.15$, 95% CI 0.04, 0.25) when used to design web-based behavioral interventions.¹⁹ According to the TPB principles, intention (ie, in this case, the expression of the patient’s degree of readiness to adhere to their NIAD) and perceived behavioral control can determine the adoption of this health-related behavior.²⁰ Moreover, an individual’s intention to be adherent is determined by his/her attitude towards adherence (ie, the degree to which the patient values adherence positively or negatively), subjective norms (ie, the perceived social pressure to be adherent), and perceived behavioral control (ie, the patient’s perceptions of his/her ability to be adherent).²⁰

In a recent meta-analysis based on studies that employed the TPB and assessed behaviors prospectively after the participants completed the TPB questionnaire, intention and perceived behavioral control explained 14.8% to 23.9% of the variance in the adoption of behaviors such as risky behaviors (14.8%), drug abstinence (15.3%), dietary behaviors (21.2%), and physical activity (23.9%).¹⁶ Intention was the main predictor of behaviors. Moreover, McEachan et al¹⁶ observed that attitude, subjective norms, and perceived behavioral control explained 36.6% to 50.3% of the variance in the intention to adopt the behaviors listed above. To our knowledge, only 1 empirical study aimed to investigate the TPB’s ability to predict future medication adherence.²¹ However, we did not find any study on the TPB’s ability to predict NIAD adherence assessed prospectively. Thus, the present study aimed to explore whether TPB predicts NIAD adherence in adults with type 2 diabetes. More specifically, we tested whether intention predicts NIAD adherence, and whether attitude and perceived behavioral control predict intention to adhere to NIAD.

METHODS

We conducted a prospective study. Adults with type 2 diabetes completed a self-administered questionnaire on TPB

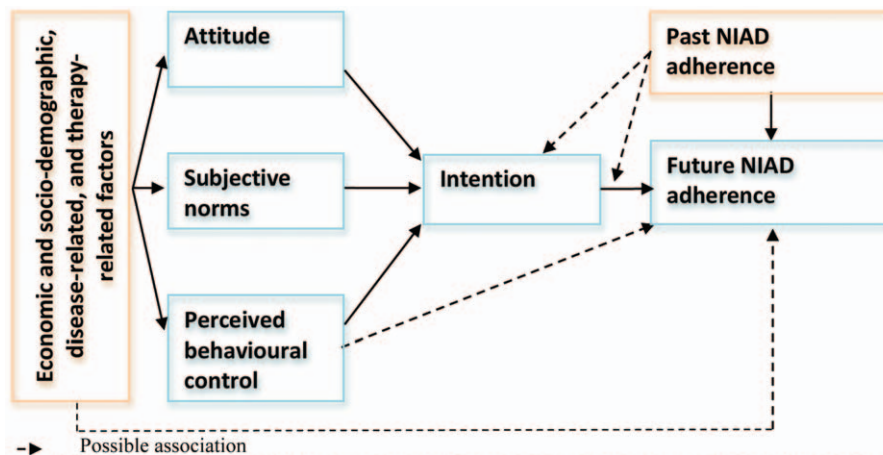
and external variables (defined below). Their NIAD adherence was measured in the 30 days before and 30 days after they completed the self-administered questionnaire using pharmacy claims data.

Theoretical Framework

Several empirical study syntheses confirm the associations between intention and behavior, and between other TPB variables and intention in respect to the TPB’s principles.^{16,18} Indeed, according to several prospective studies, intention is the main predictor of behavior.^{16,18} Perceived behavioral control becomes an important predictor of behavior when the person does not have the volition to adopt the behavior.²⁰ Past behavior is a strong confounding factor of the associations between intention and behavior, and between perceived behavioral control and behavior.¹⁶ Indeed, the results of a meta-analysis showed that when the participants’ past behavior was added to a model including intention and perceived behavioral control, the regression coefficient of intention changed substantially from 0.345 to 0.019 for risky behaviors, from 0.420 to 0.222 for physical activity, from 0.354 to 0.293 for dietary behaviors, and from 0.306 to 0.235 for drug abstinence.¹⁶ Individuals’ attitude towards the behavior, subjective norms, and perceived behavioral control predict their intention to adopt the behavior.^{16–18} Moreover, perceived behavioral control is the main predictor of intention to adopt the behavior.^{16–18}

Therefore, we based the present study on the framework shown in Figure 1, in which participants’ past behavior was NIAD adherence in the 30 days before they completed the questionnaire (past NIAD adherence). The behavior that we aimed to predict was NIAD adherence in the 30 days after the completion of the questionnaire (future NIAD adherence).

