Ignorance or Motivated Beliefs: The Role of Motivated Beliefs in Self-management of Diabetes*

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Abstract

Exercise, dieting and adherence to medicines are well-known effective measures to reduce long-term consequences of diabetes; however, patients throughout the world fail to manage their condition. We propose the existence of motivated beliefs as an explanation for this paradox. We test the empirical predictions of the economic model of motivated beliefs using data from 100 patients with diabetes. We operationalized beliefs by comparing real BMI to an individual's BMI reference point she/he is motivated to believe that she/he should start preventive effort. We measure an individual reference point to start prevention by using previously validated pictorial BMI-based body size guide. Most respondent's report a reference BMI to initiate preventive effort larger than their real BMI. The distortions between real and reference body image to start prevention are higher among males, and among younger individuals. Those with larger negative distance from the reference point are 0.64 points less likely to engage in self-management, which is 23% of the average behavior. These results open the possibility that personalized medical care should incorporate information about individual's beliefs to improve efficacy of treatment for diabetes. Our results have implications to explain the lack of self-management in other chronic conditions.

Keywords— Motivated beliefs theory; body image; self-management of diabetes; chronic conditions.

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1 Introduction

Diabetes is a major public health problem which affects around 422 million adults individuals worldwide in 2014. It is growing at increasing alarming rate and with almost 80% of this total in developing countries (World Health Organization 2016). Despite well-known benefits of self-management behavior, self-management of diabetes is low worldwide (Haas et al. 2012, American Diabetes Association 2005). Multiple behavioral theories have been raised to explain this seemingly irrational individual behavior. In this paper, we depart from traditional views and test the implications of the economic model of motivated beliefs as an alternative adaptive theory to explain this behavior.

The traditional policy toolkit to increase self-management of diabetes includes providing comprehensive insurance coverage, direct income assistance or price subsidies to reduce the economic burden of prevention, and implementing educational programs to enhance health literacy among patients with diabetes (Newman et al. 2004). An expanded set of policies to increase prevention considers supply-side actions to improve access to care and quality of treatment. Despite these policies, self-management of diabetes remains a challenge (Ahola & Groop 2013, Aziz et al. 2015).

In explaining the low prevention among people with diabetes, some researchers have turned their attention to behavioral theories that rely on individuals mechanical or cognitive shortcomings. Some argue that individuals with diabetes wrongly discount the future, or give incorrect probability weights to outcomes; some argue that individuals with diabetes fail to engage in self-management due to lack of self-control or overconfidence (Kelly & Barker 2016); Some indicate inability to control emotions such as anger associated with having the disease (Ahola & Groop 2013); While others point to the cognitive biases and mechanical or automatic mistakes in judgment in explaining the lack of self-management (Sinclair et al. 2000, Trujillo & Fleisher 2013).

The theory of motivated beliefs or reasoning assumes that an individual has some rational motive in their behavior and adapt it to achieve particular purposes (Bénabou & Tirole 2002, Bénabou 2015). In this case, one has a belief that serves her/his objective or subjective utility, purpose, or value and faces a tradeoff between the desirability of maintaining this view with the cost associated with it. The reasoning to support and protect one's beliefs may be confronted with empirical behavioral evidence; however, an individual may subdue into self-denial, wishful thinking, strategic ignorance, and other forms of protection to hold her/his beliefs (Bénabou & Tirole 2016, Carrillo & Mariotti 2000). Individuals may be motivated by their beliefs in a conscious or unconscious form. A key contribution of this framework is that beliefs have a consumable component that enhances the individual self-efficacy or increase her affective value or positive emotions (for example certain beliefs serve one to feel more attractive, smarter, or healthier). Beliefs also serve as a mechanism of protection; or provide a way to commit to a determinate future act (Oster et al. 2013). Lastly, having certain beliefs may signal others to act according to one's values (Bénabou & Tirole 2011, Di Tella et al. 2015, Golman et al. 2016).

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On the other hand, holding certain beliefs may be costly to an individual in the short, and long run. As most economic frameworks, under this model, an individual contemplates the marginal benefits regarding consumption and investment of holding certain beliefs with the costs associated with it when making a judgment to engage in a specific behavior. In this model, we focus on the consumption of motivated belief assuming that beliefs are already formed; Others have studied how signals or threats (or need to act) as an impetus for engaging in health-promoting behavior (Janz & Becker 1984, Rosenstock 1974, Mohammadi et al. 2018). In the next section, we will formally introduce this theory and clarify how this framework differs from alternatives behavioral theories in economics and psychology.

