Comparing the Monetary Value of a Quality-Adjusted Life Year from the Payment Card and the Open-Ended Format

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Keywords: willingness-to-pay, contingent valuation, payment card, open-ended question, threshold

Abstract

Background: The payment card (PC) format and the open-ended (OE) format are common methods in eliciting willing-to-pay (WTP) of one additional quality-adjusted life year (QALY). The aim of this research is to compare these two formats in eliciting the monetary value of a QALY.

Methods: A contingent valuation survey was carried out using a pre-designed questionnaire with various hypothetical scenarios. The difference between the PC and the OE formats was evaluated by a two-sample equality test. Furthermore, regression analysis was carried out to control observed heterogeneity and to test theoretical validity.

Results: In total, 461 individuals were involved, among whom 235 (51%) answered the PC question, while 226 (49%) answered the OE question. No significant difference was observed between the median of these two methods. However, in the subgroup analysis, noteworthy differences were noticed in the median for these two formats in all scenarios. Both formats were proved to be theoretically valid, whereas the OE technique was found to have a stronger association with all variables in the regression model than that of the PC format. Moreover, joint estimation indicated a positive but not significant effect on the OE results.

Conclusions: This research indicated that there was no statistical difference between the PC format and OE format and proved the validity of both, which justified the combined use of these two methods in eliciting monetary value of QALY. More research about the difference and the validity of various WTP eliciting methods would be needed for a robust estimation of WTP/QALY.

1. Background

Budget allocation is one of the most prominent matters of decision makers in health-care systems today. The allocation is a complex, multifaceted issue. One of the vital questions, related to the budget allocation, is how much health-care systems should spend on the improvement of health-related outcome in terms of one additional quality-adjusted life year (QALY). Common decision rules of economic evaluations indicate that an intervention is believed to be cost-effective if the incremental cost-effectiveness ratio (ICER) of cost-effectiveness analysis (CEA) falls below the cost-effectiveness threshold value. Generally, there are two main approaches to this value [1]. It can be seen as opportunity costs of new intervention in the health-care sector. If a commonly held view is taken, the threshold can be empirically assessed with preference elicitation methods, the most important of which is contingent valuation (CV).

CV is normally used to elicit monetary values of a non-market good or service [2] by requesting participants to state their willingness-to-pay (WTP) for obtaining a good, in this context, for QALY (always a small amount), which has been conducted in numerous studies [3–5]. Even though carefully considered CV research could yield helpful contributions to health-care decision-making, a set of questions requires further examination, regarding the most appropriate questionnaire format [6, 7]. Questionnaire format denotes the approach by which the respondent is required to provide their WTP, of which four classical techniques have been in use: open-ended (OE), closed-ended, payment card (PC) and bidding [8]. In contrast with environmental economics, where the closed-ended format has been largely utilized and was suggested as the 'gold standard' [9], the combination of the PC and the OE method has been used broadly in estimating WTP per QALY [3–5].

The PC technique was proposed by Mitchell [10] and first used in the general economics literature by Jones-Lee [11]. Respondents were given a specific range of monetary values and asked to select the maximum value they would be willing to pay for a particular benefit. On account of the good performance of imitating real life by letting respondents hesitate for their WTP, the PC has become a prevalent method of eliciting WTP in health economics.

The OE elicitation technique directly asks the respondent the maximum they would be willing to pay in a hypothetical scenario. Considering respondents tend to anchor on the proposed values when eliciting techniques imply value cues, the OE method can lead to a more precise and independent WTP value than other elicitation techniques, as it does not suggest an answer [12]. It was further verified that the OE format is an effective technique when the final decision depends on a quantile instead of the mean [13].

Given the popularity of the PC and the OE in health economics, more specifically, in estimating the monetary value of QALY, a plausible development is a direct comparison of these two formats. Although there is not any research comparing these two methods in estimating WTP/QALY, studies have examined the discrepancies of eliciting methods in other fields. A general finding is that for health-related goods, the OE format causes lower WTP values [14, 15]. However, for environmental goods [16] or an ambulance helicopter service [17], relatively equal values were reported.

The aim of this research is straightforward, taking focus on the comparison of the PC and the OE formats. First, we examined the difference of WTP/QALY estimates from these two methods. Furthermore, we investigated the theoretical validity of each method to determine which method elicits more valid monetary value of QALY.