As depicted in the model, we assumed that intention would directly predict future NIAD adherence. Moreover, we assumed that patients’ intention to adhere to NIAD would be directly



Past NIAD adherence = Past adherence was measured with information on drugs claimed by participants during the 30 days before they completed the questionnaire.
 NIAD = non-insulin antidiabetic drug
 Perceived behavioural control may be a direct predictor of behaviour when behaviour is not fully under the control of volition.
 Economic and socio-demographic, disease-related, therapy-related variables, and past NIAD adherence may be direct predictors of intention and/or behaviour and potential confounding variables of the intention-behaviour relationship.

FIGURE 1. Theoretical framework of the study.

predicted by their perceived behavioral control, subjective norms, and attitude towards NIAD adherence. Past NIAD adherence was studied as both a main potential confounding and a modifying variable in the association between intention and future NIAD adherence. We also checked whether perceived behavioral control is a confounding factor in the association between intention and future NIAD adherence. Because some economic and socio-demographic, disease-related, and therapy-related variables are known to be predictors of NIAD adherence (as evidenced in the literature),¹³ they were also considered as potential confounding variables (described below).

Study Design and Population

We performed a prospective study using both the data of a web survey and pharmacy claims data obtained through the ReMed platform. This registry contains information on prescribed medications dispensed in community pharmacies for residents of Quebec who have private drug insurance and patients enrolled in clinical or epidemiologic studies. We carried out a web survey of adults with type 2 diabetes during the period between December 2012 and February 2013. The web survey consisted of an online multisectional questionnaire containing items measuring TPB variables (intention, perceived behavioral control, and attitude) and potential confounding variables such as economic and socio-demographic, disease-related, and therapy-related variables. Details of the development and preliminary validation of this questionnaire are described elsewhere.²² The study population was drawn from the “Diabète Québec” membership file. “Diabète Québec” is the diabetic patients’ advocacy association in the province of Quebec. Through an e-mail invitation, an employee of the association contacted members (N = 6258) who met the following criteria: aged 18 years or more; reporting a diagnosis of type 2 diabetes. Only those currently prescribed at least 1 NIAD were eligible. In total, 901 people completed the web survey. We had access to pharmacy claims data through the ReMed platform for the calculation of NIAD adherence for 431 of these participants. Because the TPB variables focused on NIADs only, we excluded 91 participants who stated that they took insulin during the 30 days before they completed the questionnaire. Therefore, the present analyses are based on 340 adults with type 2 diabetes using only NIADs.

Dependent Variables

The first dependent variable was future NIAD adherence measured for the 30-day period after the date of questionnaire completion, which was the index date. The period of NIAD adherence measure was defined in respect to the temporality used to measure the TPB variables.²² Future NIAD adherence was measured as the proportion of days covered, which is the total number of days covered by at least 1 NIAD divided by 30 days, and expressed as a percentage. This method allowed us to discriminate people who did not refill any NIAD prescription from those who refilled it.²³ We did not take into account hospitalization days in our calculation because these data are missing from the ReMed platform. However, we took into account the days’ supply which overlapped the period of adherence measurement for participants who refilled their NIAD before the index date.

The second dependant variable was the intention to adhere to the NIAD, which was measured using 3 items (see Table 1) that were assessed with a 6-point Likert scale, ranging from 1 (low) to

6 (high). The total score of intention was the mean score of the 3 items.

Main Independent Variables

The intention to adhere to the NIAD and perceived behavioral control (3 items) were used as the main independent variables to predict future NIAD adherence. Because the subjective norms scale had a poor temporal stability (intraclass correlation less than 0.60) in the preliminary validation of TPB variables,²² its data were not collected. Thus, only attitude (4 items) and perceived behavioral control were used as the main independent variables to predict the intention to adhere to the NIAD. The items of these TPB variables were measured with a 6-point Likert scale, ranging from 1 (low) to 6 (high). The total score of a TPB variable was the mean score of the corresponding items.

Other Independent Variables

Past NIAD adherence was computed using the same method described above, except the measurement period was the 30-day period preceding the questionnaire completion.

The economic and socio-demographic, disease-related, and therapy-related variables such as participants’ age, sex, education level (from no education to completed university), family income, social support (high, medium, low), perceived NIAD costs (from inexpensive to very expensive), insurance regimen (public, private), number of years since diabetes diagnosis, number of antidiabetic pills prescribed for daily use, use of a pill organizer, perceived side effects of the NIAD, anxiety, and depression mood (range score = 0 [low] to 6 [high]) were self-reported through the questionnaire.²² Variables such as social support,²⁴ anxiety,²⁵ depression mood,^{26,27} and perceived side effects²⁸ were assessed using validated specific questionnaires included in our full questionnaire, which is described elsewhere.²² All these variables are considered external variables.