What is important is to explain how we test the empirical implications of this framework in the case of self-management of diabetes. We assume that an individual has the motivation to believe a reference weight, where she/he should start self-management, that is higher than their actual weight. The benefits of thinking this way can be in the form of utility from higher self-efficacy (believe that one is thinner than the weight needed to trigger prevention may increase functionally by reducing negative emotions) or improving affective emotions toward oneself. Individual may avoid confronting the real information by engaging in strategic information avoidance or asymmetric updating. Holding the beliefs that one is thinner than the required weight may have future costs as well. In our model, an individual will compare the marginal benefits and costs on holding the motivated beliefs and decide to exert preventive effort if marginal benefits are greater than marginal cost.

In simple terms, an individual with diabetes may have the motivation to believe that her/his weight is lower than the reference weight to act and decide to accrue the benefits of eating a tasty cheesecake at the moment. This action provides benefits concerning pure consumption or subjective benefits in terms of positive emotions, less anger due to suppression of choices, and affective feelings. Now, eating the cheesecake will have future negative consequences. In short, in our model individuals would exert prevention based on this calculation at the margin.

In this work, we investigate motivated beliefs by asking one hundred individuals with diabetes using a pictorial BMI-based body size guide to pinpoint at what reference body max index-image (BMI) she/he believes should have the motivation to start preventive effort. We conducted the field experiment in Hospital Nacional Arzobispo Loayza in Lima, Peru during the first nine months of 2016. This is study was part of a larger feasibility randomized clinical trial conducted between 2017 and 2018 in Lima, Peru. Using a pictorial figure reduces possible cognitive biases that may arise if a researcher asks directly (e.g. “At what BMI should you engage in self-management?”) as the individual may not be familiar with the concept of BMI. The descrepency betwene actual and perceived weight using self-reported data has been described in Peru in both rural and urban areas (de Mola et al. 2012). The pictorial BMI-based body size guide used in this study has been tested for its reliability and feasibility in a previous study on body image (Harris et al. 2008). Essentially, we used the pictorial images to elicit individual’s beliefs about a reference point when prevention should start. Distortions between actual BMI and the reference point are interpreted as motivated beliefs that trigger preventive effort.

In our data, we observe preventive effort, the individual’s reference point to start prevention, and other control covariates that may influence the benefits and costs associated with holding certain reference beliefs. We hypothesize that individuals with diabetes who reported a reference points much larger than their actual BMI are less likely to engage in prevention even after controlling for factors that affect costs and benefits of prevention. In simple terms, a negative value for the difference between actual BMI and the reference point suggests that an individual has the motivation to believe that she/he should be heavier than current weight before taking any actions and this reduces the probability of engaging in self-management activities. We also test if this effect exists even after controlling for actual weight; and if heavier individuals are likely to report lower distortions in reference point and subsequently lower effect in the preventive effort.

One should notice that an individual may have a reference point larger than actual BMI for self-efficacy reasons or strategic behavior. Under this model, observing lack of preventive behavior among individuals with diabetes is not due to ignorance regarding the efficacy of treatment; instead, we empirically test if it is due to the individual's motivated beliefs that one is lighter than needed to start prevention.

To the best of our knowledge, this is the first paper that measures and tests beliefs in the context of management of diabetes. Our methods have applications to test the predictions of the motivated beliefs framework in preventive behavior related to other chronic conditions and health behaviors such as smoking, drinking, and sexually risky behaviors.

2 Theory of Motivated Beliefs

In the following Section, we introduce our theoretical model. The model is based on Oster et al. (2013) and Brunnermeier & Parker (2005). Individuals receive anticipatory utility and hold beliefs that are not necessarily the same as reality. We assume no information signal that corrects the beliefs.

2.1 The Model

There are two states of the world $s \in \{0, 1\}$ where 0 is when the person is healthy (or not overweight), and 1 is when the person is unhealthy (or overweight). An individual's belief of whether they are healthy or not depends on what they consider healthy, or the reference BMI. This believed reference BMI may not be necessarily the same as the actual probability of being healthy. We assume that actions, self-management, or preventive efforts are chosen based on a believed probability that a person is unhealthy. In our study, actions can include any activity to be healthier such as exercising, taking medication, consuming less sugar, and trying to lose weight.

