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ESTIMATING THE SIZE OF CASH REWARDS IN HEALTH INTERVENTIONS: THE *EX-ANTE* WILLINGNESS TO EXERT EFFORT

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Abstract

This paper proposes a method to estimate the optimal size of cash rewards in health interventions. We adapt a theoretical model in which an individual chooses effort to maximize utility. Effort is costly but it provides intrinsic satisfaction that adds to the external cash reward. We considered alternative functional forms for the cost function and tested the model using data from hypothetical reward schemes to motivate individuals with diabetes to exert effort to lose weight. The value of intrinsic motivation, the curvature of the cost of effort, and the value elasticity of effort are estimated using a Nonlinear Least Squares procedure as well as a Minimum Distance approach. Results indicate that effort is rather inelastic to the size of the reward and that a high curvature of the cost of effort prevents individuals from engaging in healthy behavior.

Keywords: Intrinsic motivation; Diabetes; Stated willingness to accept; Stated willingness to deposit.

INTRODUCTION

A common practical problem in designing health interventions that rely on cash rewards is to estimate the optimal size of the cash reward. Program designers may be inclined to use the level of cash rewards implemented in other social interventions or to use arbitrary reference points such as the minimum wage. In the context of the field of Development Economics, cash rewards are usually called conditional cash transfers when goals are linked to the rewards. In this paper, we will use the term cash rewards, financial incentives or extrinsic motivation interchangeably.

Some researchers conduct exploratory qualitative research to define the size of the reward in an intervention, but no attention is given to the individual's elasticity in the level of response. This paper proposes an alternative method to elicit preferences toward effort given different cash rewards so that one can estimate the elasticity of effort to different cash rewards before conducting a randomized controlled trial (RCT). We illustrate this approach in the context of a health intervention where cash rewards are used to motivate individuals with diabetes to exert effort to lose weight. Since we start with reasonable assumptions about the individual's cost of engaging in an activity that involves effort, our method could be used in other policy areas where it is important to gauge the size of the cash reward to influence behavioral changes before conducting the intervention.

A literature review of cash rewards in health suggests different aspects of the architecture of cash incentives that could be beneficial in designing health interventions (Kane et al., 2004; Volpp et al., 2011; Sigmon & Patrick, 2012). It is well accepted that programs that incorporate positive rather than negative rewards, frequent and small cash amounts, and an element of uncertainty in the scheme tend to be more effective to motivate change in health behavior (Kane et al., 2004; Volpp et al., 2009; Blumenthal et al., 2013). Yet, less is known about the link between the size of the cash reward and the response in effort (Kane et al., 2004; Sigmon & Patrick, 2012). It is expected that the dose-response curve with respect to cash rewards follows a rank ordering shape, in which the greater the size of the reward leads to greater responses in effort. Yet, little evidence is available about this curvature or what we call in this paper the value elasticity of effort (i.e., the response in effort to different levels of cash rewards) (Kane et al., 2004; Sutherland et al., 2008).

On one hand, cash incentives could be too small and overshadow intrinsic motivation contributing to less effort exerted than would have occurred in the absence of the cash program (Gneezy & Rustichini, 2000; Deci, 1971). Offering too little could have the opposite effect to what was intended and reduce the motivation of an individual to perform a task (Frey & Jegen, 1999; Lacetera & Macis, 2010). The idea of paying may produce a negative reaction and displeasure on the individual to execute the task freely (Rabin, 1998; Benabou & Tirole, 2003). Low levels of cash rewards may also be detrimental when the payer cannot distinguish effort from outcomes. Contracts based on payments conditional on outcomes rather than effort may create disincentives for people to engage in healthy behavior as individuals who allocate larger effort may not receive the larger changes in outcomes (Edmans & Gabaix, 2016). Lastly, the benefit of low levels of cash payment and positive intrinsic motivation may not be sufficient to overcome the individual's marginal costs of engaging in the activity.

On the other hand, the cash rewards-response curve may exhibit a non-linear shape. In addition, for some programs offering large cash amounts may not be fiscally feasible. Even though results from experimental settings with high rewards may lead to cost savings in the long term, the cash amount involved may not be financially sustainable for a public insurance payer. For instance, a recent randomized controlled trial (RCT) suggests that an annual reward of 500-750 promotes reduction in smoking (Volpp et al., 2009). This amount is 33 times higher than what is used in a program at the state level in Florida Blumenthal et al., (2013). Public support for an intervention may decline as healthy individuals perceive the size of the cash reward as excessive and unfair (Lagarde et al., 2007; Blumenthal et al., 2013).

It is important to note that even in RCTs with multiple arms, the results of trials are not sufficient to plot a set of responses to different sizes of cash rewards. Traditional RCTs offer little or no guidance on how elastic an individual's effort is in response to the size of the cash reward. The results from these types of trials suggest that larger cash rewards produce larger effort or behavioral responses; yet one cannot infer if the magnitude of the value elasticity remains constant over the relevant distribution of effort or if it is variable. It is possible that at a low level of cash rewards the value elasticity is positive and elastic while after a certain level of cash rewards is reached, the value elasticity becomes inelastic. Lastly, randomizing individuals to various cash reward amounts and powering the experiment to detect effect may be too costly. Therefore, it is common for project designers in the health field to narrow their attention to one or two amounts of cash rewards based on a reference point such as minimum wage or amounts offered in other social programs.