Statistical Analyses

We assessed the psychometric properties of all TPB variables. First, we checked whether these variables contained only 1 dimension using exploratory factorial analyses. We used the Kaiser eigenvalue-greater-than-one rule²⁹ and Cattell scree plot³⁰ to determine the number of dimensions for each variable. Each dimension was considered as a variable in the next steps of our analyses. Second, we assessed the internal consistency of each dimension with Cronbach alpha coefficient. We retained only dimensions for which the Cronbach alpha coefficient was equal to or greater than 0.60.³¹

All variables retained from the preceding step were described for the full sample and according to past NIAD adherence levels ($\geq 80\%$ and $< 80\%$). The threshold of 80% has been shown to be clinically relevant in discriminating adherers and nonadherers among people with diabetes.³² Moreover, it has been used in several empirical studies.^{4–6,33–42}

To explore whether the intention to adhere to the NIAD predicts future NIAD adherence, we performed the analyses in 5 steps. Step 1—we traced a graph of the dependent variable as a function of each continuous independent variable to check the linearity between independent and dependent variables using the Local regrESSion procedure of Statistical Analysis System (SAS).⁴³ These graphs allowed us to recode continuous variables when necessary. Step 2—we performed a univariate regression model for each continuous variable and for its recoded form obtained from the first step. We considered the

TABLE 1. Psychometric Properties of the Variables* of Theory of Planned Behavior

Items	Factorial Analyses			
	r_{item}	Dimension	Eigenvalue	Internal Consistency [†]
Intention			2.22	0.89
Au cours du prochain mois, . . .				
During the next month, . . .				
je vais prendre mes médicaments antidiabétiques comme ils m'ont été prescrits	0.67			
I will take my antidiabetic drugs as prescribed				
je prendrai toujours mes médicaments antidiabétiques comme ils m'ont été prescrits	0.93			
I will always take my antidiabetic drugs as prescribed				
j'ai l'intention de prendre mes médicaments antidiabétiques comme ils m'ont été prescrits	0.95			
I intend to take my antidiabetic drugs as prescribed				
Attitude			1.95	0.79
Au cours du prochain mois, prendre mes médicaments antidiabétiques comme ils m'ont été prescrits sera pour moi . . .				
During the next month, taking my antidiabetic drugs as prescribed will be for me . . .				
1 très inutile; 2 assez inutile; 3 légèrement inutile; 4 légèrement utile; 5 assez utile; 6 très utile	0.61			
1 very useless; 2 quite useless; 3 slightly useless; 4 slightly useful; 5 quite useful; 6 very useful				
1 très insatisfaisant; 2 assez insatisfaisant; 3 légèrement insatisfaisant; 4 légèrement satisfaisant; 5 assez satisfaisant; 6 très satisfaisant	0.82			
1 very unsatisfactory; 2 quite unsatisfactory; 3 slightly unsatisfactory; 4 slightly satisfactory; 5 quite satisfactory; 6 very satisfactory				
1 très nuisible; 2 assez nuisible; 3 légèrement nuisible; 4 légèrement bénéfique; 5 assez bénéfique; 6 très bénéfique	0.76			
1 very harmful; 2 quite harmful; 3 slightly harmful; 4 slightly beneficial; 5 quite beneficial; 6 very beneficial				
1 très désagréable; 2 assez désagréable; 3 légèrement désagréable; 4 légèrement agréable; 5 assez agréable; 6 très agréable	0.57			
1 very unpleasant; 2 quite unpleasant; 3 slightly unpleasant; 4 slightly pleasant; 5 quite pleasant; 6 very pleasant				
Perceived behavioral control			2.12	0.88
Je me sens capable de prendre mes médicaments antidiabétiques comme ils m'ont été prescrits	0.92			
I am able to taking my antidiabetic drugs as prescribed				
Je prendrai facilement mes médicaments antidiabétiques comme ils m'ont été prescrits	0.93			
I will easily take my antidiabetic drugs as prescribed				
Au cours du prochain mois, prendre mes médicaments antidiabétiques comme ils m'ont été prescrits sera pour moi	0.65			
During the next month, taking my antidiabetic drugs as prescribed will be for me				
1 très difficile; 2 assez difficile; 3 légèrement difficile; 4 légèrement facile; 5 assez facile; 6 très facile				
1 very difficult; 2 quite difficult; 3 slightly difficult; 4 slightly easy; 5 quite easy; 6 very easy				

Eigenvalue = $\sum r_{\text{item-dimension}}^2$, N = sample size used, NA = not applicable, $r_{\text{item-dimension}}$ = Pearson correlation between item and dimension.

* Subjective norms variable was not reported because in the preliminary analysis of questionnaire development, its temporal stability was poor. Therefore, subjective norms variable was removed from the final questionnaire which was used for the survey.