Imagine $p = E(s)$ is the probability of having a healthy BMI and π is the person's belief about the probability p. In other words,

$$\pi_i = \Pr(\text{Actual BMI} \geq \text{Believed reference BMI}), \tag{1}$$

and

$$p_i = \Pr(\text{Actual BMI} \geq \text{Actual reference BMI}). \tag{2}$$

Let us assume binary states for probabilities. There are two periods in the model: Given π, in period 1 the person exerts prevention based on cost/benefit calculations at the margin and chooses action $a \in \{0, 1\}$. In period 2 the person receives consumption utility. This is the phase that the consequences of actions are realized (high blood sugar, diabetes, etc.). Actions are based on the chosen belief π because actions depend on beliefs and not reality. Utility given a and a realized state s is $u(a, s)$. Individuals choose π to maximize utility in period 2 written as

$$U(\pi|p) = \delta \mathrm{E}(u(\hat{a}, s)|\pi) + E(u(\hat{a}, s|p)) \tag{3}$$

where $\hat{a}(\pi) = \mathrm{argmax}_a \; \mathrm{E}[u(a, s)|\pi]$. Under binary probability assumption, we then have

$$U(\pi|p) = \delta\pi u(\hat{a}, 1) + \delta(1-\pi)u(\hat{a}, 0) + pu(\hat{a}, 1) + (1-p)u(\hat{a}, 0) \tag{4}$$

δ represents how anticipatory utility is down-weighted. We also assume that the functional form $u(.,.)$ in all periods is the same.

As a special case, if individuals learn the true weight ($\pi = p$), the utility above is simply:

$$(1+\delta)[pu(1, 1) + (1-p)u(0, 0)] \tag{5}$$

We assume utilities according to Table 1. We assume the utility of taking no action when overweight ($s = 1$), $u(0, 1)$, is equal to $-C + B$, where C is the cost of not taking any action when one should take actions and B is the utility from deceiving oneself (motivated belief). B captures the motivation behind incorrect beliefs and involves increases in affective value or positive emotions. We also assume the following: the utility of taking action when overweight ($s = 1$), $u(1, 1)$ is zero, i.e., there is no negative or positive utility if the person is overweight and takes action. The utility of taking action when not overweight ($s = 0$), $u(1, 0)$, is equal to $1 - D$, where D includes any psychological cost. Finally let us assume that the utility of taking no action when not overweight ($s = 0$), $u(0, 0)$, is equal to 1.

	Not overweight	Overweight
Takes no action	$u(0, 0) = 1$	$u(0, 1) = -C + B$
Takes action	$u(1, 0) = 1 - D$	$u(1, 1) = 0$

Table 1: Assumptions about utilities under different scenarios

Note that if $B - C$ and D are smaller than 1, then the highest utility is achieved when an agent who is not overweight takes no action (no health costs but also to effort). However, this assumption is not required. The utility maximization requires that agents fully realize C, B, and D and there is no bounded rationality.

As we mentioned, actions are chosen in period 1 and are based on anticipated utility. No action will be chosen ($a = 0$) if

$$\pi u(0, 1) + (1-\pi)u(0, 0) \geq \pi u(1, 1) + (1-\pi)u(1, 0) \tag{6}$$

Utilities in Equation 6 only depend on π and not p since actions are based on beliefs and not realities. Furthermore, the projection factor δ does not change how actions are chosen as it cancels out on both sides of the inequality. Substituting the utilities leads to the following inequality.

$$\pi \leq \frac{D}{D + C - B} \tag{7}$$

other words, an individual takes action if $\pi > D/D + C - B$ and takes no action otherwise. Figure 1 shows the range of beliefs that lead to action and no action. This suggests that actions depend on the parameters C, B, and D.

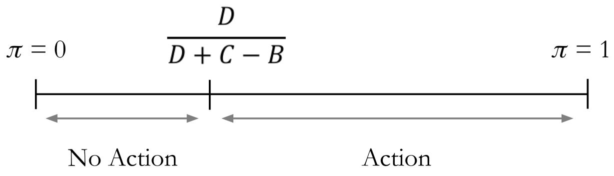

Figure 1: Ranges of action and non action depending on the value of π

The main implications of 7 are (1) actions depend on the benefits of having incorrect beliefs or choosing a higher reference BMI. (2) If D is significantly larger than $C - B$, then the range of no action increases. The intuition behind this is that if the cost of taking action when no action is required is large, agents are more likely to take no action. (3) For larger values of C the range of action increases (agents are more likely to take action). This means if the cost of taking no action when action is required increases, agents are more likely to take action. (4) For larger values of B the range of no action increases. This means that if the motivation for being wrong increases, the agent is more likely to take no action.