Our review of 16 recent highly cited RCT studies of health interventions using cash rewards indicates that only three explain how the researchers determined the size of the cash reward. One used the minimum wage as a reference while the other two studies used reference values from previous studies. None used rigorous formative research to define the initial size of the reward. The majority used one or two cash rewards schemes. From these readings, policy makers may consequently ask if they can achieve similar behavioral changes in magnitude with less or more cash. Furthermore, from these studies policy makers cannot be sure if the rewards are sufficiently large to cover the marginal cost of effort associated with the health behavior, or if the health programs designed to motivate healthy behaviors were cost-effective (Blumenthal et al., 2013).

Our model is in the spirit of the behavioral economics framework presented by DellaVigna and Pope (2017) to study how monetary and non-monetary interventions motivate individuals to complete computer tasks that require a costly effort. Starting from the first principles, we assume that an individual will make effort to maximize her/his utility. Effort provides utility to the individual from intrinsic motivation and from a monetary reward that the individual receives from her/his effort. Monetary rewards motivate an individual to exert effort as the return of effort increases linearly with changes in the magnitude of the cash reward. However, exerting effort is costly. Therefore, given some level of reward, an individual would exert effort until the marginal benefit of effort equals its marginal cost.

We considered two standard cost functions to model effort: the power cost function and the exponential cost function. Both functions fit the cost of effort involved in most health behaviors. For instance, the cost of effort according to these functions is always positive, monotonic, and convex while the derived elasticity of value of effort would be constant at all levels of effort (power cost function) or decreasing (exponential cost function). Another advantage associated with these cost functions is that they are mathematically tractable in empirical work.

We fit the model using data from individuals with diabetes attending a large public hospital in Peru who were asked about their ex-ante preferences to exert effort to lose weight under different hypothetical reward scenarios. Our data comes from patients with diabetes who met the inclusion criteria (e.g., older than 18 years of age; diagnostic with diabetes type II, uncontrolled sugar level, not using insulin) to be in a feasibility RCT to explore how individual and group cash rewards motivate individuals with diabetes to lose weight (www.clinicaltrials.gov NCT02891382, 2014). Using this information, we computed three fundamental parameters using a Nonlinear Least Squares procedure: the elasticity of losing weight to reward, the curvature of the cost of losing weight, and the intrinsic value associated to losing weight.

This approach has several advantages. First, it will allow researchers and policy makers to estimate how elastic effort is to reward, which in turn allows the computation of net benefits associated with different levels of rewards. Second, the approach will determine the magnitude of how costly individuals perceive the effort involved. Third, our methods will inform the question of whether individuals are willing to exert effort in the absence of a cash reward.

MODEL

We start with a simple economic model of an individual's decision to exert effort in preventive behavior. For a representative individual, the net utility from preventive effort E depends on the internal satisfaction it provides m plus any monetary reward received and, on the other hand, the cost of exerting a given level of effort $C(E)$. The presence of intrinsic motivation allows for the possibility that an individual may engage in preventive effort even in the absence of cash incentives. An individual also receives utility from effort if the effort is compensated with a monetary reward r. If we assume that the individual's marginal utility from internal motivation is constant and equal to *m* while the marginal utility of the rewards is also constant and equal to *r*, the utility from exerting a level of preventive effort for a representative individual is equal to:

$$u(E) = (m + r)E \quad C(E) \tag{1}$$

We assume that preventive effort is non-negative *E* 0 and that the cost function of effort is convex (i.e., both the first and second derivatives of the cost function are positive), so that more effort is always costlier, and this happens at an increasing rate. Following DellaVigna and Pope (2017), we first consider the following cost power function:

$$C(E) = \frac{\kappa E^{1+\gamma}}{1+\gamma} \tag{2}$$

where k *is* a cost adjustment scalar and is a parameter that describes the curvature of the power cost function. As a result, the problem of the individual is to choose *E* to maximize utility:

$$\max_E (m + r)E \quad \frac{\kappa E^{1+\gamma}}{1+\gamma} \tag{3}$$

The first order condition for an optimal level of effort implies that an individual will exert effort until the marginal benefit of effort equals marginal cost:

$$(m + r) \quad k{*}E \; = 0 \tag{4}$$

which leads to the optimal level of preventive effort for the individual:

$$E^* = \left[\frac{(m+r)}{\kappa}\right]^{\frac{1}{\gamma}} \tag{5}$$

Notice that, for a given level of cash reward, the optimal solution is a function of three parameters *m*, *k* , *gamma*, which values can be estimated using non-linear least squares.

Fundamental Results from the Power Cost Function

To estimate the structural parameters of the model, we will empirically test a series of additional theoretical results that are implied from the model.

- An increase in total reward (*m* + *r*) given a positive level of intrinsic motivation *m* will produce an increase in the optimal amount of preventive behavior if 1. We can see this result by looking at the partial derivatives of *E*⇤ with respect to (*m* + *r*):

$$\frac{\partial E^*}{\partial(m+r)} = \left(\frac{1}{\kappa\gamma}\right)\left(\frac{m+r}{\kappa}\right)^{1/(\gamma \quad 1)} > 0 \tag{6}$$

- A negative k implies a negative optimal effort. We truncate effort to be positive or equal to zero.