[†] Cronbach alpha coefficient.

appropriate variable form to be the one that better explained the dependent variable. Step 3—we considered external variables that were associated with the dependent variable at a P value less than 0.20 as potential confounding variables.⁴⁴ Then, we assessed the presence of multicollinearity between these potential confounding variables using Belsley criteria.⁴⁵ Before building the statistical model, we computed a matrix of Spearman correlations between studied variables. Step 4—according to our theoretical framework, we constructed 3 statistical models of future NIAD adherence prediction: initial model 1a included intention because perceived behavioral control was not associated with future NIAD adherence at a P value less than 0.20. Then, we added past NIAD adherence to initial model 1a. Finally, we added external variables associated with future NIAD adherence at a P value less than 0.20 to the latter model.⁴⁴ To predict the intention to adhere to the NIAD, we also constructed 3 statistical models. The first of these models (initial model 1b) included attitude and perceived behavioral control. Past NIAD adherence was added to the initial model 1b to obtain the second model. Finally, we added external variables associated with the intention to adhere to the NIAD at a P value less than 0.20 to this second model to construct the third model.⁴⁴

We also explored the interaction between intention and past NIAD adherence in the regression model predicting future NIAD adherence. Because of the statistical significance (statistical threshold = 0.05) of this interaction, the results for the prediction of NIAD adherence are reported according to past NIAD adherence levels (past adherers, Proportion of days covered (PDC) $\geq 80\%$; past nonadherers, PDC $< 80\%$).

All statistical analyses were performed using SAS version 9.4 software,⁴³ and statistical tests were bilateral.

The ethical approval for the present study (DR-002-1369) was obtained by the Research Ethics Committee of CHU de Québec, Québec.

RESULTS

In total, 340 adults with type 2 diabetes were included in the present study. There are no missing data for these people. The mean PDC was 87.9% (SD = 25.1%) before and 89.7% (SD = 23.8%) after the participants completed the questionnaire. Moreover, 86.2% of the participants had good past NIAD adherence (PDC $\geq 80\%$).

TPB Variables

The factorial analyses of TPB variables confirmed that the items of intention, perceived behavioral control, and attitude each measured a unique dimension (see Table 1). The Cronbach alpha values were 0.89, 0.88, and 0.79 for intention, perceived behavioral control, and attitude, respectively. On average, we observed a high intention to adhere to the NIAD (mean score = 5.78/6, SD = 0.710), a high level of perceived behavioral control (mean score = 5.70/6, SD = 0.665), and a high score for attitude (mean score = 5.55/6, SD = 0.617) (see Table 2).

External Variables

The external variables are described in Table 2. The mean age of the people in our sample was 62.6 years (SD = 9.18). Of the participants, 57.7% were men, 38.5% had a university degree, and 13.8% (see Table 2) had a family income of \$CAN 60,000 or more. The mean number of years since diabetes diagnosis was 9.05 years (see Table 2) (SD = 8.13). Sixty-nine percent of participants used a pill organizer, 74.7% had to take less than

5 antidiabetic pills per day, and 11.8% (see Table 2) perceived that their antidiabetic medication had side effects.

Correlation Matrix Between Variables

The correlation matrix showed that intention (Spearman correlation = 0.13, $P = 0.016$) and perceived behavioral control (Spearman correlation = 0.14, $P = 0.007$) were positively associated with past NIAD adherence, but not with future NIAD adherence. Attitude was not associated with past or future NIAD adherence. Perceived behavioral control and attitude were positively associated with intention to take the NIAD (Spearman correlation = 0.58, $P < 0.001$; and Spearman correlation = 0.20, $P < 0.001$, respectively).

Prediction of Future NIAD Adherence

Our first hypothesis was that intention would predict future NIAD adherence in adults with type 2 diabetes. The initial model 1a including intention resulted in an explained variance of only 0.32%. The effect of intention on future NIAD adherence was not statistically significant (see Table 3). When past adherence was added to the initial model 1a, the explained variance increased from 0.32% to 29.26%, and the effect of intention substantially changed from regression coefficient (β) = 1.883 (95% CI -1.700, 5.467), to β = 0.544 (95% CI -2.487, 3.575). Among the external variables studied, social support, sex, perception of adverse effects of medication, use of a pill organizer, and family income were statistically associated with future NIAD adherence at a P value less than 0.20. When these external variables were added to the preceding regression model, the effect of intention decreased to 0.109 (95% CI -2.931, 3.149), and the explained variance became 33.44%.

