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Possibilities to Model Patients' Preferences and Their Willingness to Pay for a Molar Treatment

Próba modelowania preferencji pacjenta i jego gotowość do płacenia za leczenie zębów trzonowych

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A – research concept and design; **B** – collection and/or assembly of data; **C** – data analysis and interpretation; **D** – writing the article; **E** – critical revision of the article; **F** – final approval of article

Abstract

Background. This study is an attempt to model patient's preferences for molar treatment and the willingness to pay (WTP) for a chosen health alternative. The results from modeling could be used as a basis for making more efficient decisions from both medical and economic point of view. The study is based on questions from Vernazza's interview.

Objectives. The first purpose of present study is to be explored and established the most wished preferences from previously stated ones and closely related with patient choice's WTP. The second aim is to be built and interpreter models of the consumer choices and its WTP.

Material and Methods. The sample consisted of 111 adult patients who visited for treatment different dental cabinets located in Plovdiv, Bulgaria. The study was conducted using the method of direct anonymous questionnaire containing questions on the choice of health alternative and the WTP for it; demographic, social and economic characteristics of respondents; history and severity of dental diseases, and frequency of dental visits. The study used two types of regression models: binominal logit of patient's choice and negative binominal of the WTP for a crown that led to statistically credible results.

Results. The main predictor for the willingness to pay turned out to be the total monthly income of the household. Other factors, such as frequency of visits to the dentist, age or employment status of respondents can not be used to explain the changes in their WTP.

Conclusions. The economical factors especially the WTP and the household income stay essential. That empirically confirmed fact puts the economic welfare and it variables as predictors with critical meaning in health market researches. The second important outline is that we found a similarity in results with Vernazza's study. That fact supports a reliability of the applied instrument **(Dent. Med. Probl. 2016, 53, 1, 41–49).**

Key words: decision making, out-of-pocket payments, molar, decision modeling.

Sowa kluczowe: podejmowanie decyzji, opłaty nierefundowane, ząb trzonowy, modelowanie procesów decyzyjnych.

The purpose of this study is to model two variables of essential importance to the analysis of the financial burden of certain dental diseases. These are the patients' preferences for the treatment of a broken molar with treated root canals and their willingness to pay for the selected option.

The tools used to identify patients' preferences and their willingness to pay are based on Vernazza's interview [1] used in his doctoral thesis entitled "The monetary value of oral health: willingness to pay for treatment and prevention". Vernazza used an interview for his study. We compiled a direct anonymous questionnaire containing Vernazza's questions relating to:

– alternative health conditions that respondents were facing: explanations were given in the beginning of the questionnaire;

– reasons for and frequency of the visits to the dentist.

To elicit willingness to pay, Vernazza [2] used the so-called payment cards with different amounts printed on them that the respondent chooses to pay. The choice of maximum amount to pay is established using accessory technique according to which the respondent was asked to place these cards in three piles: amounts that he or she is willing to pay, amounts that he or she could not afford, and amounts that he or she is hesitating about.

In our questionnaire, which aimed to measure the willingness to pay, we formulated a direct open question immediately following the chosen health option. For the full picture concerning the set of auxiliary scenarios used to extract individual valuations of WTP, as well as for comparative analysis of their benefits and drawbacks, one can refer to the work of Robert et al. [3].

Materials and Methods

Between April 2013 and May 2013, we conducted a study among adult patients within the city of Plovdiv. The full list of all practicing dentists in the city was taken from the Regional College of the Bulgarian Dental Association. Five dentists who confirmed their willingness to take part to the study were randomly selected. They were given 25 questionnaires each to distribute among their respective patients. The study involved only persons aged 18+ without further selection, based on voluntary participation. Of all 125 questionnaires, 111 were returned.

More specifically, the questionnaire contained questions relating to:

1) demographic characteristics of respondents;

2) economic and social status: income per household, employment, state/private health insurance, or exposure to occupational diseases;

3) history of dental diseases of respondents, including frequency of visits to the dentist and reasons for those visits;

4) choice of treatment option;

5) determination of the willingness to pay through a direct open-ended question concerning the chosen treatment option and sub-options.

The respondents were given two options for the treatment of a cracked molar with removed nerves. Option A provided respondents with the opportunity to retain their tooth using root canal therapy and restoration with a crown, whereas option B involved extraction of the tooth followed by four possible scenarios:

1) leaving a gap (B1);
2) placing a removable denture (B2);
3) placing a bridge (B3);
4) placing an implant (B4).