- In this model, optimal effort will be zero in the case of no reward and negative intrinsic motivation *m*, which would be the case when preventive effort produces displeasure. If *m* ⊚ 0 effort will be positive only if *r* is big enough. As a result, at low level of cash rewards may not be enough to compensate the negative internal displeasure of the activity.
- Effort could be zero if the marginal cost of the activity is larger than marginal benefit (*m* + *r*) at all levels of effort. This could happen even in cases where intrinsic motivation plus a low level of cash reward is positive.

Extending the framework to the Exponential Cost Function

In the case of the power cost function, it is straightforward to derive that the elasticity of preventive effort with respect to the total benefit (*m* + *r*) is constant at 1 (DellaVigna et al., 2016). This may seem too restrictive, considering that higher levels of self-management activities (e.g., weight management, exercise, etc.) provide lower value for larger efforts. Alternatively, one may assume that the cost of preventive effort follows an exponential cost function form.

To see a full derivation of these results, please see DellaVigna and Pope (2017). Fortunately, the general results discussed above also follow when one assumes an exponential cost function.

EMPIRICAL STRATEGY

In the previous section we presented a model for a representative individual where more effort is always costlier (and at an increasing rate), the reward to effort is constant (at best) or decreasing, and there are both an intrinsic motivation as well as extrinsic monetary incentive to exercise effort. To empirically estimate this basic model, we are going to introduce heterogeneity across individuals so that, in addition to the cognitive level, the preventive behavior cost function depends on the observed characteristics of the individuals.

Thus, the first order condition for optimal effort in the case of power cost function for individual *i* becomes:

$$\log(E_i^*) = \frac{1}{\gamma}[\log(m+r) \quad \log(\kappa)] + \beta x_i + \epsilon_i \tag{9}$$

where x_i is a set of the individual's observed characteristics (such as age, gender, marital status, household size, and education level), gamma is a vector of coefficients associated with each variable, and error is an unobserved *i.i.d.* random error, normally distributed with zero mean and finite variance.

Our empirical aim was to estimate the value of intrinsic motivation (*m*), the curvature of cost function and the scalar of the cost function using data from our sample. Having these parameters, we would estimate the elasticity of effort with respect to value. As the parameters in the model are nonlinear, we used a Nonlinear Lest Squares (NLS) procedure to estimate these parameters given the available data (Fox & Weisberg n.d.; Ratkowsky, 1993) for a detailed description of the method). We first estimate the model ignoring the individual's observed characteristics, we then include age and gender, and finally we estimate the model including all the individual's observed characteristics x.

In the case of exponential cost function, the equation to be estimated using NLS was:

$$E_i^* = \frac{1}{\gamma}[\log(m+r) \quad \log(\kappa)] + \beta \log x_i + \epsilon_i \tag{10}$$

Note that these equations could be estimated using a Minimum Distance Estimator approach; yet this approach ignores the possibility of including individual heterogeneity in the cost of effort function. Our approach incorporates differences in cost of effort due to individual observable variables. However, as it is standard in this literature, we assume that the effect of the reward of preventive effort as well as the intrinsic motivation is homogenous across individuals.

Data

Before starting our feasibility randomized trial, we conducted a survey with 100 patients with diabetes who met our inclusion criteria for a trial to be conducted in a later phase. We asked demographic, socio-economic, and health-related questions as well as gathered information on diagnostics, time since diagnosis of diabetes, and knowledge regarding diabetes.

Table 1 summarizes characteristics of the individuals enrolled in the experiment before conducting our trial. These patients did not participate in the feasibility randomized 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.

TABLE 1. SUMMARY STATISTICS FOR ALL RESPONDENTS

Variables	N	Mean	St. dev.
Panel A			
Age	100	55.17	11.79
Female	100	0.67	0.47
Married	100	0.33	0.47
Household Size	100	4.04	1.84
Education Level (N=100) Less than			
high school	11	0.11	0.00
High school	46	0.46	0.00
More than high school	43	0.43	0.00
Employed	100	0.55	0.50
Monthly Income Level (N=100) 0-2000			
soles	39	0.39	0.00
2001+ soles	35	0.35	0.00

Unknown	26	0.26	0.00
Insured	100	0.66	0.00
Panel B			
Self-reported Health Status (N=100)			
Poor	11	0.11	0.00
Good	52	0.52	0.00
Very Good	37	0.37	0.00
Weight (kg)	100	68.47	8.45
Height (cm)	100	161.61	8.18
BMI	100	26.32	3.56
Percentage Who Desire to Lose Weight	100	0.55	0.00
Years with Diabetes	100	6.92	5.07
Glycosylated Hemoglobin	59	8.93	1.64
Percentage Taking Diabetic Medication	100	0.92	0.00
Percentage Who Received Diabetes Education	97	0.24	0.00
Percentage Who Exercised to Lose Weight	98	0.53	0.00
Percentage Who Tried to Reduce Sugar Intake	98	0.75	0.00

Notes: We included all respondents to compute summary statistics. Married refers to being legally married; non-married includes single, living together, divorced, separated, widowed, and those who did not respond. Questions with three or more choices were collapsed to three choices. For most variables we did not impute values for missing. There were 14 missing values for weight, for which we imputed the mean of the other values of 68.47 kg, and 1 missing value for height, for which we imputed the mean value of 161.21 cm. Exchange rate is 3.37 Peruvian Nuevo Soles to 1 US Dollar (2016).

55% were employed, and 66% had health insurance. 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. Additionally, 55% of patients expressed a current desire to lose weight; and 75% indicated that they had tried to reduce sugar intake.