Prediction of the Intention to Adhere to the NIAD

Our second hypothesis was that perceived behavioral control and attitude would predict the intention to adhere to the NIAD. The initial model 1b, including only these 2 TPB variables, explained 64.2% of the variance in the intention to adhere to the NIAD. The effects of perceived behavioral control and attitude on the intention to adhere to the NIAD were as follows: β = 0.882 (95% CI 0.792, 0.971) and β = -0.044 (95% CI -0.141, 0.052), respectively. When we added past adherence to the initial model 1b, these parameters did not change (see Table 3). The results were quite similar when we added the external variables associated with intention to adhere to the NIAD at a P value less than 0.20 (see Table 3).

Interaction Between Past Adherence and Intention to Adhere to the NIAD

The interaction between intention and past NIAD adherence was statistically significant ($P = 0.032$). Therefore, we repeated the analyses after stratifying the participants according to past NIAD adherence levels, PDC $< 80\%$ (47 participants), and PDC $\geq 80\%$ (293 participants) (see Table 4).

Comparing past nonadherers to past adherers, the regression model containing intention showed that the explained variance in future NIAD adherence was 5.4 times, higher but remained small (2.11%/0.39%). When we added the external variables to the model containing intention, the explained variance among past nonadherers (37.96%) remained higher than that among past adherers (4.78%). However, the adjusted effect of intention on future NIAD adherence was higher for past nonadherers (β = 5.686, 95% CI -10.174,

TABLE 2. Description of Studied Variables According to Past Noninsulin Antidiabetic Drug Adherence Levels

Variables	Full Sample (N = 340)		Past Adherence* ≥80%, n = 293		Past Adherence* <80%, n = 47	
	N	%	n	%	n	%
TPB variables						
Intention to adhere to NIAD (mean, SD)	5.78	0.71	5.80	0.69	5.64	0.84
Perceived behavioral control (mean, SD)	5.70	0.67	5.73	0.62	5.48	0.88
Attitude towards NIAD adherence (mean, SD)	5.55	0.62	5.56	0.60	5.48	0.71
Socio-demographic and clinical factors						
Age (mean, SD)	62.64	9.18	62.81	8.93	61.60	10.70
Sex						
Men	196	57.7	171	58.4	25	53.2
Women	144	42.3	122	41.6	22	46.8
Level of education						
University completed	131	38.5	114	38.9	17	36.2
College completed	49	14.4	42	14.3	7	14.8
High school completed	51	15.0	45	15.4	6	12.8
Less than high school	109	32.1	92	31.4	17	36.2
Family income in \$ 1,000 CAD						
60 or more	47	13.8	40	13.7	7	14.9
From 50 to less than 60	36	10.6	27	9.2	9	19.1
From 30 to less than 50	71	20.9	66	22.5	5	10.6
Less than 30	38	11.2	32	10.9	6	12.8
No response	148	43.5	128	43.7	20	42.6
Social support						
High	176	51.8	152	51.9	24	51.0
Medium	123	36.2	110	37.5	13	27.7
Low	41	12.0	31	10.6	10	21.3
Perceived NIAD costs						
Inexpensive	67	19.7	56	19.1	11	23.4
Little expensive	135	39.7	111	37.9	24	51.1
Quite expensive	103	30.3	93	31.7	10	21.3
Very expensive	35	10.3	33	11.3	2	4.3
Insurance						
Public	144	42.3	130	44.4	14	29.8
Private	196	57.7	163	55.6	33	70.2
Number of years since diabetes diagnosis (mean, SD)	9.05	8.13	9.57	8.06	8.06	8.49
Number of antidiabetic pills/day	3.48	1.98	3.59	2.02	2.76	1.54
<5	254	74.7	221	72.4	42	89.4
≥5	86	25.3	81	27.6	5	10.6
Use of pill organizer						
Yes	236	69.4	210	71.7	26	55.3
No	104	30.6	83	28.3	21	44.7
Perceived side effects of NIAD						
Yes	40	11.8	32	10.9	8	17.0
No	300	88.2	261	89.1	39	83.0
Anxiety						
score <3	243	71.5	208	71.0	35	74.5
Score ≥3	97	28.5	85	29.0	12	25.5
Depression	0.66	1.12	0.66	1.12	0.66	1.15
NIAD adherence in past month (mean, SD)	87.94	25.06	96.71	5.16	33.26	30.25
NIAD adherence in next month (mean, SD)	89.71	23.82	94.86	12.54	56.61	45.06

NIAD = noninsulin antidiabetic drugs.

* Past adherence = NIAD adherence in the 30 days before the web survey. NIAD adherence was measured as the proportion of days covered which is the total number of days covered by at least 1 NIAD divided by 30 days and expressed as a percentage.

21.546) than past adherers ($\beta = -1.543$, 95% CI $-3.669, 0.583$) (see Table 4). However, these effects remained statistically nonsignificant. For the past nonadherers, we observed that the CIs were very large (see Table 4).