2. Methods

2.1. Study design and sample

We conducted a CV survey on Chinese general population between June 1st, 2019 and August 10th, 2019. A relatively low response rate was observed in the pilot study of the probability sample survey. Hence, quota sampling was used in the final survey with quotas based on sex, age, and income. A questionnaire that measures maximum WTP per QALY for various hypothetical scenarios was used in this research. This survey was carried out with trained interviewers through telephone (mobile app WeChat). Five different health statuses were defined using five-level EuroQol five-dimensional questionnaire (EQ-5D-5L) descriptions, including three treatment settings and two end-of-life scenarios. More details will be discussed in the next section. All subjects were asked for their full consent to participate in the study and no financial incentives were offered.

2.2. Questionnaire

The full questionnaire contained 22 questions concerning quality of life, WTP, and demographic items as well as health-related issues. The demographic section included questions about age, sex, marital status, education, and family income. First, we evaluated the individuals' present health state using the EQ-5D-5L. Part 2 consisted of a hypothetical health state and a WTP exercise in which we asked individuals to state the maximum amount he or she would be willing to pay for treatment for a hypothetical condition. An example of part 2 can be found in the Additional file 1 [see Additional file 1]. To avert possible extreme WTP values and reveal general treatment in each scenario, small QALY gains, 0.2 QALY and 0.4 QALY, were applied in this research. Altogether, 10 eliciting scenarios were constructed (see Table 1).

Table 1
Scenarios of questionnaire

No		Health state	EQ-5D-5L description	QALY gain	Period (months)†
1	Treatment scenario	Mild	12122	0.2	15
2		Mild	12122	0.4	31
3		Moderate	23332	0.2	5
4		Moderate	23332	0.4	10
5		Severe	44332	0.2	3
6		Severe	44332	0.4	6
7	Terminal illness		44332	0.2	15
8			44332	0.4	26
9	Immediate death		11115	0.2	3
10			11115	0.4	6

† The period was calculated as follows:
For mild, moderate, and severe health states, QALY gain/(1-utility of health state)*12
For terminal illness, QALY gain/utility of health state*12+3
For immediate death, QALY gain/utility of health state*12

The WTP payment was defined as the amount of out-of-pocket expense to purchase an assumed intervention. Participants were asked if he or she would pay for the treatment. Those who replied "No" were then asked to give their reasons. If the answer was "yes", the participant was requested to provide the maximum amount they were willing to pay out of pocket. The PC had the following categories: 3200 RMB (5 percent of Chinese GDP per capita, USD 457), 6450 RMB (10 percent of Chinese GDP per capita, USD 922), 12,900 RMB (20 percent of Chinese GDP per capita, USD 1,844), 25,800 RMB (40 percent of Chinese GDP per capita, USD 3,688), 51,600 RMB (80 percent of Chinese GDP per capita, USD 7,376), 77,400 RMB (120 percent of Chinese GDP per capita, USD 11,064), 103,200 RMB (160 percent of Chinese GDP per capita, USD 14,753).

2.3. Data analysis

Previous studies have applied two different methods of converting the data on WTP and QALY gains into WTP per QALY estimates, namely aggregated method and disaggregated method [18, 19]. The aggregated approach calculates the ratio by dividing the mean of WTP by the mean of QALY, whereas the disaggregated method estimates WTP/QALY for individuals, and subsequently estimates the mean value of WTP/QALY, which was proved to be a more appropriate method as it takes account of heterogeneity in preferences [18, 19]. Hence, the disaggregated method was applied in this research.

Descriptive statistics (mean, SD, median, inter-quartile range, minimum, maximum) for the WTP values of the PC and the OE formats were computed. First, we compared the mean and the median WTP/QALY obtained from the two elicitation methods using a two-sample equality test. Furthermore, a subgroup analysis of diverse scenarios was conducted.

Log-linear multiple regression was carried out to control observed heterogeneity and test theoretical validity. In a broad sense, the theoretical validity of WTP/QALY estimates refers to whether the estimates concur with the underlying

theory. The subsequent variables were selected for regression analysis in conformity with previous researches [20–23]: age, income, hypothetical health state, and QALY gain. Age was proven to be a significant factor of WTP/QALY in previous research [20], indicating that being younger led to a higher WTP/QALY. Income is positively associated with WTP/QALY [21] and thus should be captured in the regression analysis. Furthermore, we also assumed that worse health state scenario [22] and smaller QALY gain should lead to a higher WTP/QALY [23]. A natural logarithm was administered to the data for WTP/QALY and age. Categorical variables were coded with dummy variables. Statistical analysis was performed with IBM SPSS version 23.0.