In the course of the study were interviewed 111 adult patients. The number of valid filled-in questionnaires was 111. Demographic information was gathered using questions relating to gender, age and education. Social and economic characteristics were established through questions on employment, state/private health insurance and income of the household. The question on household income was close-ended with an eight-level scale in increments of BGN 300. The lowest income level was up to BGN 200, and the highest level was BGN 2000 or more. It should be noted that the exchange rate of the Bulgarian currency against the Euro is fixed (EUR 1 = BGN 1.95583) as part of the policy of currency board introduced in 1997. The average monthly exchange of the Bulgarian currency against the US dollar over the period of the study was USD 1 = BGN 1.50 in April 2013 and USD 1 = BGN 1.51 in May 2013 [4].

In addition, a question concerning the payment vehicle (similar to that of Vernazza's study) for dental services was asked. The following options were considered: services covered by the state health insurance (National Health Insurance Fund), services covered by private health insurance, and direct payment by the patient.

The data was processed using SPSS 22 software with correlation and non-parametric analyses at a significance level of $p< 0.05$ and it was interpreted by binominal logit model of patient preferences and a negative binominal model for the willingness to pay for a crown.

Results

The average age of respondents was 45.17 years of age with a standard deviation 14.31. The distribution by gender was as follows: men 41.8% (n = 46) and women 58.2% (n = 64).

The proportion of holders of a Master degree was the highest (37.3%, n = 41), followed by high school graduates (30.9%, n = 34). Holders of a Bachelor degree occupy 24.5% (n = 27) of validly filled-in questionnaires, while people with elementary education and holders of a Doctor of Philosophy degree accounted respectively for 0.9% (n = 1) and 6.4% (n = 7).

Much higher was the proportion of employed people (81.8%, n = 90) compared to those who

were unemployed and thus had no income from salaries (18.2%, n = 20).

A significant part of respondents (86.5%, n = 96) chose option A, which means that they preferred to retain the tooth and have it treated rather than have it extracted.

Those who opted for extraction of the molar (13.5% n = 15) chose the following sub-options:

1) extraction of the tooth leaving a gap (40%, n = 6);

2) removable prosthesis with a false tooth (33.3%, n = 5);

3) bridge with a false tooth (46.7%, n = 7); and

4) implant and a false tooth on top (46.7%, n = 7).

The proportions and numbers of those who have selected any of the sub-options are higher than for those who have selected option B because some respondents have given more than one answer.

The average amount that respondents who chose option A are willing to pay was BGN 121.30, with standard deviation of BGN 84.53. The lowest amount specified was BGN 20, and the highest one was BGN 500. One respondent chose that option but indicated that he was willing to pay BGN 0 for the specific treatment, and four respondents left the willingness-to-pay field unfilled.

The graphic representation of frequency distribution of answers on willingness to pay for option A is given on Figure 1 and it is obviously different from normal distribution.

The Kolmogorov-Smirnov non-parametric test (Kolmogorov-Smirnov Z = 1.997; P = 0.001) confirms that fact. The absence of normal distribution for the dependent variable limits the possibility to use the ordinary least squares method or the analyze of variance (ANOVA) based on F-statistics.

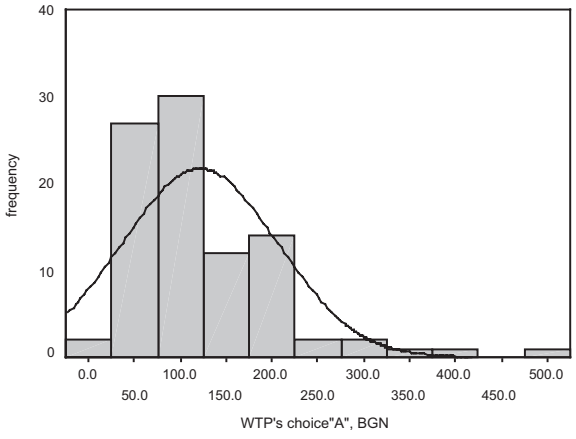

Fig. 1. Empirical frequency distribution of willingness to pay for option A

1. Logistic Regression Model Describing the Correlation Between Initial Choice (Treatment vs. Extraction) and Dental History

The initial choice is a dichotomous value that represents the chosen basic scenario for tooth treatment. Logically, that choice may depend on several variables. In our case, these are the history of dental diseases, or rather the frequency of recent manipulations, and the income level. We believe that the level of education may also be taken as an independent variable.