The regression model containing attitude and perceived behavioral control showed that the explained variance in the intention to adhere to the NIAD was 1.4 times higher for past nonadherers than for past adherers (84.5%/59.4%). Perceived

TABLE 3. Associations Showing How Theory of Planned Behavior Works in Adults with Type 2 Diabetes

Variables	Full Sample (N = 340)		
	β	95% CI	R ² (%)
Prediction of prospective NIAD adherence			
Initial model 1a			0.32
Intention to adhere to NIAD	1.883	−1.700, 5.467	
Initial model 1a adjusted for past NIAD adherence			29.26
Intention to adhere to NIAD	0.544	−2.487, 3.575	
Past NIAD adherence (≥80% vs <80%)	37.186	30.958, 43.415	
Initial model 1a adjusted for past NIAD adherence and external variables*			33.44
Intention to adhere to NIAD in next month	0.109	−2.931, 3.149	
Past NIAD adherence (≥80% vs <80%)	36.509	30.267, 42.752	
Prediction of the intention to adhere to NIAD [†]			
Initial model 1b			64.17
Perceived behavioral control	0.882	0.792, 0.971	
Attitude	−0.044	−0.141, 0.052	
Initial model 1b adjusted for past NIAD adherence			64.27
Perceived behavioral control	0.887	0.797, 0.978	
Attitude	−0.047	−0.143, 0.050	
Past NIAD adherence (≥80% vs <80%)	−0.066	−0.199, 0.067	
Initial model 1b adjusted for past NIAD adherence and external variables [‡]			64.39
Perceived behavioral control	0.890	0.798, 0.982	
Attitude	−0.051	−0.150, 0.047	
Past NIAD adherence (≥80% vs <80%)	−0.068	−0.204, 0.066	

Initial model 1a = model including intention only.

Initial model 1b = model including attitude and perceived behavioral control only.

Past adherence represented the measure of taking of NIAD in participants during the month before web survey completion.

β = regression coefficient, CI = confidence interval, NIAD = noninsulin antidiabetic drugs, R² = percentage of explained variance.

* Only external variables associated with NIAD adherence in next month with a P value <0.20 were included in the initial model 1 as potential confounding variables. These variables were the social support, sex, perception of adverse effect of medication, use of pill organizer, and family income.

[†] Subjective norms variable was not included in the intention prediction model because of its poor reliability.

[‡] Only external variables associated with intention to adhere to NIAD with a P value <0.20 were included in the initial model 2 as potential confounding variables. These variables were the age of participants, their perception of adverse effect of medication, their level of education, and the use of organizer.

behavioral control was the main predictor of intention to adhere and showed a similar magnitude in the past adherers ($\beta = 0.894$, 95% CI 0.792, 0.997) and past nonadherers groups ($\beta = 0.795$, 95% CI 0.601, 0.990). The addition of external variables did not change these results (see Table 4).

DISCUSSION

Three relevant findings can be drawn from the present study. First, a high proportion of people included in our analyses had good past and good future NIAD adherence. Second, past NIAD adherence was both a strong predictor and a modifying factor for the prediction of future NIAD adherence. Third, the TPB was good at predicting intention to adhere to the NIAD in adults with type 2 diabetes, but not at predicting future NIAD adherence even after stratifying participants according to past adherence level. Moreover, the TPB better predicted both intention to adhere to the NIAD and future NIAD adherence in the past nonadherers group than the past adherers group. Thus, the TPB could be more effective in predicting the NIAD adherence of past nonadherers than that of past adherers.

A high proportion of people included in our analyses had good past adherence. The proportion of NIAD adherers, measured as the proportion of days covered using a pharmacy claims database and stratified with a cut-off of 80%, has been

assessed in many retrospective cohort studies.^{3–7,34} In these studies, the proportions of NIAD adherers varied from 45.0%⁶ to 70.6%,⁴ which is lower than the proportion we observed. This discrepancy between our result and those reported in the literature could be partially explained by the particularity of our participants, who were all members of the Provincial Diabetes Association and long-term users of an NIAD. Indeed, one of core functions of this association is to help its members prevent diabetes complications by offering them diabetes information, diabetes education, and self-management training workshops. Therefore, people from this association could be better informed about diabetes self-management and might have better tools to self-manage their diabetes than those from the general population with type 2 diabetes. Moreover, our participants were volunteers. Thus, they could be more likely to take care of their diabetes. Another explanation is the period considered (30 days) for the assessment of NIAD adherence, as it was shorter than the periods used in the literature (from 3 to 12 months in previous studies).^{3–7,34}

Past NIAD adherence was a strong predictor of future NIAD adherence. Indeed, the addition of past NIAD adherence to the initial model 1a, substantially increased the explained variance from 0.32% to 29.3%. To our knowledge, only 1 previous study aimed to investigate the TPB's ability to predict future medication adherence while controlling for the past