To elicit an individual’s ex ante willingness to exert effort to lose weight, we draw lessons from the public goods literature where individuals are questioned about their willingness to accept certain financial reward as compensation for approving an undesired social project, a situation known in the economic literature as a “not in my backyard” problem (Frey & Oberholzer-Gee, 1997). Specifically, we posed patients with one of two hypothetical reward schemes: the stated willingness to accept (WTA), where rewards are strictly nonnegative, and the stated willingness to deposit (WTD), where there is a chance of losing money.

In the first scheme, the stated willingness to accept (WTA), the patient is posed with a hypothetical scenario where she is invited to enroll in a three-month weight loss program aimed at losing one kilogram (i.e., 2.2 pounds) every other week in exchange of a fixed monetary compensation. Specifically, the patient has to state her willingness to participate if the biweekly reward were: (a) 50 Soles, (b) 100 Soles, (c) 150 Soles, (d) 200 Soles, (e) 250 Soles, (f) 500 Soles, or (g) nil (no monetary reward at all). In 2016, the exchange rate was 3.37 Peruvian Soles to 1 US Dollar.

In the second scheme, the stated willingness to deposit (WTD), the patient is posed with a hypothetical scenario where she is invited to enroll in a three-month weight loss program aimed at losing one kilogram every other week in exchange of a monetary compensation that is a function of achieving the weight lost goal and be willing to risk her own money. Thus, the patient would have to consider a hypothetical scheme where, every other week, she would be asked to make a deposit upfront. If the weight lost goal is achieved (one kilogram in two weeks) she receives double the amount deposited, but if the goal is not accomplished, the patient loses the amount deposited and a new deposit has to be made for the next round. Specifically, the patient has to state her willingness to deposit (a) 25 Soles for a chance of winning 50 Soles if she loses one kilogram in two weeks, (b) 50 Soles, (c) 75 Soles, (d) 100 Soles, (e) 200 Soles, (f) 250 Soles or (f) nil (no deposit at all).

Table 2 shows differences in WTA by group of respondents.

TABLE 2. SUMMARY STATISTICS FOR ALL RESPONDENTS

Variables	N	Mean	St. dev.	Min	Max	Median	Mode
Panel A. WTA Full sample	92	96.96	58.51	50	500	100	100
Female	66	84.39	35.91	50	150	100	50
Male	26	128.85	87.38	50	500	100	100
Age (years) 32 – 50	35	98.86	36.68	50	200	100	100
51 – 62	28	98.57	45.76	50	200	100	50
63 – 81	29	93.10	86.32	50	500	50	50
Education Level Less than high school	10	65.00	24.15	50	100	50	50
High school	45	96.67	40.45	50	200	100	100
More than high school	37	105.95	78.37	50	500	100	100
Panel B: WTD Full Sample	98	21.78	14.34	0	50	20	20
Female	67	23.73	14.10	0	50	20	20
Male	31	17.58	14.19	0	50	10	20
Age (years) 32 – 50	35	25.71	13.57	0	50	20	20
51 – 62	31	22.58	16.07	0	50	20	20
63 – 81	32	16.72	12.16	0	50	10	10
Education Level Less than high school	11	13.64	8.97	0	30	10	20
High School	45	24.56	14.33	0	50	20	20
More than high school	42	20.95	14.83	0	50	20	20

Notes: Eight individuals did not answer the questions on WTA. Two individuals did not answer the questions on WTD. Seven respondents reported a WTD value of 0. WTD values of 0 were changed to equal 0.02 prior to running the log transformation regression. Married refers to being legally married; non-married includes single, living together, divorced, separated, widowed, and those who did not respond. Questions with three or more choices were collapsed to three choices. For most variables we did not impute values for missing, though there were 14 missing values for weight, for which we imputed the mean of the other values of 68.47 kg, and 1 missing value for height, for which we imputed the mean value of 161.21 cm. Exchange rate is 3.37 Peruvian Nuevo Soles to 1 US Dollar (2016).

TABLE 3. SUMMARY STATISTICS FOR ALL RESPONDENTS TO WTA QUESTIONS

Variables	N	Mean	St. dev.
Demographics Characteristics Age	552	54.64	(11.94)
Female	552	0.72	(0.45)
Married	552	0.29	(0.46)
Household Size	552	4.04	(1.79)
Socio-Economic Characteristics			
Education Level			
Less than high school	552	0.11	(0.31)
High school	552	0.49	(0.50)
More than high school	552	0.40	(0.49)
Employed	552	0.54	(0.50)
Have insurance	552	1.33	(0.47)
Health Characteristics Weight (kg)	552	68.45	(8.52)
Height (cm)	552	161.30	(8.13)
Years with Diabetes	552	6.62	(4.71)
Education of diabetes	546	1.76	(0.43)
Have exercise	552	1.45	(0.50)

Notes: We included all respondents who responded to the Willingness to Accept questions to compute summary statistics. Married refers to being legally married; non-married includes single, living together, divorced, separated, widowed, and those who did not respond. Questions with three or more choices were collapsed to three choices. For most variables we did not impute values for missing, though there were 14 missing values for weight, for which we imputed the mean of the other values of 68.47 kg, and 1 missing value for height, for which we imputed the mean value of 161.21 cm. Exchange rate is 3.37 Peruvian Nuevo Soles to 1 US Dollar (2016).