3. Results

3.1. Respondent characteristics

Table 2 displays the demographic characteristics of respondents. In total, 461 individuals were involved, among whom 235 (51%) answered the PC question, while 226 (49%) answered the OE question. 61% of participants had a college degree. Around 35% of respondents had income less than 3000 RMB. Almost 19% participants in this research proclaimed that they were having some health problems. However, for all the dimensions in EQ-5D-5L, most respondents stated no problem, which yielded a relatively high utility score of 0.95. A small portion of respondents (5%) had experienced hospitalization during the year. We found no significant differences between elicitation methods for all variables except education (p = 0.001).

Table 2
Respondents' characteristics (N = 461)

	Full sample	PC	OE
Characteristic	Mean ± SD or N (%)	Mean ± SD or N (%)	Mean ± SD or N (%)
n	461 (100%)	235 (51%)	226 (49%)
QALY			
0.2	222 (48%)	113 (48%)	109 (48%)
0.4	239 (52%)	122 (52%)	117 (52%)
Scenario			
Mild	101 (22%)	51 (22%)	50 (22%)
Moderate	87 (19%)	44 (19%)	43 (19%)
Severe	84 (18%)	45 (19%)	39 (17%)
Terminal illness	94 (20%)	51 (22%)	43 (19%)
Immediate death	95 (21%)	44 (19%)	51 (23%)
Age	32.86 ± 11.84	31.92 ± 11.27	33.84 ± 12.36
Gender			
Male	219 (48%)	110 (47%)	109 (48%)
Female	242 (52%)	157 (53%)	117 (52%)
Education*			
≤Primary school	29 (6%)	11 (5%)	18 (8%)
Secondary school	76 (17%)	25 (11%)	51 (23%)
High school	76 (17%)	39 (17%)	37 (16%)
≥College	280 (61%)	160 (67%)	120 (53%)
Marital status			
Single	223 (48%)	105 (45%)	118 (52%)
Married	235 (51%)	130 (56%)	105 (47%)
Divorced/separated	2 (0%)	0 (0%)	2 (1%)
Widowed	1 (0%)	0 (0%)	1 (0%)
Income			
≤3000	162 (35%)	83 (35%)	79 (35%)
3001−5000	173 (38%)	85 (36%)	88 (39%)
> 5000	126 (27%)	67 (29%)	59 (26%)

* indicates there is significant difference between PC group and OE group on education

	Full sample	PC	OE
Health utility	0.95 ± 0.07	0.95 ± 0.06	0.94 ± 0.09
Hospitalization experience during the year			
Yes	20 (5%)	7 (3%)	14 (6%)
No	441 (95%)	228 (97%)	213 (94%)
Health problems			
Yes	86 (19%)	44 (19%)	42 (19%)
No	375 (81%)	191 (81%)	184 (81%)
* indicates there is significant difference between PC group and OE group on education			

3.2. Comparing formats with unconditional analysis

The distribution of WTP for QALY of the PC and the OE formats is displayed in Fig. 1. Furthermore, Table 3 presents descriptive statistics of WTP/QALY for the two elicitation methods. This research witnessed a small number of non-traders, which is 28 (12%) for the PC, 36 (16%) for the OE with no significant difference of these two groups. Nevertheless, the mean WTP values of these two formats vary dramatically, which is 97,507 RMB (SD 124,148) for the PC, 176,048 RMB (SD 3420,739) for the OE. However, the median values of the PC and the OE are quite similar, which is 32,250 RMB for the PC and 50,000 RMB for the OE. We examined equality among mean and median WTP/QALY. Results reported in the right part of Table 3 indicate that the mean WTP/QALY of the OE method was significantly higher than that of the PC format. However, no significant difference was found between the median of these two methods. Figure 2 displays the ratio of accepted bids according to the elicitation method. These two crossing lines indicated that the OE format tended to elicit more extreme values, though the difference between two elicitation methods did not seem to be substantial.