We assume that $D_i = D$ and $B_i = B$, i.e. the cost of taking action when no action is required and the benefit of lying to oneself does not vary across individuals. However, we let C vary across individuals.

$$a_i = \begin{cases} 1, & \text{if } \pi_i > D/(D + C(X_i, \text{BMI}_i) - B) \\ 0, & \text{otherwise.} \end{cases} \tag{8}$$

where X_i is a vector of individual-specific demographics such as age and gender, and BMI_i is individual's true BMI. Model in Equation 8 should be compared to the traditional model of individuals actions in which action only depend on the actual probability of being overweight. In other words

$$a_i = \begin{cases} 1, & \text{if } p_i > 0 \\ 0, & \text{otherwise.} \end{cases} \tag{9}$$

What does this framework tell us about the effect of individual-specific characteristics on actions? The answer to this depends on how C depends on such characteristics. For instance, in order to understand how age affects actions, we need to know how C depends on age. Under the assumption that $\partial C/\partial \text{age} > 0$ (i.e. the cost of taking no action when action is required increases with age), then the models tell us that older agents are more likely to take actions since the action range increases.

2.2 Empirical Implications

Following the model in Section 2.1, actions depend on beliefs and beliefs depend on individual characteristics. We can re-write the model in Equation 8 as

$$a_i = \begin{cases} 1, & \text{if } \pi_i - D/(D + C(X_i, \text{BMI}_i) - B) > 0 \\ 0, & \text{otherwise.} \end{cases} \tag{10}$$

, or simply

$$a_i = \begin{cases} 1, & \text{if } f(\pi_i, X_i, \text{BMI}_i) + \epsilon > 0 \\ 0, & \text{otherwise.} \end{cases} \tag{11}$$

where ϵ is an error distributed by the standard logistic distribution. In the following Sections, we will discuss our data and methodology and test the model presented in the current Section.

3 Data and Methods

We conducted a survey with 100 patients with diabetes who met our inclusion criteria for a feasibility randomized clinical trial to be conducted in a later phase (Trial registration: ClinicalTrial.gov Identifier: NCT02891382). We asked demographic factors (age, gender, and marital status), socioeconomic (household income, education level, employment, and occupation), and health-related questions (self-reported health, weight, height, last measure of glucose) as well as gathered information on diagnostics, time since diagnosis of diabetes, and knowledge regarding diabetes.

We also ask everyone to answer questions about reference point to start prevention using a BMI-based body size guide (BSGs) for women and men. Our pictorial images contain 10 bodies that range from underweight to class III obesity. As previous research, figures were standardized and composited faces based on local culture were added to the pictures. Figure 2 shows the ten bodies images used in our study for males and females. This figure has been previously used and validated in field research to assess belief about weight-related concepts (Harris et al. 2008).

Using this BSGs images, individuals were asked to identify the pictorial figure where they belief they should start preventive measures to manage their diabetes. To translate images to BMIs, we assigned the first image (the thinnest image) to the borderline underweight BMI that is 18.5. We also assigned the last image (the most overweight) to the borderline extreme obesity BMI as 41. We then divided the range (18.5–41) into nine intervals (since there are nine images) and assigned a BMI to each image. Figure 2 shows the BMI assigned to each body type image.

We then proceed to compare actual BMI to reference BMI to start prevention. For everyone, we computed the difference between actual BMI and reference BMI to start preventive effort. A negative value for this variable indicates that an individual believes that they should be heavier before starting preventive measures. In our model, an individual is motivated to exert preventive effort based on a relative point that it is given by the believed BMI. In simple terms, a reference point for BMIs larger than actual BMIs indicates that the individual has the motivate to belief that they are lighter than they need before starting preventive effort. We interpret this reference point as an individual motivated belief to avoid prevention.

Table 2 summarizes the characteristics of the individuals enrolled in the experiment before conducting our trial. On average our respondents were 55 years of age; 67% were female; and 89% had completed high school or a higher level of education. Fifty five percent (55%) were employed,

	A	B	C	D	E	F	G	H	I	J
BMI	18.5	21.0	23.5	26.0	28.5	31.0	33.5	36.0	38.5	41.0
Weight Categories	Under weight	Normal Weight		Over weight	Class I Obesity		Class II Obesity		Class III Obesity	

Figure 2: Body image and motivated belief

and 33% are legally married. Most people with diabetes in our sample reported good or very good health (89%), and on average the time since diagnosis of diabetes was seven years.

We asked everyone questions related to exercise, dieting and adherence to medicines. These are well-accepted effective self-management activities in diabetes care (Toobert et al. 2000, American Diabetes Association 2018, Gandhi et al. 2008). We asked individuals since they were diagnosed with diabetes if they exercise regularly; we also asked if they diet regularly; and if they have tried to consume less sugar . Lastly, we asked individuals if they are currently taking their prescribed medicines. Each outcome was coded as dummy variable: 1 if they perform the activity; 0 otherwise. We also compute a total preventive index that adds each of the preventive activities. In this case, the variable is coded 4 (if they do exercise, adherence to medicine, take less sugar, and dieting); 3 (if they do any of three activities); 2 (if they do two activities), 1 (they only do one activity), and 0 (none of the activities). Fifty three percent of our sample have tried physical activity, 75% tried to reduce sugar intake; and 55% have tried to lose weight. See Table 1, panel B for a summary of the outcome variables.

