Willingness To Pay To Eliminate the Risk of Restenosis Following Percutaneous Coronary Intervention
A Contingent Valuation

Jason R. Guertin, MSc; Aihua Liu, MSc; Michal Abrahamowicz, PhD; David J. Cohen, MD, MSc; Salma Ismail, MSc; Jacques LeLorier, MD, PhD; James M. Brophy, MD, PhD; Stéphane Rinfret, MD, SM

Background—Percutaneous coronary intervention (PCI) remains limited by the risk of restenosis. Patients’ perceptions of the health benefits and value of avoiding restenosis are incompletely known.

Methods and Results—We used a contingent valuation approach to assess the willingness to pay (WTP) for a hypothetical treatment that eliminates the risk of restenosis among 270 PCI patients. Patients were provided with a scenario describing a baseline 10% or 20% probability of restenosis in the year following the procedure, which could lead to repeat PCI or, more rarely, bypass surgery, without any increase in mortality. Six different “take it or leave it” bids ($500, $1000, $1500, $2000, $2500, and $3000) and both risk levels were randomly assigned. Multiple logistic regression was used to identify independent predictors of a positive response to the WTP question. Using nonparametric methods, the median WTP to eliminate the risk of restenosis was estimated at $2802. As expected, higher income was independently associated with a higher probability of a positive response to the WTP question (odds ratio, 2.81; 95% CI, 1.32 to 5.97). Bids also were independently associated with the probability of being willing to pay, and this association followed a quadratic effect. Below $1500, bid had little impact on patient answers. However, as prices increased, the probability of being willing to pay started to decrease sharply.

Conclusion—The potential to eliminate the risk of restenosis, a benign complication, would have substantial value for patients undergoing PCI. (Circ Cardiovasc Qual Outcomes. 2011;4:46-52.)

Key Words: restenosis ■ stents ■ cost-benefit analysis

Percutaneous coronary intervention (PCI) with stent implantation effectively reduces angina in patients with coronary artery disease.1 However, benefits of PCI remain limited in the following year by restenosis, a nonfatal and relatively benign complication that nevertheless can lead to recurrent symptoms, repeat revascularization (RR) procedures,2,3 and a decrease in quality of life (QOL).4 Drug-eluting stents (DES) reduce the risk of restenosis and subsequent RR procedures by 50% to 75% compared to bare-metal stents (BMS).5 Despite their efficacy, there is debate about whether the increased effectiveness of DES compared with BMS justifies their incremental cost.6,7

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The contingent valuation approach assesses, in monetary values, all benefits associated with a preferred health state. This goal may be achieved by asking how much money an individual would trade to avoid a given decrement in health in a hypothetical market and then determining his or her maximum willingness to pay (WTP) for avoiding this detrimental condition.8 By doing so, the contingent valuation quantifies, through a single or a series of questions, all of the benefits arising from avoiding a detrimental health condition, whether they are gains in leisure or work time, reduction in pain levels, or any other benefit that may be achieved by avoiding the detrimental health condition. Although this method may overestimate the value of examined goods,9 assessing patients’ WTP for a treatment that provides a preferred condition can produce additional information on the impact a condition can have on patient well-being. Contingent valuation is of particular interest for understanding treatments that reduce restenosis because the clinical consequences of restenosis generally are short lived.10 The goal of this project was to use this technique to measure how much Canadian patients value treatments that could eliminate restenosis post-PCI.

Received March 25, 2010; accepted September 13, 2010.

From the Université de Montréal (J.R.G., J.L.); Centre Hospitalier de l’Université de Montréal Research Centre (J.R.G., S.I., J.L., S.R.); Department of Epidemiology, Biostatistics and Occupational Health (A.L., M.A., J.M.B.), McGill University; and Division of Clinical Epidemiology (A.L., M.A., J.M.B.) and Division of Cardiology (J.M.B.), McGill University Health Centre, Montreal, Canada; Saint Luke’s Mid America Heart Institute (D.J.C.), Kansas City, Mo; and Institut universitaire de cardiologie et de pneumologie de Québec (S.R.), Quebec City, Canada.

Guest Editor for this article was Brahajee K. Nallamothu, MD.