Table 3
Descriptive statistics and equality tests of WTP per QALY using PC and OE formats

	All sample	PC	OE	P value
Non-trader, N (%)	64 (14%)	28 (12%)	36 (16%)	0.227
Mean	135,096	97,507	176,048	0.000**
Standard deviation	306,673	124,148	420,739	–
Median	50,000	32,250	50,000	0.618
Maximum	5,000,000	516,000	5,000,000	–
Minimum	500	8,000	500	–
PC payment card, *OE* open-ended				

The results of subgroup analysis are presented in Table 4, which are, to some degree, inconsistent with the whole sample analysis. Noteworthy differences were found in the median for these two formats in all scenarios. For terminal illness scenario and immediate death scenario, the OE method elicited significantly higher median values, whereas for

treatment scenario, the PC led to higher median. The OE elicitation formats led to a higher mean of all scenarios, but the significant difference was only witnessed for immediate death scenario.

Table 4
Comparison between the PC and the OE formats by different scenarios

Scenarios		n	Mean ± SD	Median	Equality test of mean	Equality test of median
Treatment scenario	PC	128	40,282 ± 54,679	32,250	0.593	0.003*
	OE	115	44,123 ± 57,230	25,000		
Terminal illness	PC	44	220,983 ± 128,185	225,750	0.132	0.050*
	OE	32	297,500 ± 259,447	250,000		
Immediate death	PC	35	151,561 ± 162,383	64,500	0.023*	0.006**
	OE	43	438,488 ± 780,139	250,000		

PC payment card, *OE* open-ended, *SD* Standard deviation,

*indicates there is significant difference between PC group and OE group ($p < 0.05$); **indicates there is significant difference between PC group and OE group ($p < 0.01$)

3.3. Comparing formats with conditional analysis

3.3.1. Separate estimations by elicitation format

For each elicitation method we looked for the determinants of WTP/QALY with log-linear multiple regression models (see models 1–2 in Table 4). In the OE format, all variables were found to have significant effect on the value of WTP/QALY. More specifically, for the OE technique, participants' age was verified to be negatively relevant to their WTP: as respondents' age increase, their WTP decreased, which was consistent with the research assumption. However, in case of the PC question, age was not a statistically significant variable. WTP/QALY was also proved to be significantly influenced by valuation scenarios in both models, while participants were prepared to pay more for more serious conditions. We found a positive effect of income on WTP/QALY for both formats—which argues for the validity of the stated-preference survey [24], even though the difference of WTP/QALY values for income group 3001–5000 RMB and base-case group (income less than 3000 RMB) was not significant. Furthermore, we confirmed that for both formats, smaller QALY gain led to a higher WTP/QALY.

3.3.2. Joint estimation over the two elicitation formats

We studied the impact of the elicitation technique on WTP over the whole sample by introducing dummy variables for the OE format (the PC format as the reference). Even though not significant, model 3 in Table 2 contains results indicating a positive effect on the OE results, consequently verifying the results of the conditional analyses. Regarding the determinants of WTP, the joint estimation confirms previous results: a significant and negative effect of age and QALY gain, a significant and positive effect of income. WTP/QALY was also proved to be affected by valuation scenarios.

Table 5
Linear regression for positive WTP values (natural logarithms)

	Model 1 (PC, n = 207)				Model 2 (OE, n = 190)				Model 3 (All, n = 397)			
	b	S.E.	Beta	*P*	b	S.E.	Beta	*P*	b	S.E.	Beta	*P*
Constant	10.95	0.66		0.00**	12.12	0.93	-	0.00**	11.44	0.57	-	0.00**
OE (vs. PC)	-	-		-	-	-	-	-	0.11	0.10	0.04	**0.30**
Age	-0.21	0.19	-0.06	0.26	-0.63	0.26	-0.13	0.02*	-0.41	0.16	-0.09	0.01*
Scenario (vs. treatment scenario)												
Terminal illness	1.94	0.15	0.67	0.00**	2.46	0.24	0.55	0.00**	2.18	0.13	0.60	0.00**
Immediate death	1.11	0.16	0.35	0.00**	2.15	0.21	0.54	0.00**	1.66	0.13	0.46	0.00**
Income (vs. ≤3000)												
3001–5000	0.13	0.14	0.05	0.33	0.40	0.20	0.12	0.05*	0.27	0.12	0.09	0.03*
> 5000	0.62	0.15	0.23	0.00**	0.94	0.22	0.25	0.00**	0.81	0.13	0.25	0.00**
QALY gain (vs. 0.2 QALY)												
0.4 QALY	-0.505	0.12	-0.21	0.00**	-0.72	0.17	-0.22	0.00**	-0.61	0.10	-0.21	0.00**
Adjust R^2	0.51	-	-	-	0.53	-	-	-	0.50	-	-	-

PC payment card, *OE* open-ended, *S.E.*, standard error, *QALY* quality-adjusted life year

* indicates that there are statistically significant differences at the 5% level; ** indicates that there are statistically significant differences at the 1% level

4. Discussion

We compared WTP/QALY estimates generated from the PC format and the OE format and found that the OE resulted in higher median, but without statistical significance. Further investigation with conditional analysis demonstrated that there was no statistical difference between these two formats and proved the validity of both.