Table 3 shows the share of responses in our sample by 10 categories in body image guide. The second column displays how we translate the visual image into reference BMI to start prevention. Most of our respondents are in categories F and G which correspond to a reference BMI of 31 and 33.5. These BMI represent obese category. Interestingly, 3.2 percent of responded are in category D which is the closest one to a normal BMI (BMI <25). Not surprisingly, nobody select the extremes of the distribution (A,B, C, I, J). As we mentioned before, this information captures the distribution of beliefs about when to start prevention.

We first explore whether beliefs about reference BMI are correlated with actual BMI. While we found no relationship between the two variables (correlation = 0.1; P-value = 0.33) across our sample, for most individuals the choice of unhealthy BMI lies above their actual BMI as can be seen in Panel (A) of Figure 3.

Categories	Statistics (N = 100)
The Independent Variable and Controls	
Actual BMI	
min	19.00
max	37.02
mean ± sd	26.32 ± 3.56
Believed Reference BMI	
min	26
max	36
mean ± sd	31.41 ± 1.96
Weight (kg)	
min	52
max	100
mean ± sd	68.47 ± 8.45
Age	
min	32
max	81
mean ± sd	55.17 ± 11.79
Gender	
Male	33 (33%)
Female	67 (67%)
Level of education	
Low	11 (11%)
Medium	46 (46%)
High	43 (43%)
Married	
No	67 (67%)
Yes	33 (33%)
Employed	
No	45 (45%)
Yes	55 (55%)
Dependent Variables	
Since you were diagnosed with diabetes, have you ever tried physical activity or exercise regularly?	
No	45 (46%)
Yes	53 (54%)
Are you taking or being treated with any of the following medications?	
No	8 (8%)
Yes	92 (92%)
Since you were diagnosed with diabetes, have you ever tried to consume less sugar or sweets?	
No	23 (23%)
Yes	75 (77%)
Since you were diagnosed with diabetes have you ever tried to lose weight?	
No	45 (45%)
Yes	55 (55%)
Overall number of preventive actions taken	
0	1 (1%)
1	12 (12%)
2	26 (27%)
3	27 (28%)
4	32 (33%)
mean ± sd	2.79 ± 1.07

Table 2: Descriptive statistics of the main variables in the sample

Body Type	Equivalent BMI	Share
A	18.5	0
B	21.0	0
C	23.5	0
D	26.0	3.2
E	28.5	12.9
F	31.0	51.6
G	33.5	30.1
H	36.0	2.2
I	38.5	0
J	41.0	0

Table 3: Share of respondents selecting each body type

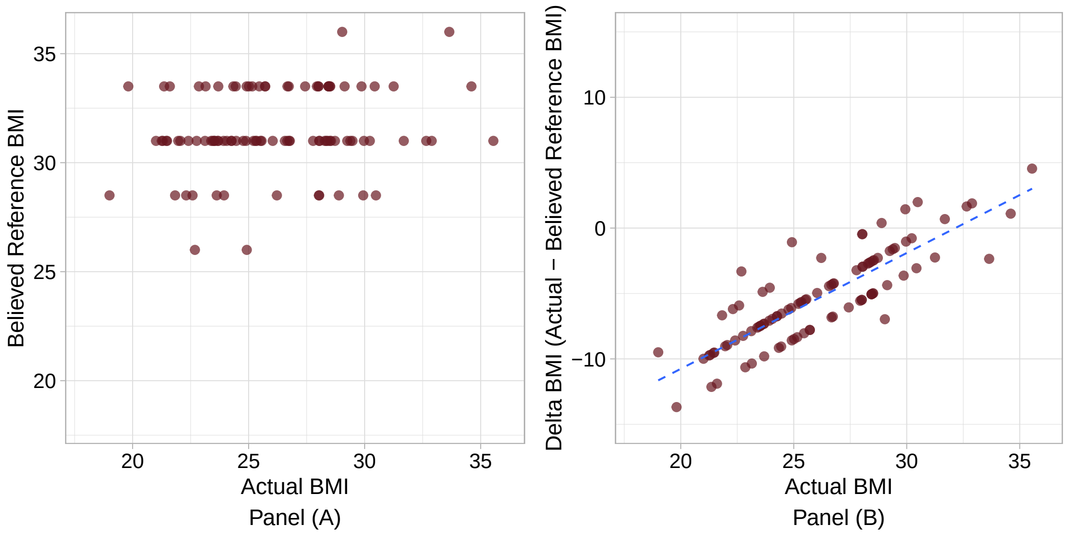

Figure 3: The relationship between believed reference BMI and delta BMI versus actual BMI across the sample

We then create a variable (delta BMI) that captures the difference between actual BMI and the reference BMI belief to start prevention. Panel (B) in Figure 3 displays the relationship between actual BMI and delta BMI. Results indicates a strong positive correlation (0.86; P-value <0.01) between both variables which suggests that distortion in beliefs is smaller for heavier individuals. In other words, heavier individuals hold certain distortions in motivated beliefs (still negative delta); however, the distortion is smaller than the observed distortion in individuals with lower BMI.