Correspondence to Stéphane Rinfret, MD, SM, Clinical and Interventional Cardiology, Multidisciplinary Cardiology Department, Institut universitaire de cardiologie et de pneumologie de Québec 2725, Chemin Ste-Foy, Quebec City, Quebec G1V 4G5, Canada. E-mail stephane.rinfret@criucpq.ulaval.ca

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Circ Cardiovasc Qual Outcomes is available at http://circoutcomes.ahajournals.org

DOI: 10.1161/CIRCOU5OUTCOMES.109.915421

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WHAT IS KNOWN

- Restenosis occurs in ≈15% of patients undergoing percutaneous coronary intervention (PCI) with bare-metal stents.
- In a previous contingent valuation study in the United States, patients presented with a 30% risk of restenosis following PCI were willing to pay median amounts of $273, $366, and $1162 for a 10%, 20%, and 30% reduction in the risk of restenosis, respectively.

WHAT THIS STUDY ADDS

- Our study shows that patients in a public healthcare system would be willing to pay a median amount of $980 for SCAN 2802 for a procedure that would eliminate the risk of restenosis following PCI.
- Our study also identified that before undergoing cardiac catheterization followed by ad hoc PCI, 90.7% of patients believed that PCI could prolong their life span, and 92.2% of patients believed that it could improve their quality of life.

Methods

Patient Population
Between November 18, 2005, and March 7, 2008, all patients undergoing cardiac catheterization with ad hoc PCI at the Centre Hospitalier de l’Université de Montréal were approached to participate in the study. The only exclusion criteria were (1) patient refusal, (2) any clinical situation that does not safely allow the administration of the questionnaire before the catheterization, and (3) inability to understand French or English. The study protocol was approved by the hospital’s Scientific and Ethical Research Committees, and all patients provided written informed consent.

Data Collection
Immediately before the planned cardiac catheterization, trained investigators administered an in-person questionnaire to collect socioeconomic data, WTP, and health-related QOL assessments. Clinical data were extracted from patients’ hospital charts. The questionnaire also included questions regarding patients’ perspective on PCI.

WTP Assessment
We used the contingent valuation method to assess patients’ WTP for a hypothetical treatment that would eliminate the risk of restenosis (and subsequent RR) in the year following a PCI. The question was asked following an ex post perspective. In other words, the question was given to patients who require or may directly benefit from the proposed program. We used a closed-ended dichotomous format question to assess the patients’ WTP for the proposed program. With this method, patients were provided a single dichotomous “take it or leave it” (ie, yes or no) question that asked whether they would be willing to pay a proposed amount for the treatment or intervention being evaluated.

To assess the monetary value of a treatment that would eliminate the risk of restenosis in the year after a PCI, each patient was asked before their planned cardiac catheterization the following question:

“If you undergo an angioplasty or stent procedure today, there is a risk that the blockage in the artery will come back in the next 6 to 12 months, a complication called restenosis, which could lead to recurrent chest pains (or other symptoms). Restenosis does not put your life in danger but could result in 1 or more revascularization procedure(s) in the future. Those procedures could be another angioplasty, implantation of a stent, or, in rare cases, coronary artery bypass surgery. The risk of restenosis is around X%. Let us suppose the existence of a new treatment that reduces this risk to 0%. Would you be willing to pay $Y for this new and improved treatment? 1) Yes 2) No.”

Each patient was randomly assigned a single price (Y) of $500, $1000, $1500, $2000, $2500, or $3000. The price range was decided based on current incremental cost of DES compared to BMS, which was between $1500 and $2000 in most Canadian hospitals. The investigators explained to the patients that in order to obtain this new treatment, they would be required to pay out of pocket the proposed amount before the intervention. To test whether WTP would increase with the magnitude in baseline risk, patients were randomly assigned to 1 of 2 alternative risks of restenosis (X): 10% or 20%. The combination of 6 different prices and 2 baseline risk values resulted in 12 alternative scenarios distributed with equal probabilities among the patients. To mitigate the hypothetical bias, the fact that some patients are willing to say yes within a hypothetical context but are unwilling when presented with a real context, we added a second WTP question in order to validate the response to the first question. If the patient answered yes to the proposed bid, the amount was increased by $500, and the patient was asked again whether he or she would be still be willing to pay. In the event that patients refused to answer the WTP scenario questions or gave an “I don’t know” response, they were considered to reject the proposed amount (ie, were assigned the no response). Although no consensus exists, Blumenschein et al suggested adding an “are you sure” question as a means to validate the patient’s answer. Adding a second WTP was believed to increase patients’ reflection time on the initial question by focusing on the economic value of avoiding restenosis. The lowest proposed amount ($500) was selected because it was representative of the selected range of bids while remaining a marginal increase compared to initial proposed amounts.