Table 3 shows the descriptive statistics of the respondents. In the case of WTA, the modal response as well as the median is 100 Soles. This is consistent with other conditional cash transfer programs in Peru. For instance, Juntos a Peruvian social inclusion cash transfer program provides 200 Soles every two months to women with children under 5 years of age. The minimum value to accept participation was 50 Soles every other week which represents around 12% of the official minimum wage in Peru in 2016, being 850 Soles a month (e.g., 212.50 Soles a week). This is consistent with figures provided in the literature to estimate optimal size of cash reward from formative research (Rawlings, 2006). The average value reported for participation in the program was around 100 Soles (by weekly) with 59 Soles as a standard deviation. This represents 200 Soles a month which is approximately 24% of monthly minimum wage. Interestingly, none of the respondents reported a WTA value of zero. From the sample, eight did not respond to these questions. The WTA is higher for males and for individuals with higher education. This may be consistent with higher earned wages and cost of time for this group. It is important to mention that interviewers need some patience to engage participants given that, perhaps for cultural reasons, they usually stated up-front that just improving their health would be enough incentive to exert effort, but when they considered the monetary payments, they indeed provided answers.

The responses to the WTD questions are presented in Table 2. As expected, the amounts to participate are consistently lower than the amount reflected in the WTA questions. Seven individuals refused participation in an uncertain contract scheme to lose weight. Individuals would allocate on average 21 Soles every other week with a maximum of 50 Soles. Older, and more educated male participants were less likely to allocate their own money to assert effort to lose weight. This may reflect that these individuals were more realistic about their capacity to change behavior.

Finally, in our empirical section effort is measured as a dummy variable that equals 1 if the respondent takes the offer or is willing to deposit the money. For everyone, we construct one response for each level of cash reward.

In the next section, we explore how elastic to losing weight individuals are in relation to cash reward size assuming two different cost functions of losing weight. We will present the results using all responses from the WTA section. This implies that the sample size for the estimation of optimal effort compromises 552 responses (e.g., 92 individuals with six complete WTA answers). In the robustness checks section, we will discuss the results using the WTD responses.

RESULTS

We started by running a naïve linear probability model to explore the role of cash rewards in the probability of losing weight. As shown in Table 4, using WTA responses, the value elasticity of effort is positive and inelastic (0.129 power cost function; and 0.189 in the exponential cost function). In both cases, the results were statistically significant at $p < 0.01$. Although results from these regressions may suggest that policy makers should not expect a big individual response in effort by increasing the size of the reward, these results are difficult to interpret as they are not based on a conceptual framework. In fact, these results do not provide full information on how cost of effort increases with effort; or how important is intrinsic motivation and external reward to move individuals to exert effort to lose weight. Both elements will impact the individual's optimal level of effort.

TABLE 4. OLS ESTIMATES OF THE DETERMINANTS OF EFFORT TO LOSE WEIGHT AMONG PEOPLE WITH DIABETES

	Constant Cost Function Coeff./ St. Err.	Exponential Cost Function Coeff./ St. Err.
ln (Received Reward)	0.129***	0.186***
	(0.005)	(0.007)
Individual Characteristics Age	0.001	0.041
	(0.001)	(0.083)
Female	0.087***	0.180***
	(0.021)	(0.044)
Married	0.0147	0.039
	(0.023)	(0.047)

Household Size	0.005	0.005
	(0.005)	(0.026)
Education (Ref: less than high school)		
High School	-0.0643**	-0.129*
	(0.033)	(0.067)
More than High School	-0.058	-0.129*
	(0.036)	(0.074)
Years w/Diabetes	-0.002	0.001
	(0.002)	(0.014)
Constant	-0.1380*	(0.259)
	(0.080)	(0.343)
R-sqr	0.586	0.585
N	552	552

Notes: Robust Standard Error in Parentheses,(***) Significant at 1%, (**) at 5%, (*) at 10%. All control variables in the constant cost function are included in their scale while in the exponential cost function are included in log form. In the constant cost function, before taking the log, the dependent variable was transformed to a value 0.02 when the values were zero. Married refers to being legally married; non-married includes single, living together, divorced, separated, widowed, and those who did not respond. Questions with three or more choices were collapsed to three choices. We did not impute values for missing, though there were 14 missing values for weight, for which we imputed the mean of the other values of 68.47 kg, and 1 missing value for height, for which we imputed the mean value of 161.21 cm. Exchange rate is 3.37 Peruvian Nuevo Soles to 1 US Dollar (2016).

The additional analysis driven by economic theory is more informative in terms of the whole picture to motivate changes in health behavior using monetary rewards. Table 5 shows the results from a Nonlinear Least Squares procedure for both cost functions for three different models. In this section, we discussed the results from the model where we included all the control variables (Panel C).

TABLE 5. NON-LINEAR ESTIMATES OF THE DETERMINANTS OF EFFORT TO LOSE WEIGHT AMONG PEOPLE WITH DIABETES (N=552)

	Constant Cost Function Coeff./ St. Err.	Exponential Cost Function Coeff./ St. Err.
Panel A: Model 1		
Curvature of the cost function (1/gamma)	0.124***	0.491***
	(0.025)	(0.078)
Intrinsic motivation value (*m*)	22.532***	27.231***
	(4.734)	(7.009)
Scalar of the cost function (k)	31.443***	41.3562*
	(10.913)	(25.329)
Controls Demographic	No	No
Control Education	No	No
Control Health (years with diabetes)	No	No
Panel B: Model 2		
Curvature of the cost function (1/ gamma)	0.271***	0.467***
	(0.029)	(0.051)
Intrinsic motivation value (*m*)	24.734***	27.391***