As we have shown in the results, there was significant difference with the mean WTP/QALY estimates. Nevertheless, considering the distribution difference, the comparison of mean estimates of these two measures shall be considered less important than that of median estimates [13]. The equality tests of median proved no significant difference of these two formats which was verified again by log-linear multiple regression analysis. Our finding is that these two methods seem to lead to similar estimates, which is consistent with research into willingness-to-pay for a hearing aid [25].

Finding a significant coefficient of the different variance is a necessary condition for a general claim about validity [23]. Probing the theoretical validity is the most popular test of validity applied to stated-preference techniques mostly

since it is comparatively easy to perform. Our findings implied that both the PC format and the OE format are theoretically valid method for eliciting monetary value of QALY, though the OE technique had a stronger association with all variables in the regression model. In theory, the PC question tends to cause range bias. In the OE form, only after a careful reflection can respondents answer WTP question [12], which might be a fundamental procedure in assessing the value of health.

There are certain insights that might be gained from comparing these two CV methods. Compared with the PC, the OE format led to lower values for less serious conditions and higher values for more serious conditions. Once again, we draw our conclusions here based on the equality test of the median instead of the mean estimates. The mean is very sensitive to assumptions about the distribution, to skewness and to outliers in the data whereas the median is more robust [26]. The performance of the OE format appears to be highly satisfactory, especially when log-linear regression analysis was chosen, since it allows a reasonably wide range of distributional shapes. Whereas the PC format failed to comply with the assumption that being younger leads to a higher WTP/QALY, it was consistent with all other assumptions, which indicated acceptable theoretical validity. The combination of PC and OE formats has been widely used to estimate the monetary value of a QALY [3, 5, 27], which can be justified by the discoveries of this research.

This is the first study to compare WTP/QALY estimates generated from the PC and the OE formats. However, we have encountered certain practical limitations. First, only the theoretical validity of the two eliciting methods was performed; essential elements like external validity and reliability were not assessed in this study. Second, due to the sampling procedure, the sample used in this study is not a perfect representation of the Chinese population. Those with higher levels of education were over-represented. However, we found that education level had no significant impact on WTP/QALY. Hence, the potential bias in the WTP estimate is likely to be minor. Finally, a critical limitation is the imaginary nature of all WTP surveys. Like other studies, the participants might find it hard to picture a hypothetical health state that significantly differs from conditions that they have experienced before. More research about the validity of various WTP eliciting methods would be needed for a robust estimation of monetary value per QALY.

5. Conclusions

The study compared WTP/QALY estimates generated from the PC and the OE formats and found that the OE resulted in a higher median, but without statistical significance, subgroup analysis indicated for different health states these two methods elicited different estimates. Further investigation with conditional analysis demonstrated that there was no statistical difference between these two formats and proved the validity of both, which justified the combined use of these two methods in eliciting the monetary value of QALY. More research about the validity of various WTP eliciting methods would be needed for a robust estimation of WTP/QALY.

6. Abbreviations

PC: payment card

OE: open-ended

WTP: willing-to-pay

QALY: quality-adjusted life year

ICER: incremental cost-effectiveness ratio

CEA: cost-effectiveness analysis

CV: contingent valuation

EQ-5D-5L: five-level EuroQol five-dimensional questionnaire

7. Declarations

Ethics approval and consent to participate

According to Ethical review methods for human biomedical research issued by Ministry of Health in China, scientific research department of Shenyang Pharmaceutical University, who is responsible for the ethics review, ruled that no formal ethics approval was required in this case. Considering the survey was carried out via telephone, written consent was not available. Instead, verbal informed consent was obtained from the respondents for the publication of this report

Consent for publication

Not applicable.

Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

Competing interests

The author declares that he has no competing interests.

Funding

This work was supported by the Research Project of Liaoning Province Education Department (2019), China (Grant No. 2019WZD01). The funders of the study had no role in study design, data collection, data analysis, data interpretation, writing of the manuscript, or publication of this article.