QOL Assessment
To assess a possible relationship between QOL and WTP, patients also were asked to provide mental health status information using the Symptom Checklist-90-R (SCL-90-R) and QOL information using the 36-item Medical Outcome Study Short-Form Health Survey (SF-36) questionnaire.

Statistical Analyses
Continuous variables are described as mean±SD and categorical variables by frequencies. Nonnormally distributed continuous variables were compared with the Wilcoxon rank sum test.

To estimate the median WTP, we used the nonparametric method proposed by Kriström. Assuming that the probabilities of WTP corresponding to each bid increase monotonically with decreasing price, a linear interpolation should provide a reasonably accurate approximation to the true relationship. Thus, the median WTP can be estimated as the bid at which the probability of a positive response, estimated from the linear model, is 50%. If the observed proportions of positive responses did not follow a monotone curve, this was interpreted as due to sampling error or too-small increases between the adjacent bids. In that case, the probabilities were recalculated by combining the adjacent bids until all the probabilities followed a monotone sequence, and the median was reestimated using the combined bids.

The responses to the WTP question were assessed by 2 approaches. In the first approach, only the first amount assigned was considered. The second, more conservative approach was used to avoid overestimation of the true WTP. In that approach, a patient was considered as willing to pay the first amount only if he or she also agreed to pay $500 more than the originally assigned price. This second amount was not used when estimating the median WTP.

We used multiple logistic regression to identify patient characteristics independently associated with a higher probability of respond-
ing by the affirmative to the WTP question. Separate analyses were performed for each of the 2 approaches discussed previously. Price, risk of restenosis, patient income, history of PCI, history of myocardial infarction (MI), and history of coronary arterial bypass graft (CABG) surgery were hypothesized a priori to influence the patients’ answers to the WTP question and, therefore, were forced into the model regardless of their statistical significance. We then used forward and backward model selection procedures in separate analyses to identify additional statistically significant \( (P<0.05) \) determinants of the responses to the WTP question among the following variables: age, sex, education, working status, chronic heart failure, history of MI, history of CABG surgery, somatization score, depression score, anxiety score, SF-36 mental component score (MCS), and SF-36 physical component score (PCS).

To investigate how increasing price affects the patients’ responses to the WTP questions, we considered 4 alternative models for the effect of price. All 4 models adjusted for the same a priori-selected covariates but represented the effect of price differently. Specifically, the models represented the effect of price using the following functions: linear (model 1), logarithmic (model 2), 2-term quadratic function with separate linear and quadratic terms (model 3), and restricted 1-term quadratic function without the linear term (model 4). In the quadratic models, original prices were transformed to price increment, calculated as price−$500 (ie, centered to have 0 value at the minimum price of $500 considered in our study). In model 3, we tested the quadratic component for the nonlinearity of the effect of price. Model 4 restricts the estimated quadratic function to have the maximum value at a price of $500, which ensures a monotonically decreasing effect of price. In contrast, model 3 may yield a nonmonotone effect of price, which would be considered clinically implausible and likely to reflect overfitting. In addition, we tested the significance of the linear term in model 3. The lack of significance of the linear term \( (P>0.05) \) was interpreted as the evidence that the monotone effect of price, estimated in model 4, provided equally good fit to data as the more complex, and possibly nonmonotone, function estimated in model 3. We then used the Akaike information criterion (AIC), which accounts for the difference in each model’s degrees of freedom, to determine the best fitting among the 4 alternative models.

A 2-tailed \( P<0.05 \) for the Wald test was considered statistically significant for all tests. Analyses were performed using SAS version 9.1.3 (SAS Institute; Cary, NC) statistical software.