We next explore whether delta BMI varies across demographic groups such as gender, age, and education. This is shown through density plots for the delta BMI in Figure 4. We find the distortion between the actual BMI and the reference beliefs BMI to be negative and larger for females than males. Males with diabetes believe that they need to gain more weight than females before triggering self-management behavior. Younger groups also show a larger negative delta than older adults. Additionally, highly educated individuals show larger negative delta than less educated individuals. This implies that younger and more educated individuals with diabetes have motivated beliefs that may reduce preventive effort than older and less educated counterparts. One tentative explanation for the differences across age groups is that older diabetic patients are more accurate to adjust the reference BMI with respect to actual BMI given longer exposure to evidence that contradicts beliefs. However, the same arguments cannot be made about education

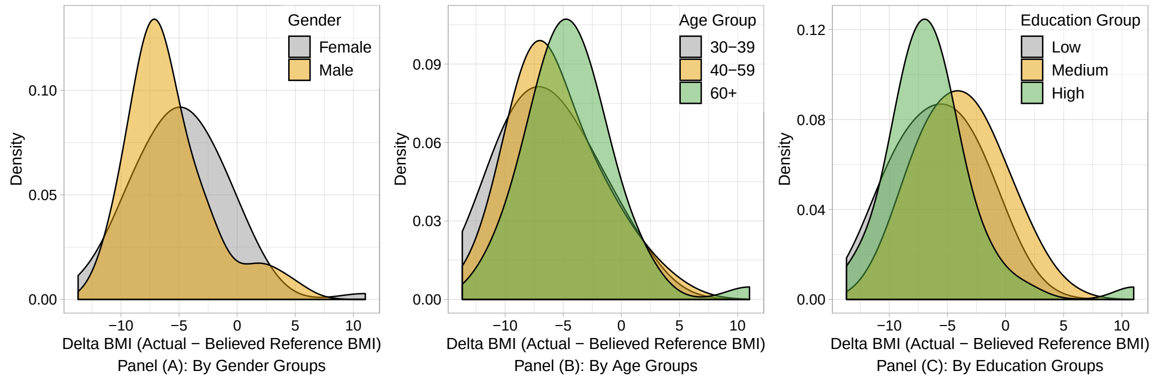

Figure 4: Density plots of delta BMI (actual – motivated belief reference BMI) across demographic groups

groups. While one can argue that more educated people are more informed about the reference BMI, evidence suggests that they choose higher BMIs for starting preventive care.

4 Summary of the Findings

As we mentioned above, an individual with a reference point to start prevention larger than her/his actual BMI implies that she has a motivated belief to think that her BMI should be greater than her actual BMI before starting any action. In this Section, we provide the summary of a sequential regression analysis to test if having a reference belief that one must be heavier than they actually are before acting reduces preventive effort.

For each outcome of interest (physical activity, taking medication, consuming less sugar, and losing weight), we run six models. In the first model, we explore if the distortion in beliefs has an influence on outcome after controlling for age and gender (basic controls); second model includes an extended set of control covariates (marital status, education, insurance, occupation and health). Then, we implement two additional models (model 3 and 4) to explore if the distortion in perceived image with respect to the reference point influences preventive effort after controlling for actual weight. Model 3 only contains basic controls and Model 4 has an extended set of controls. Our last two set of specifications (Model 5 and Model 6) test if belief plays a role after controlling for actual weight and the interaction of belief and actual weight. Again, Model 5 has basic controls and Model 6 includes a more extended set. In all case, we run linear probability models and all the standard errors are robust. Regression using logit models are similar and are available upon request from the authors. Results are shown in Table 4.