Modeling is possible directly on the basis of input data for independent variables or on the basis of their values grouped in a certain way. For example, the questions used to elicit the frequency of recent manipulations are by nature quantitative and continuous measures of respondents' dental history. However, we could also build our models on the basis of their dichotomous value: presence or absence of such interventions, or a history of disease. In the initial question, income was divided into eight levels, but, there too, we could attribute dichotomous values such as low/high income for the purposes of our model, or use the ordinary scale from 1 to 8. Since the dependent variable, i.e. the initial choice, is discrete, with two values, it would be appropriate to use binominal logit regression to study the changes to this variable induced by the factors.

Like in Vernazza's study, we used coded dichotomous scales for factor variables: presence/ /absence of experience with a crown, with root canal treatment, tooth extraction, and income level (low level up to BGN 800; mid and high level above BGN 800.01).

Table 1 shows the results from logit regression analysis.

The results from the table, which give a general idea of the model's properties, do not allow us to conclude that it has statistical power. All four independent variables are not statistically significant predictors. The variables income level and history of dental diseases chosen do not allow us to explain the dispersion of the dependent variable initial choice (treatment vs. extraction). It is obvious that for this sample the changes to preferences cannot be explained by changes to the income or to the number of recent interventions. The coefficients of determination of Cox & Snell and Nagelkerke take values close to zero with 0.053 and 0.096 respectively.

We obtain very similar results trying to build the same model using data from the sample based on the actual number of interventions in terms of

Table 1. Evaluation of regression coefficients of the logistic function with patient's choice as dependent variable and income level and dental history as independent variables

Independent variable	Odds Ratio (Exp (B))	B	SE	Wald test	*P* Value	95% confidence interval
Monthly household income (low – up to 800 BGN; mid and high – above 800.01 BGN)	1.26	0.235	0.588	0.159	0.690	0.40–4.00
Experience of crown (versus no experience)	3.93	1.369	0.739	3.431	0.064	0.92–16.72
Experience root canal treatment (versus no experience)	0.90	–0.111	0.714	0.024	0.878	0.22–3.63
Experience of extraction (versus no experience)	0.39	–0.935	0.635	2.169	0.141	0.11–1.36
Constant		1.779	0.579	9.448	0.002	

Table 2. Evaluation of regression coefficients of the logistic function with patients' choice as dependent variable and the actual measured values of income and dental history as independent variables

Independent variable	Odds Ratio (Exp (B))	B	SE	Wald test	*P* Value	95% confidence interval
Monthly household income	1.11	0.11	0.148	0.506	0.477	0.83–1.48
Experience of crown	4.20	1.44	0.632	5.159	0.023	1.22–14.51
Experience of root canal treatment	0.56	–0.58	0.373	2.430	0.119	0.27–1.16
Experience of extraction	0.75	–0.29	0.168	3.03	0.082	0.54–1.04
Constant		1.37	0.774	3.391	0.066	

Table 3. Marginal effect of independent variables on patient choice

Independent Variable	Mean	B	Mean*B	F(Z)	B* F(Z)
Household income	4.42	0.11	0.4862	0.0864	0.0095
Experience of crown	0.771	1.44	1.1102	0.0864	0.1244
Experience of root canal treatment	0.706	–0.58	–0.4095	0.0864	–0.0501
Experience of extraction	1.064	–0.29	–0.3086	0.0864	–0.0251
Constant	1	1.37	1.37		
Z =			2.2484		

crowns, root canal treatments, number of extracted teeth, and level of income. Such a model has only one statistically significant variable, which is the number of crowns placed. The data for the model is summarized in Table 2.

Like the previous model, this one does not offer high analytical value. In this case, only one independent variable has a statistically significant effect on the respondents' initial choice. It is the number of crowns installed, or the crown experience determined as an absolute value. The coefficient in front of that variable has a statistically signification evaluation (B = 1.44; P = 0.023). The coefficients of determination for this model are slightly higher: Cox & Snell R^2 = 0.089 and Nagelkerke R^2 = 0.161.

The marginal effect of independent variables on the probability for choosing the option to keep the tooth and have it treated rather than choosing extraction is shown in the table below (see Table 3). To represent the marginal effect of predictors on the resulting variable we have used Dougherty's approach [5].