	(5.119)	(6.993)
Scalar of the cost function (k)	33.993***	43.4365*
	(10.781)	(24.976)
Controls Demographic	Yes	Yes
Control Education	No	No
Control Health (years with diabetes)	No	No
Panel C: Model 3		
Curvature of the cost function (1/)	0.329***	0.475***
	(0.037)	(0.054)
Intrinsic motivation value (*m*)	26.897***	26.897***
	(7.768)	(7.782)
Scalar of the cost function ( )	37.653***	42.72282*
	(11.674)	(26.985)
Controls Demographic	Yes	Yes
Control Education	Yes	Yes
Control Health (years with diabetes)	Yes	Yes

Notes: Robust Standard Error in Parentheses, (***) Significant at 1%, (**) at 5%, (*) at 10%. All control variables in the constant cost function are included in their scale while in the exponential cost function are included in log form. In the constant cost function, before taking the log, the dependent variable was transformed to a value 0.02 when the values were zero. Married refers to being legally married; non-married includes single, living together, divorced, separated, widowed, and those who did not respond. Questions with three or more choices were collapsed to three choices. We did not impute values for missing, though there were 14 missing values for weight, for which we imputed the mean of the other values of 68.47 kg, and 1 missing value for height, for which we imputed the mean value of 161.21 cm. Exchange rate is 3.37 Peruvian Nuevo Soles to 1 US Dollar (2016).

In the case of the Power Cost Function, the value elasticity of effort is positive and inelastic (0.329); but the parameter is greater than the one obtained using the naïve Ordinary Least Squares (OLS) approach. It is still statistically significant at $p < 0.01$. The estimation indicates that an individual receives positive satisfaction from the effort (m = 26.897, $p < 0.01$). However, the coefficient of the scalar of cost function indicates a steep change in cost (37.653, $p < 0.01$). Interpreting these results together suggests that an individual will exert effort at zero cash reward as the FOC for maximizing utility would imply a low positive level of effort. Figure 1 displays the level of optimal effort (level where marginal benefit equals marginal cost) under the assumption of power cost function at different level of rewards. Assuming internal satisfaction and a certain level of rewards, one could see that optimal level increases with reward size.

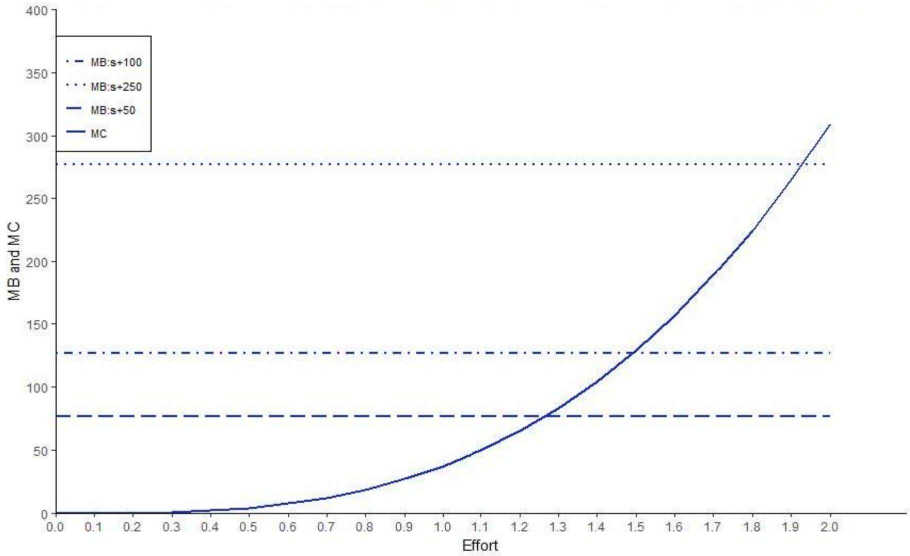

FIG 1. LEVELS OF OPTIMAL EFFORT, POWER COST FUNCTION

Fitting the data to an Exponential Cost Function highlights similar findings. Individuals show a similar curvature of the cost function (0.475, $p < 0.01$). Notice, however, as shown in the previous section, in this case, the value elasticity of effort will depend on the level of reward and (✈). An individual receives positive satisfaction (*m*); and the estimate in this case is like the one estimated using a power cost function. The scalar of the cost function (42.723, $p < 0.10$) is positive and higher than in the case of the power cost function. These results suggest that an individual would need at least up to 16 Soles every other week to exert positive effort. Figure 2 shows optimal level of assuming an exponential cost function. As was mentioned before, at a low level of reward an individual would prefer not to exert effort. After a certain level of reward (around 16 soles every other week), it is optimal for an individual to exert positive effort. Notice that optimal level increases with the level of cash reward.