TABLE 4. Prediction of Future Noninsulin Antidiabetic Drug Adherence and Intention to Adhere to the Noninsulin Antidiabetic Drugs According to the Past Noninsulin Antidiabetic Drug Adherence Levels in Adults With Type 2 Diabetes

Variables	Past Adherence* $\geq 80\%$, n = 293			Past Adherence* $< 80\%$, n = 47		
	β	95% CI	R ² (%)	β	95% CI	R ² (%)
Prediction of future NIAD adherence						
Initial model 1a			0.39			2.11
Intention to adhere to the NIAD	-1.136	-3.240, 0.968		7.644	-8.001, 23.289	
Initial model 1a adjusted for external variables [†]			4.78			37.96
Intention to adhere to NIAD	-1.543	-3.669, 0.583		5.686	-10.174, 21.546	
Prediction of the intention to adhere to the NIAD [‡]						
Initial model 1b			59.43			84.47
Perceived behavioral control	0.894	0.792, 0.997		0.795	0.601, 0.990	
Attitude	-0.067	-0.172, 0.038		0.118	-0.123, 0.359	
Initial model 1b adjusted for external variables [§]			59.76			85.79
Perceived behavioral control	0.900	0.796, 1.004		0.760	0.555, 0.966	
Attitude	-0.078	-0.185, 0.030		0.137	-0.114, 0.388	

Initial model 1a = model including intention only.

Initial model 1b = model including attitude and perceived behavioral control only.

β = regression coefficient, CI = confidence interval, NIAD = noninsulin antidiabetic drugs, R² = percentage of explained variance.

* Past adherence represented the measure of taking of NIAD in participants during the 30 days before questionnaire completion. NIAD adherence was measured as the proportion of days covered, which is the total number of days covered by at least 1 NIAD divided by 30 days, and expressed as a percentage.

[†] Only external variables associated with NIAD adherence in next month with a *P* value < 0.20 were included in the initial model 1 as potential confounding variables. These variables were the social support, sex, perception of adverse effect of medication, use of pill organizer, and family income.

[‡] Subjective norms variable was not included in the intention prediction model because of its poor reliability.

[§] Only external variables associated with intention to adhere to the NIAD, with a *P* value < 0.20 , were included in the initial model 1b as potential confounding variables. These variables were the age of participants, their perception of adverse effect of medication, their level of education, and the use of pill organizer.

behavior.²¹ This study showed that past behavior (history of nonadherence to medical advice) was a strong predictor, explaining 23% of future immunosuppressant therapy adherence—a value relatively close to the value that we observed (29.3%). Our result is also in line with those of meta-analyses by McEachan et al.¹⁶ These authors controlled for past behavior and showed that the TPB (intention and perceived behavioral control) explained variance ranging from 26.7% for drug abstinence to 40.1% for risky behavior predictions.¹⁶ In this meta-analysis, perceived behavioral control had a minor contribution in the prediction of future immunosuppressant therapy adherence. Our result suggests that past NIAD adherence plays an important role in the prediction of future NIAD adherence.

Studying the modifying effect of past NIAD adherence allowed us to observe that the TPB better predicted both intention and future NIAD adherence in the past nonadherers group than the past adherers group. However, the explained variance of future NIAD adherence remained low (2.1% for nonadherers and 0.39% for adherers) when external variables were not controlled, and the effect of intention on future NIAD adherence remained statistically nonsignificant (see Table 4). These results are not in line with the TPB's principles.²⁰ Indeed, the mean score of intention to adhere to the NIAD was very high both in the past nonadherers and past adherers groups (see Table 1). According to the TPB's principles,²⁰ one should observe high future NIAD adherence among both past nonadherers and past adherers. In fact, in line with their high mean score on the intention variable, past adherers maintained their NIAD adherence level during the 30 days after the completion of the questionnaire (before web survey: mean PDC = 96.7%,

SD = 5.2; after web survey: mean PDC = 94.9%, SD = 12.7%). Similarly, in line with their high score on the intention variable, past nonadherers also substantially improved their NIAD adherence level during the next 30 days (before web survey: mean PDC = 33.3%, SD = 30.3%; after web survey: mean PDC = 57.6%, SD = 44.3%). Thus, we could consider that many people put their words into action. Our question is as follows: Why did we observe a low explained variance and the absence of an effect of intention on future NIAD adherence? We propose 2 hypotheses. First, these results could be partially attributed to the lack of statistical power, especially for the past nonadherers group, which included only 47 participants. In fact, according to the manual of TPB analyses, a sample size of 80 people is acceptable for TPB studies using a multivariate regression approach.³¹ Second, our results could be explained by the fact that we used an objective method to measure future NIAD adherence. Indeed, the results of a meta-analysis showed that future physical activity was better predicted by TPB variables when physical activity was measured through a self-report method (25.7% of the variance explained) compared with an objective method (12.1% of the variance explained).¹⁶ In fact, the TPB variables were always self-reported by study participants; thus, these variables could be affected by desirability bias, resulting in an overestimation of their scores. This is not the case for NIAD adherence in our study or other behaviors assessed using an objective method.