Looking at exercise, the results suggest that people with motivated beliefs that they need to be heavier than their actual weight (negative delta) are less likely to exercise (See Model 1 and Model 2 in Table 4-A). Yet, these results are not statistically significant even when one controls for actual weight (Models 3 and 4). The effect becomes positive when we include an interaction term in Models 5 and 6. One extra unit increase in delta BMI reduces probability of exercising by 18.0–25.5 percentage points, but the effect is smaller for people with higher weights. These results are statistically significant at $p < 0.01$. The last two models suggest that individuals with motivated beliefs that they are thinner than the required BMI to take any action are less likely

Table 4: Regression of different dependent preventive activities on delta BMI and other controls

Panel (A) — Dependent Variable: Doing Exercise

Controls	(1) Basic	(2) Expanded	(3) Basic	(4) Expanded	(5) Basic	(6) Expanded
Delta BMI (Actual - Ref. Point)	-0.010	-0.010	-0.015	-0.015	0.184***	0.265***
	(0.014)	(0.015)	(0.018)	(0.019)	(0.071)	(0.077)
Weight			0.004	0.005	-0.008	-0.009
			(0.009)	(0.010)	(0.009)	(0.009)
Delta BMI * Weight					-0.003***	-0.004***
					(0.001)	(0.001)
Adjusted R^2	-0.035	-0.070	-0.045	-0.079	-0.002	0.001

Panel (B) — Dependent Variable: Taking Medication

Controls	(1) Basic	(2) Expanded	(3) Basic	(4) Expanded	(5) Basic	(6) Expanded
Delta BMI (Actual - Ref. Point)	0.005	0.003	-0.001	-0.002	-0.020	-0.050
	(0.007)	(0.006)	(0.009)	(0.009)	(0.034)	(0.037)
Weight			0.004	0.004	0.005	0.007*
			(0.003)	(0.003)	(0.004)	(0.004)
Delta BMI * Weight					0.0003	0.001
					(0.0004)	(0.001)
Adjusted R^2	0.031	0.026	0.029	0.023	0.020	0.021

Panel (C) — Dependent Variable: Consuming Less Sugar

Controls	(1) Basic	(2) Expanded	(3) Basic	(4) Expanded	(5) Basic	(6) Expanded
Delta BMI (Actual - Ref. Point)	0.020	0.019	0.029**	0.033**	0.313***	0.344***
	(0.014)	(0.014)	(0.015)	(0.014)	(0.063)	(0.072)
Weight			-0.006	-0.011	-0.023***	-0.026***
			(0.008)	(0.009)	(0.007)	(0.008)
Delta BMI * Weight					-0.004***	-0.004***
					(0.001)	(0.001)
Adjusted R^2	0.035	0.037	0.032	0.049	0.178	0.199

Panel (D) — Dependent Variable: Losing Weight

Controls	(1) Basic	(2) Expanded	(3) Basic	(4) Expanded	(5) Basic	(6) Expanded
Delta BMI (Actual - Ref. Point)	0.058***	0.046***	0.006	0.002	0.125*	0.080
	(0.010)	(0.010)	(0.013)	(0.012)	(0.065)	(0.070)
Weight			0.038***	0.036***	0.031***	0.032***
			(0.006)	(0.006)	(0.007)	(0.007)
Delta BMI * Weight					-0.002**	-0.001
					(0.001)	(0.001)
Adjusted R^2	0.180	0.256	0.395	0.420	0.408	0.421

Panel (E) — Dependent Variable: All Preventive Activities

Controls	(1) Basic	(2) Expanded	(3) Basic	(4) Expanded	(5) Basic	(6) Expanded
Delta BMI (Actual - Ref. Point)	0.073**	0.058*	0.017	0.016	0.604***	0.642***
	(0.030)	(0.030)	(0.038)	(0.036)	(0.160)	(0.181)
Weight			0.040**	0.034	0.006	0.003
			(0.019)	(0.022)	(0.018)	(0.019)
Delta BMI * Weight					-0.008***	-0.009***
					(0.002)	(0.002)
Adjusted R^2	0.055	0.050	0.099	0.074	0.191	0.163

to exercise. This effect is statistically large in magnitude. The effect of the delta in adherence to medicine is not statistically significant and opposite direction to our hypotheses (See Table 4-B). In all cases the results are not statistically significant. Looking at eating behavior such as taking less sugar and dieting support the idea that individuals who choose a reference BMI higher than their actual BMI are less likely to reduce their intake of sugar. These results are statistically significant in Models 3-6 in Table 4-C). When we include an interaction term, the impact of delta BMI in reducing intakes of sugar varies from 31.0 to 34.0 percentage points and is significant at $p < 0.01$. As in the case of exercise, additional weight reduces the effect of the delta on the behavior of reducing intake of sugar. Notice that these effects represent 41%-45% of the average value of individuals who reported that they take less sugar as a preventive measure.