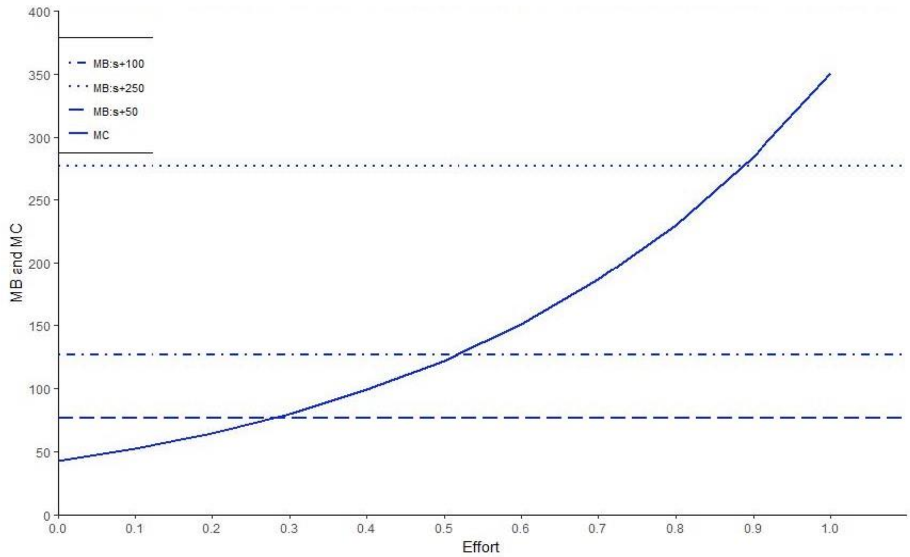

FIG 2. LEVELS OF OPTIMAL EFFORT, EXPONENTIAL COST FUNCTION

Turning our attention to the value elasticity of effort, given the estimated parameters ✈ and *m*, one could report different levels of elasticities (one should recall that in the case of exponential function the value elasticity of effort is not constant). The first implication from this analysis is that above the minimum required to exert positive effort (e.g., 16 Soles every other week), the value elasticity of effort is positive. Now, for a reward level of approximately 60 Soles every other week, the value elasticity of effort is around 3 which represents a very elastic response. At 200 Soles every other week, the value elasticity of effort is still positive and around 1.37. If one assumes a reward of 500 Soles every other week would reduce the elasticity to 0.91. However, this would imply a level of reward bigger than the monthly minimum wage (around 850 Soles a month). In short, the results suggest that individuals have a very elastic response to a lower level of rewards above 16 Soles every other week; however, the value elasticity of effort becomes inelastic at a high level of rewards (around 500 Soles bi-weekly).

These results suggest that, under both types of cost functions, individuals with diabetes receive internal satisfaction from exerting effort to lose weight. The curvature of the cost function and the scalar imply that preventive effort is costly. Therefore, a low level of reward is not enough to outweigh the marginal cost of effort. The value elasticity of effort is positive in both estimations. Yet, the value may oscillate 0.32-1.3 for reasonable sizes of the cash rewards (between 80-200 Soles every other week). For higher values of rewards, the analysis indicates a low level of value elasticity of effort. This means that researchers or policy makers may achieve low pay out from offering extremely high reward amounts.

These results are inconsistent with previous findings in the literature of smoking cessation and substance abuse. For instance, (Lussier et al. 2006) reports that larger sizes of the cash rewards create a larger response in reduction of substance abuse than smaller cash rewards; yet their results are based on two magnitudes of cash rewards. As we pointed out, the value elasticity of effort may differ between the size of the reward and the cost of effort. Positive effects of cash reward size and effort in the case of smoking cessation abuse have been reported by Hughes (2003), Correia & Benson (2006), Sindelar (2008), Volpp et al., (2009).

ROBUSTNESS CHECKS

In this section, we present three different robustness checks that we conducted. First, we estimated the NLQR parameters starting from a reduced-form model where only age and gender were included. We then ran models where marital status and household size (two possible choice variables) were included. In our last model specification, we included the variables for education level as well as years since diagnosis of diabetes. Overall, the main findings reported in the previous sections do not change significantly for both the power cost function and exponential cost function. Broadly speaking, in all estimations an individual receives intrinsic benefits from preventive care. However, given the curvature of the cost function, low levels of rewards are not enough to motivate individuals to exert preventive effort and the value elasticity of rewards in most cases is inelastic (See panel A and panel B in Table 5).

TABLE 6. NON-LINEAR ESTIMATES OF THE DETERMINANTS OF EFFORT TO LOSE WEIGHT AMONG PEOPLE WITH DIABETES (WTD)

	Constant Cost Function Coeff./ St. Err.	Exponential Cost Function Coeff./ St. Err.
Individual Characteristics Age	0.001	0.041
	(0.001)	(0.078)
Female	0.087***	0.180***
	(0.019)	(0.041)
Married	0.015	0.039
	(0.021)	(0.044)
Household Size	0.004	0.005
	(0.005)	(0.024)
Education (Ref: less than high school) High School	-0.064*	-0.1290*
	(0.030)	(0.062)
More than High School	-0.058*	-0.1290*
	(0.033)	(0.074)
Years w/Diabetes	(0.002)	0.001
	(0.002)	(0.013)
R-sqr	0.642	0.585
N	552	552
Curvature of the cost function (1/gamma)	0.329***	0.475***
	(0.037)	(0.054)
Intrinsic motivation value (*m*)	26.897***	26.897***
	(7.768)	(7.782)
Scalar of the cost function (k)	37.653***	42.72282*
	(11.674)	(26.985)

Notes: Robust Standard Error in Parentheses, (***) Significant at 1%, (**) at 5%, (*) at 10%. All control variables in the constant cost function are included in their scale while in the exponential cost function are included in log form. In the constant cost function, before taking the log, the dependent variable was transformed to a value 0.02 when the values were zero. Married refers to being legally married; non-married includes single, living together, divorced, separated, widowed, and those who did not respond. Questions with three or more choices were collapsed to three choices. We did not impute values for missing, though there were 14 missing values for weight, for which we imputed the mean of the other values of 68.47 kg, and 1 missing value for height, for which we imputed the mean value of 161.21 cm. Exchange rate is 3.37 Peruvian Nuevo Soles to 1 US Dollar (2016).