Authors' contributions

ZY and LS conceived the original concept of the study, applied for the grant and assisted in study protocol development and implementation. ZY, FL, JM, ZZ and CW conducted this survey and wrote the manuscript. All authors contributed to the final design of the study protocol and have read and approved the final manuscript.

Acknowledgments

The authors would like to thank all respondents for their participation in this research.

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Figures
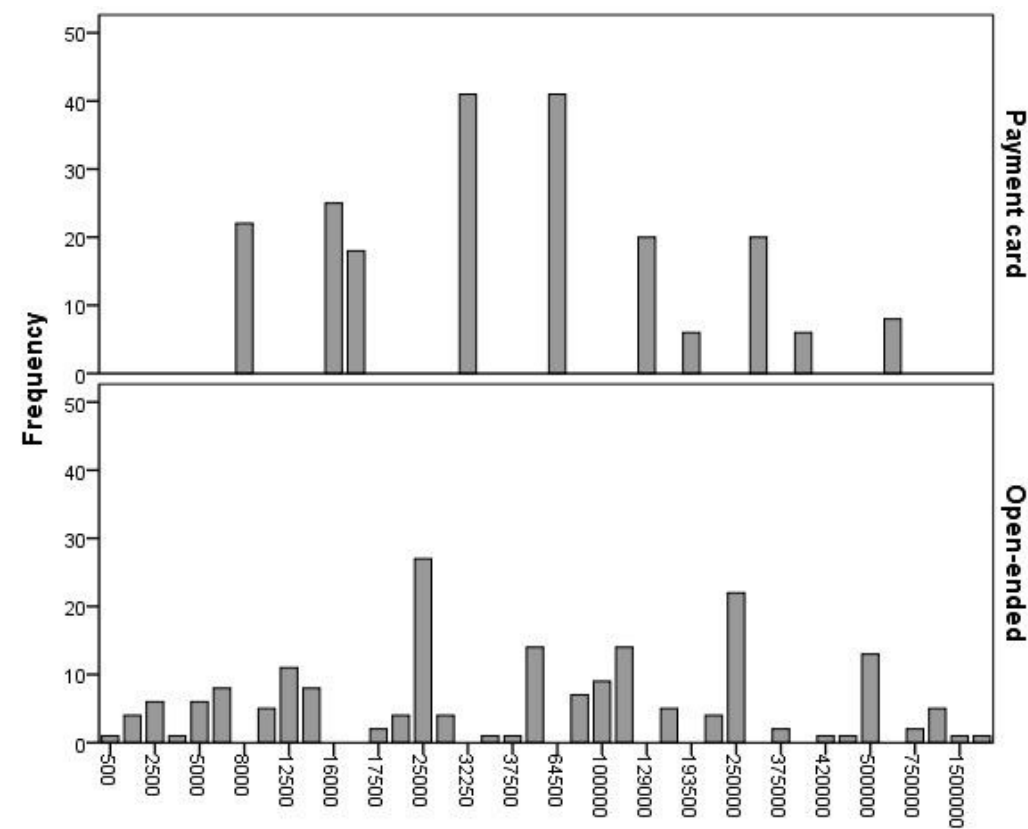
Figure 1

The distribution of willingness-to-pay per QALY of the PC and the OE formats
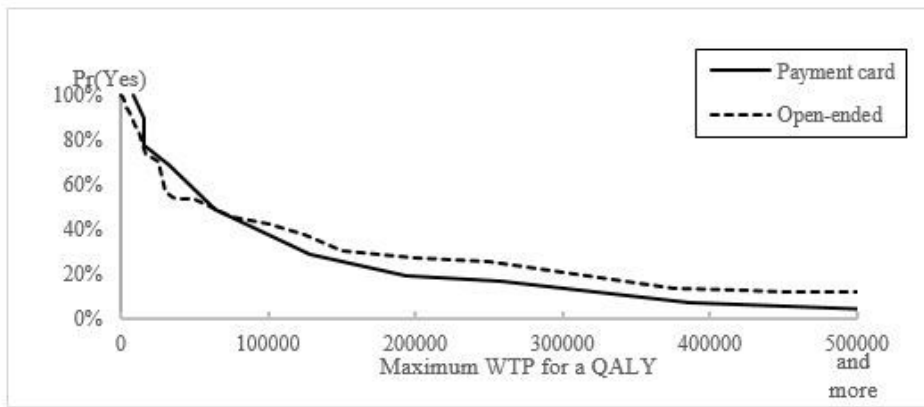
Figure 2

Proportion of accepted bids by elicitation format