**Results**

**Patient Sample**

A total of 312 patients were approached to participate in our study. Of these, 270 (87%) completed both parts of the WTP questionnaire and were included in our analysis. Three patients gave protest answers (eg, patients refused to answer the WTP question due to ideological convictions), and 7 patients responded with an “I don’t know” answer; all were assumed to have given a negative response to the WTP offer. Socioeconomic and clinical characteristics of the study population are presented in Table 1.

**Table 1. Demographic Characteristics of the Study Population**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y (mean±SD)</td>
<td>64.1±10.9</td>
</tr>
<tr>
<td>Male sex</td>
<td>198 (73.3)</td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
</tr>
<tr>
<td>Married or living as married</td>
<td>175 (65.5)</td>
</tr>
<tr>
<td>Divorced or separated</td>
<td>41 (15.4)</td>
</tr>
<tr>
<td>Widowed</td>
<td>25 (9.4)</td>
</tr>
<tr>
<td>Never married</td>
<td>26 (9.7)</td>
</tr>
<tr>
<td>Employment status</td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>91 (34.2)</td>
</tr>
<tr>
<td>Retired or unemployed</td>
<td>175 (65.8)</td>
</tr>
<tr>
<td>Gross family annual income</td>
<td></td>
</tr>
<tr>
<td>&gt;$60 000 and missing</td>
<td>213 (78.9)</td>
</tr>
<tr>
<td>&gt;$60 000</td>
<td>57 (21.1)</td>
</tr>
<tr>
<td>Education level</td>
<td></td>
</tr>
<tr>
<td>Grade school</td>
<td>42 (15.6)</td>
</tr>
<tr>
<td>High school</td>
<td>121 (44.8)</td>
</tr>
<tr>
<td>College</td>
<td>52 (19.3)</td>
</tr>
<tr>
<td>University</td>
<td>55 (20.4)</td>
</tr>
<tr>
<td>Clinical characteristics</td>
<td></td>
</tr>
<tr>
<td>Stable angina and inducible ischemia</td>
<td>132 (49.8)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>64 (23.9)</td>
</tr>
<tr>
<td>History of MI</td>
<td>104 (40.8)</td>
</tr>
<tr>
<td>History of PCI</td>
<td>76 (28.9)</td>
</tr>
<tr>
<td>History of CABG surgery</td>
<td>38 (14.2)</td>
</tr>
</tbody>
</table>

Table 1. Demographic Characteristics of the Study Population

Data are presented as no. (%), unless otherwise indicated.

**Patient Perceptions on the Role of PCI**

The majority of patients initially believed that PCI could prolong their life span and improve their QOL (90.7% and 92.2%, respectively).

**WTP**

Most (68.9%) patients were willing to pay the amount proposed in the first question. Among those who were willing to pay the first amount, the majority (85.9%) also were willing to pay $500 more. Therefore, 59.2% of study patients were willing to pay both proposed amounts. Figure 1 shows the percentage of patients who gave a positive response to the WTP questions as a function of the price being asked. Because >50% of the patients responded positively to the $3000 price, we can assume that the median WTP amount, using only the response to the first question, is at least $3000. Based on linear extrapolation, the median WTP was esti-
patients were indeed able to discriminate between the levels of restenosis risk assumed in the 2 scenarios.

**QOL**

Mean scores of several dimensions of QOL assessed with the SCL-90-R and SF-36 questionnaires are presented in Table 2. Patients who were willing to pay had similar anxiety, depression, and somatization scores as assessed by the SCL-90-R questionnaires as those who refused. The SF-36 MCS and SF-36 PCS were also similar in patients who were and were not willing to pay the proposed amount.

**Effect of Price on the Probability of a Positive Response to the WTP Question**

Among the 3 alternative models (see Statistical Analysis section) that yielded clinically plausible, monotonically decreasing effects of price, the restricted quadratic model 4 fit the data much better than the 2 other models (AIC, 300.9 for model 4, 304.0 for model 1, and 307.3 for model 2). Model 4 fit was also marginally better than the implausible nonmonotonic function estimated with the unrestricted 2-term quadratic model 3 (AIC, 301.1). Moreover, in model 3, the linear term corresponding to the best-fitting model (model 4) for the data much better than the 2 other models (AIC, 300.9 for model 4, 304.0 for model 1, and 307.3 for model 2). Model 4 fit was also marginally better than the implausible nonmonotonic function estimated with the unrestricted 2-term quadratic model 3 (AIC, 301.1). Moreover, in model 3, the linear term was statistically nonsignificant (P=0.18). The latter finding corroborates our expectation that the highest probability of a positive answer corresponds to a price, which is not significantly different from the minimum price of $500 considered in our study and, thus, provides further support for the clinically plausible model 4.