When we sum up the product of the average values of independent variables (Mean) and the coefficients (B) for the value of parameter "Z", we obtain 2.2484, and for "e^{-Z}" and "F(Z)" we obtain 0.1056 and 0.0864 respectively. On the basis of these statistics, the highest marginal effect on the choice to have the tooth treated versus extraction was obtained from experience with crowns. In this case, the probability to choose to keep the tooth and have it treated rather than extracted increases by 12.44 percent points per unit of increase in the number of crowns placed as part of the history of dental diseases.

2. Modeling the Willingness to Pay for a Crown

Several approaches are possible for modeling WTP.

The first approach involves the building of a tobit (censored) regression model provided that a lower limit and an upper limit have been assumed for WTP. Another condition to the use of a tobit model is that the dependent variable, in this case WTP, should be a continuous quantity.

The second approach can be implemented using models with a discrete dependent variable. In that direction there are two potential choices: a negative binominal regression or a regression based on the Poisson distribution.

A third possibility to explain the changes in WTP could be found in a mono- or multifactor regression built using the ordinary least squares method. In this case there are several conditions concerning the initial data: the variables used must be continuous and with normal distribution.

Table 4 shows Pearson correlation coefficients (r_s) for observed quantitative variables that could logically be predictors for the willingness to pay.

The highest correlation coefficient obtained is between the willingness to pay and household income (r_s = 0.472). Among procedures performed recently, which are a kind of evaluation of dental history, a relatively higher correlation is obtained between the willingness to pay and cleaning of scale. In all other cases, including age, no statistically significant correlations could be found. This suggests that household income is probably the most appropriate factor to use for modeling WTP for a crown.

The dispersion of WTP in the eight income groups used exceeds in all cases its average value. This is shown in Table 5.

With this in mind and taking into consideration the discrete nature of the dependent variable, as well as the absence of normal distribution, as most appropriate model of the willingness to pay with independent variable the total household income (HI) could be used the negative binominal model. The explanation of our model is based on the clarifications given by the "UCLA: Statistical Consulting Group" [6]. The negative binominal model of WTP for a crown, presented as a linear combination of the dummy variables that characterize income in the different groups and a constant, takes the following analytical appearance:

$$\text{Ln (WTP)} = \beta_0 + \beta_1 \cdot HI_2 + \beta_2 \cdot HI_3 + \\ + \beta_3 \cdot HI_4 + \beta_4 \cdot HI_5 + \beta_5 \cdot HI_6 + \beta_6 \cdot HI_7 + \beta_7 \cdot HI_8.$$

Table 6 shows the negative binominal regression coefficients with their standard errors, the Wald Chi-Square test, p-values and the 95% confidence interval of estimates.

We should note that the estimates of coefficients in column "B" represent the expected log counts that have an additive effect on household income. However, statistically significant are only the coefficients of HI_8 and HI_6 variables, and the constant. Therefore, the analytical appearance of our model will be as follows:

$$\text{Ln (WTP)} = 3.912 + 1.02 \cdot HI_6 + 1.47 \cdot HI_8.$$

The coefficients in Table 6 have an additive effect on Ln (WTP), which means that with each increase of the dummy variable HI_6 compared to HI_1 by one unit the expected value of the natural logarithm for the willingness to pay will increase by 1.02. The same applies to the effect of the other statistically significant variable, HI_8, but in that case the increase compared to HI_1 will result in the increase of the natural logarithm of WTP by 1.47 units.

After reversing the logarithm for the willingness to pay, we will obtain the following exponential function:

$$\text{WTP} = e^{3.912 + 1.02 \cdot HI_6 + 1.47 \cdot HI_8} = 50 \cdot e^{1.02 \cdot HI_6} \cdot e^{1.47 \cdot HI_8}.$$

In this case, the estimates of coefficients have a multiplication effect on the actual expected values of WTP and represent the incident rate. This model is statistically credible (compared to a similar model without predictors and only with a constant), which is confirmed by the so-called omnibus test (likelihood ratio chi^2 = 28.481 with df = 7, and P = 0.000). The test of effects of the model also gives a positive estimate of its statistical significance (Wald chi^2 = 31.64 with df = 7 and P = 0.000). This suggests the conclusion that the household income variable on the proposed scale could be used as predictor for the expected willingness to pay to keep the tooth or for placing a crown.