Second, we investigated whether using the WTD data leads to different conclusions. In WTD, the value of exerting effort to lose weight is driven by an individual's willingness to participate in a contingent contract (See Table 6). As we pointed out in the previous section, the WTD figures are smaller than WTA for a similar level of effort. Interestingly, the results from this analysis led us to reach similar conclusions regarding the value of intrinsic motivation, the curvature of the cost function, and the value elasticity of effort. However, in this case, the value elasticity of effort is smaller than the estimate using WTA data while the curvature of the cost function is more pronounced.

Third, we estimated the parameters of interest (*k*,*m*) using a Minimum-Distance approach under the assumption of the power cost function as well as the exponential cost function. Essentially, under this method, we did not include any possible heterogeneity in the cost functions that may come from individual differences such as age, gender, marital status, and other observable covariates. We derived confidence intervals using standard bootstrap methods.

TABLE 7. MINIMUM DISTANCE ESTIMATOR OF THE DETERMINANTS OF EFFORT TO LOSE WEIGHT AMONG PEOPLE WITH DIABETES

	Constant Cost Function Coeff./ St. Err.	Exponential Cost Function Coeff./ St. Err.
Curvature of the cost function (1/gamma)	0.215***	0.187*
	(0.083)	(0.124)
Intrinsic motivation value (*m*)	4.2E-09	1.604
	(0.001)	(2.415)
Scalar of the cost function (*k*)	313.158***	1.565
	(5.615)	(2.395)

Notes: Robust Standard Error in Parentheses, (***) Significant at 1%, (**) at 5%, (*) at 10%. Both models do not include control variables. In the constant cost function, before taking the log, the dependent variable was transformed to a value 0.02 when the values were zero. We use as moments the average efforts for the following rewards 0, 50 and 250. Exchange rate is 3.37 Peruvian Nuevo Soles to 1 US Dollar (2016).

Table 7 shows the main results using WTA responses. The results are like those obtained using the NLQR approach. However, the value elasticity of effort is less inelastic under both cost specifications and the intrinsic motivation parameters are smaller than previous estimates. The scalar of the cost function is still positive under both estimation methods. All this suggests that, although effort increases with reward, the internal motivation value of the activity is such that low level of rewards may not be sufficient to motivate an individual to exert preventive effort.

CONCLUSION

This paper proposes a method to estimate the size of cash rewards in health interventions using information about individuals' ex ante preferences to exert effort to lose weight. The approach uses a questionnaire regarding a hypothetical scheme and probe individuals about their willingness to exert effort to lose weight at different levels of financial reward. We test two hypothetical schemes: the stated willingness to accept (WTA), where rewards are strictly nonnegative, and the stated willingness to deposit (WTD), where there is a chance of actually losing money.

Making reasonable assumptions about the cost associated to lose weight among individuals with diabetes, we can compute three relevant parameters: the curvature of the cost of effort, the intrinsic value of exerting effort, and the value elasticity of effort. We argued that these parameters are valuable for researchers to define more feasible experimental interventions. For instance, using this information, one could model the possible dose-response effort curve with respect to different levels of cash rewards before implementing a trial where the range of the interventions must be determined in advance. We also argued that knowing these parameters provide relevant information to policy makers who would like to motivate changes in health behavior using cash rewards. Our methodology could be used in a larger set of social contexts where policy makers look for the use of cash rewards to influence changes in social behavior.

Our approach is a first attempt to determine the optimal amount of cash reward assuming this amount is fixed for each level of effort. This implies that we only focus on one of the many dimensions of the reward scheme. Certainly, the architecture of a reward schemes may consider other elements such as group versus individual, frequency, what do we reward among other elements. Here the variation considered is very specific. However, defining the size of the cash reward is usually the salient aspect of the scheme in most health interventions. Future research should consider other aspects as they estimate size of the cash reward. One starting point for future researchers may be to consider incentive schemes that are convex (to map the convexity of effort cost). We hope our paper motivates this type of empirical work in the future.

The results suggest that an individual receives intrinsic satisfaction from the effort to lose weight. Yet, at low levels of cash rewards (e.g., 16-40 Soles every other week), the marginal benefit of effort is not enough to cover the marginal cost of effort. We find that the elasticity of effort with respect to the cash reward is inelastic. In the case of an exponential cost function of effort, the results suggest that the response in effort to size of the reward is very elastic at low level of rewards. Yet, at higher levels of rewards, the response becomes inelastic (in our case this happens around 200 Soles every-every-another week). Lastly, the curvature of the cost of effort to lose weight among the people with diabetes in our sample is steep.

The aim of this method was not to investigate the channels through which cash rewards motivate individuals to change health behavior. It could be that cash rewards change an individual's perception of the internal value of effort; or it could be that cash rewards may have an income effect that reduces the cost of effort (e.g., increased intake of more expensive and nutritious food). As we described earlier, in our economic model we assumed that the marginal value of effort was constant so that intrinsic motivation did not depend on the size of the reward. Our model also assumed that a cash reward does not impact the cost of effort. Lastly, we assumed that the intrinsic value of effort was constant across individuals. Future research could consider expanding the economic model to incorporate these assumptions.

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