The highest explained variance for future NIAD adherence prediction in our analyses including external variables was 38.0% (in the past NIAD nonadherent group). Thus, at least 62.0% of the variance remained unexplained by the full model.

This result suggests that to better understand the prediction of medication adherence, one needs to construct a predictive statistical model based on multilevel determinants such as healthcare team and health system-related, socioeconomic-related, disease-related, therapy-related, and patient-related factors.¹³ However, the objective of the present study was to explore the TPB's ability to predict future NIAD adherence and, therefore, to identify patient-related determinants that can be modified to improve NIAD adherence.

We found that intention to adhere to the NIAD was predicted by attitude and perceived behavioral control both among past nonadherers and past adherers. Moreover, perceived behavioral control was the main predictor of intention to adhere to the NIAD. These results are in line with the TPB's principles²⁰ and with a previous empirical study.²¹ Indeed, Chisholm et al²¹ found that attitude, subjective norms, and perceived behavioral control together explained 41.0% of the variance in the intention to adhere to immunosuppressant therapy. In addition, Chisholm et al²¹ observed that perceived behavioral control was the main predictor of intention. However, one should note that the magnitude of the explained variance in our study was higher than that observed by Chisholm et al. This difference could be partially explained by the type and the previous level of adoption of health-related behavior. Indeed, we observed that the explained variance in intention to adhere to the NIAD increased when the past adherence level decreased (past adherers R² (exponent): 59.4%, mean PDC = 96.7%; full sample R² (exponent): 64.2%, mean PDC = 87.9%; past nonadherers R² (exponent): 84.5%, mean PDC = 33.3%). These results suggest that clinicians or researchers who are interested in understanding the readiness of adults with type 2 diabetes in terms of NIAD adherence should keep in mind that patients' past adherence level could be central to the success of adherence-enhancing interventions. Thus, clinicians or researchers could adapt adherence-enhancing interventions according to patients' past adherence level.

Our study has a few limitations. First, we were not able to collect data on subjective norms. This limitation could have influenced not only the effects of attitude and perceived behavioral control on intention but also the explained variance of intention prediction. However, we think that the impact could be minor because subjective norms were not often reported as a major factor in TPB variables.¹⁶ Second, we did not have a sufficient sample to show the TPB's ability to predict future NIAD adherence particularly in the past nonadherers. Third, we were not able to collect the pharmacy claims data for all web survey participants (N = 340 instead of N = 901). Thus, the observed effects might be affected by a selection bias. However, the impact of this bias was minor because the characteristics of the participants in our sample were quite similar to those of all participants in the web survey (mean age: 62.6 vs 62.7 years; sex: 42.3% women vs 41.4% women; mean number of years since diabetes diagnosis: 9.1 vs 10 years; intention: 5.8/6 vs 5.8/6; attitude: 5.6/6 vs 5.5; perceived behavioral control: 5.7/6 vs 5.7/6). Finally, included participants were members of a diabetes association. These persons could be predisposed to adhere to their NIAD compared with the general population with type 2 diabetes. This limits the generalizability of our results.

However, our study also has several strengths. First, it is the first study to assess the TPB's ability to predict future NIAD adherence and intention to adhere to NIAD according to past NIAD adherence level in adults with type 2 diabetes. This allowed us to show the modifying effect of past health-related

behavior in the prediction of future health-related behavior. Second, we used a rigorous method to take into account potential confounding variables. Third, we used TPB variables with a good degree of validity in our analyses. Finally, we used an objective method to measure NIAD adherence. This allowed us to decrease the desirability bias that can be present when adherence is self-reported.

CONCLUSIONS

The present study suggests that TPB is a good tool to predict intention to adhere and future NIAD adherence, particularly in past NIAD nonadherers. Our results could have implications for clinical practices and research. This study helps health professionals (physicians, pharmacists, nurses, and health educators) and researchers understand the adoption of NIAD adherence in adults with type 2 diabetes using the TPB. Health professionals and researchers should keep in mind that the past NIAD adherence level could influence the TPB's ability to predict NIAD adherence among adults with type 2 diabetes. Therefore, the content of future NIAD adherence-enhancing interventions based on TPB should be adapted according to investigators' aim to either improve or maintain the NIAD adherence of adults with type 2 diabetes. It is relevant to discriminate past adherers from past nonadherers when one wishes to implement NIAD adherence-enhancing interventions.

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