Discussion

In the process of modeling of the initial choice, i.e. whether to have the tooth extracted or to save it and have it treated, Vernazza [7] encoded the output in terms of presence/absence for relevant interventions or in terms of low/high for the income. In the first model of the base preference, independent variables are the socio-economic status, experience with crowns, experience with root canal treatment and with tooth extraction. All four variables appear to be statistically significant predictors of the basic patient choice. We saw that a similar model in the frame of our study was statistical-

Table 4. Correlation coefficients between willingness to pay for a crown, dental history for the past two years, household income and respondent's age

		WTP for a crown	Number of manipulations (dental history for the past two years)							Household income	Age
			Scale and polish	Fillings	Crowns	Bridge	Root Canal Treatment	Extraction	Dentures		
WTP for a crown	Pearson's r *P* Value	1	0.317** 0.002	0.191 0.072	0.05 0.64	−0.186 0.079	0.119 0.266	−0.155 0.144	−0.003 0.977	0.472** 0	−0.185 0.079
Scale and polish	Pearson's r *P* Value	0.317** 0.002	1	0.464** 0	0.136 0.192	−0.087 0.406	0.260* 0.011	−0.04 0.705	−0.072 0.49	0.086 0.415	−0.224* 0.031
Fillings	Pearson's r *P* Value	0.191 0.072	0.464** 0	1	0.412** 0	0.02 0.851	0.512** 0	0.292** 0.004	−0.17 0.101	0.072 0.491	−0.178 0.087
Crowns	Pearson's r *P* Value	0.05 0.64	0.136 0.192	0.412** 0	1	0.163 0.117	0.690** 0	0.345** 0.001	−0.113 0.28	−0.116 0.27	0.075 0.475
Bridge	Pearson's r *P* Value	−0.186 0.079	−0.087 0.406	0.02 0.851	0.163 0.117	1	0.115 0.268	0.009 0.93	0.385** 0	−0.02 0.848	0.007 0.947
Root Canal Treatment	Pearson's r *P* Value	0.119 0.266	0.260* 0.011	0.512** 0	0.690** 0	0.115 0.268	1	0.278** 0.007	−0.082 0.435	−0.089 0.398	−0.03 0.778
Extraction	Pearson's r *P* Value	−0.155 0.144	−0.04 0.705	0.292** 0.004	0.345** 0.001	0.009 0.93	0.278** 0.007	1	−0.125 0.229	−0.239* 0.021	0.249* 0.016
Dentures	Pearson's r *P* Value	−0.003 0.977	−0.072 0.49	−0.17 0.101	−0.113 0.28	0.385** 0	−0.082 0.435	−0.125 0.229	1	0.129 0.219	0.063 0.548
Household income	Pearson's r *P* Value	0.472** 0	0.086 0.415	0.072 0.491	−0.116 0.27	−0.02 0.848	−0.089 0.398	−0.239* 0.021	0.129 0.219	1	−0.213* 0.038
Age	Pearson's r *P* Value	−0.185 0.079	−0.224* 0.031	−0.178 0.087	0.075 0.475	0.007 0.947	−0.03 0.778	0.249* 0.016	0.063 0.548	−0.213* 0.038	1

* Significance of Pearson's r at 0.05 level (2-tailed).
** Significance of Pearson's r at 0.01 level (2-tailed).

Table 5. Average values and dispersion of WTP depending on household income group

Monthly household income	Average WTP	Number	Dispersion
≤ 200 BGN	50.00	2	0.00
200.01–500 BGN	78.75	16	3171.67
500.01–800 BGN	106.09	23	2861.27
800.01–1100 BGN	103.00	10	1690.00
1100.01–1400 BGN	96.67	6	2426.67
1400.01–1700 BGN	138.57	14	6767.03
1700.01–2000 BGN	121.67	6	3776.67
> 2000 BGN	216.43	14	16778.57
Total	122.09	91	7167.81

NBL regression model, they lie in the fact that in our study WTP is a discrete variable, i.e. it may only have whole positive values.

Observing equations 2 and 3, we could discuss the importance of the constant. The fact that, if the respondents had no income at all, i.e. if the household income could be equal to zero, then the expected value of the willingness to pay would be BGN 50 is difficult to interpret from an economic point of view. In this case, a more logical explanation would probably be that the price for placing a crown or for the treatment in view of saving the tooth is funded from savings or a loan. There is another plausible hypothesis: that the price which specialists who provide that dental service could offer on the market takes a minimal value of BGN 50.