The effect of the delta on the effort to lose weight in all models are in the expected direction (i.e, people with actual BMI smaller than target BMI are less likely to take action to lose weight). However, they are not statistically significant in all models except model 5 (see Table 4-D). People who have the motivated beliefs that the reference BMI is larger than the actual BMI are 12.5 percentage points ($p < 0.10$) less likely to take any dieting effort to lose weight. This encompasses approximately 23% of the current average of individuals dieting which represents an important effect on behavior.

The last panel in Table 4 shows the results when one adds all preventive actions (exercise, adherence to medicines, less sugar and dieting). In all models, having an actual BMI smaller than the target belief BMI to start prevention reduces any type of preventive action. This effect fluctuates from 0.01 points in Model 4 to 0.64 points in Model 6 which is 23% of the mean of the variable. Note that the dependent variable varies from 0 to 4. Looking at the last model in Table 4-E indicates that the delta in motivated beliefs reduces preventive effort by 0.64; this result is significant at $p < 0.01$. As before, the effect of the delta is lower for heavier individuals. According to the results, the effect of the delta for additional unit in weight (kgs) is reduced by 0.009, $p < 0.01$. Even after this reduction, our results suggest an important and significant effect of motivated beliefs in preventive effort.

5 Discussion

Our emphasis to explain self-management behavior among people with diabetes starts from the notion that an individual with diabetes takes action based on their belief about when they should take action, i.e., a reference BMI. The choice of the reference BMI varies across individuals and depends on the individual's motivations. These motivated beliefs provide emotional and objective benefits that are weighted against future costs. Her or his behavior in our model is goal-oriented. In our framework, individuals do not fail to engage in preventive measures due to cognitive biases, rational over optimism (Van den Steen 2004), bounded rationality, or automatic limitations in responses (shortcoming of System 1) as the one suggested by Kahneman (2011). Instead in our model, individuals are rational and adaptive in their way that they process information.

Motivated beliefs in this paper are operationalized by asking each participant with diabetes to pinpoint a pictorial figure at what BMI they belief they would have a motivation to start self-management behavior. Our results suggest that individuals who have the motivation to believe that their actual BMI are lower than the target BMI tend to be younger and more educated. This result is consistent with the idea that younger individuals with diabetes receive positive emotions or objective increase in self-efficacy that outweights the marginal cost of these motivated beliefs.

Taking together our results, we found that individuals with larger target BMI than actual BMI are less likely to engage in important self-management actions such as exercising, taking less sugar and/or dieting. These results are statistically significant in most cases and important in magnitude.

Our empirical approach does not allow us to discern why these motivated beliefs are formed and how they are re-evaluated over time (Sharot & Garrett 2016). It could be that individuals' are motivated to believe that they could be heavier than they are to feel positive emotions; or it could be that these beliefs increase daily self-efficacy or are used to overcome self-control problems. Alternatively, the social cognitive theory suggests that individual behavior is shaped by observing and learning from others through social interactions, experience, and media or other outside influences. In this paper, this would support individuals with wide reference ranges in BMI being less likely to change behavior as they may also have perceived motivations based on what is considered the norm (or abnormal) in their larger social context. This is to say if everyone's BMI is at level X, an individual may perceive that as normal and not needing preventive or treatment strategies – even if X is defined as a hazard (Bandura 1986, Borhaninejad et al. 2017).

Furthermore, we cannot discern the future costs associated with the belief that one is thinner that the target BMI. As in most economic works, we observed elicit preferences toward preventive behaviors and interpret them according to an economic framework. Future research should pay attention to how beliefs are formed, and more importantly, how individuals update their motivated beliefs over time in the light of new information. Another fruitful line of inquiry may be to explore to what extend strategic ignorance, self-denial, and/or signaling play a role in the formation of motivated beliefs among individuals with diabetes. Knowing about the role of each factor may help patients form different beliefs.

Our study has profound implications for clinical practice and public health. Most physicians concentrate in providing information to patients with diabetes as a mean to improve their health literary, which would improve self-management. Frequently, physicians talk to patients based on objective biomarkers such as weight and BMI. Our findings suggest that correcting patients' beliefs can also be helpful. Future research could explore if other visuals or graphical means may be more effective to assess and correct individuals' motivated beliefs.

Lastly, understanding an individual's motivated beliefs in the case of diabetes may have vast implications for other chronic conditions such as hypertension as well as other health behaviors. Broadly speaking, our approach moves from the notion that the lack of self-management in patients with diabetes is due to low health literacy or mechanical cognitive shortcomings. Our adaptive model of individual behavior fits into the trend in economics, psychology and neuroscience known as affective revolution or second cognitive revolution (Harré 1994, Haidt 2007, Von Hippel & Trivers 2011, Egidi et al. 1992).

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