Table 6. Evaluation of regression coefficients of willingness to pay to keep the tooth and for a crown using a negative binominal model

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test	df	*P* Value
			Lower	Upper	Wald Chi-Square		
Constant	3.912	0.4091	3.110	4.714	91.449	1	0.000
HI_8	1.465	0.4361	0.611	2.320	11.290	1	0.001
HI_7	0.889	0.4703	–0.032	1.811	3.575	1	0.059
HI_6	1.019	0.4363	0.164	1.874	5.459	1	0.019
HI_5	0.659	0.4707	–0.263	1.582	1.962	1	0.161
HI_4	0.723	0.4470	–0.153	1.599	2.614	1	0.106
HI_3	0.752	0.4260	–0.083	1.587	3.119	1	0.077
HI_2	0.454	0.4334	–0.395	1.304	1.099	1	0.295
HI_1	0[a]	.	.	.	.	.	.
Scale	1[b]						
Negative binomial	0.315	0.0473	0.234	0.423			

ly insignificant and that only the absolute number of recently placed crowns could predict preferences. The reason for the low reliability of that model probably lies in the small quantity of the studied sample. For the same reason, the models of patient choice for tooth extraction are not statistically credible and should not be discussed.

To study the changes to the willingness to pay, Vernazza [8] used three tobit regression models: WTP for all choices combined (irrespective of initial choice); WTP for root canal treatment and WTP for extract and leaving a gap. Using the Heckman selection method, he proposed a final WTP model combining all preferences where the only significant factor appears to be the household income. Our efforts to model WTP only for tooth treatment (excluding the other options) led to similar results: only the monthly household income appeared significant (see Table 4 and Table 6). As concerns the reasons why we chose the This is at least a "price" that potential patients would be highly willing to pay.

There are many other studies that have identified and defined a strong correlation between patient income and willingness to pay. In a study covering 203 patients with jaw fractures it was established that most patients were willing to pay a higher price for restoration or in case there were no scars from the intervention, or if the nerves of the third molar were not devitalized. The clinical characteristics of respondents have no effect on the willingness to pay to the difference of socio-demographic and psychological health characteristics of covered patients [9]. These findings are quite similar to our results so far as recent clinical history did not become a predictor neither for patient preferences nor the willingness to pay for the chosen option. Some studies discovered an interesting correlation between WTP and the presence or absence of esthetic considerations. Augusti et al. [10]

revealed that most patients with a missing tooth in the frontal part of their smile preferred an implant and were willing to pay a higher price for that. The farther back the missing tooth was located, the lower was the amount that patients were willing to pay.

Another study on the willingness to pay for an implant came to similar conclusions. Al Garni et al. [11] covered 100 patients and found out that income and oral health were the essential predictors for WTP. In their study, gender and, most of all, the acceptability of the implant appeared most important.

Household income is one of the major factors that determine the levels of ability to pay according to Widström and Seppälä [12]. Their study conducted in three large municipalities near Helsinki proved that clinical (dental) history and the urgency of the dental service were also factors of critical importance.

Studies on the willingness to pay in the field of health care, especially in countries where until recently there was a universal system covering the expenses funded exclusively from the state budget, represent quite a challenge. There are several reasons to claim that. The estimation of the maximum amount that a patient would be willing to pay is difficult in itself due to the very nature of the question and to the absence of a perfect market of health services. Nevertheless, such a claim is not fully valid for dental care. The amount covered for dental services by the mandatory health insurance represents a relatively small annual set of services for which in 2014 the budget of the Bulgarian NHIF allocated BGN 120 million (7.8% of the contributions for outpatient care). It should be noted that the only public health fund managed by the NHIF occupies a monopolistic situation, which is confirmed in part by our results: all respondents had insurances with the National Health Insurance Fund and only one had an additional health insurance with a private company.

Finally, the tools that we used proved to be quite reliable. We confirmed the positive correlation between income level as a predictor and WTP revealed by the study of Vernazza, which we took as a base, as well as by some other above mentioned studies. From the very presence of such statistically significant correlation and with reference to affirmations by recognized authors like Drummond et al. [13] we could conclude that the obtained WTP estimates are relatively reliable and could be used in economic valuation.

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