**Predictors of a Positive Answer to the WTP Question**

Results of simple logistic regression analyses for predicting the probability of being willing to pay the proposed amount (conservative approach) are presented in Table 3. As expected, patients with a gross family income of ≥$60,000 and those assigned to a greater risk of restenosis in the following year (20% versus 10%) were more likely to be willing to pay the proposed amount. Using the restricted quadratic function, corresponding to the best-fitting model (model 4) for the effect of price, an increase in price was associated with a significant decrease in patient WTP (P=0.014).

Table 4 summarizes the results of the final multivariable logistic regression model selected by both the forward and the backward procedures. The model identified 2 variables as

![Figure 2. Percentage of patients positively responding to the WTP question as a function of the presented risk of restenosis following PCI. Positive response to the WTP question is based on the conservative approach assumption. The ■ curve represents the percentage of patients positively responding to the WTP question when presented with a 20% risk of restenosis following PCI. The ● curve represents the percentage of patients positively responding to the WTP question when presented with a 10% risk of restenosis following PCI.](image-url)

![Table 2. Patient QOL and Mental Health Status According to WTP the Proposed Amount](table-url)
independent, statistically significant predictors of the probability of answering positively to the WTP question (Table 4). Patients with gross family income ≥$60 000 were more than twice as likely to respond positively to WTP questions than those with a lower income (OR, 2.81; 95% CI, 1.32 to 5.97). An increase in price was shown to have a significant quadratic relation to patient response to the WTP question (P = 0.001). In general, below $1500, price had little impact on patient response to the WTP question. In contrast, as the prices increased from $1500 to $3000, the probability of positively responding to the WTP question started to decrease sharply. For example, for patients with a gross family income <$60 000; risk of restenosis 20%; and a history of PCI, MI, and CABG surgery, the estimated probabilities of their answering yes to the WTP question were 0.81, 0.80, and 0.77 for the original bids of $500, $1000, and $1500, respectively. However, for the patients with the same characteristics, the estimated probability decreased to 0.72 at $2000 and 0.64 at $2500 and was as low as 0.53 for the maximum price of $3000. None of the other sociodemographic variables or clinical characteristics was independently associated with the probability of being willing to pay the proposed amount (Table 4).

### Discussion

Patients waiting for a coronary angiography with ad hoc PCI would be willing to pay a median amount of $2802 for a treatment that would eliminate their risk of restenosis following PCI. Considering that patients who refused to answer the WTP question and those who responded with an “I don’t know” response were considered to reject the proposed amount, the actual median WTP amount might be even higher. As expected, higher income and lower prices favored answering positively to the WTP question, upholding the internal validity of the method we used. Although higher prices were shown to decrease the patients’ probability of positively responding to the WTP question, the relation seemed to follow a quadratic relationship, mainly beyond $1500. Such results seem to indicate that the ability to pay (and not the price of the treatment eliminating the risk of restenosis) would be the only parameter of importance at prices below $1500. This finding could imply that patients consider that such a therapy is worth at least $1500. Alternatively, this finding may indicate that patients do not consider the budgetary impact of the increase as being constant. For example, increasing the price from $500 to $1000 may not have the same impact for patients as increasing the price from $2000 to $2500.

To the best of our knowledge, this study is the first to estimate patients’ WTP for the elimination of a risk of restenosis in a publicly funded healthcare system setting. Greenberg et al previously reported that US patients were willing to pay no more than $US 273 and $US 366 for a similar 10% and 20% reduction of the risk of restenosis. Several reasons may explain the differences in observed WTP between both studies. First, both risk scenarios in our study assessed patients’ WTP for the complete elimination of the risk of restenosis. Although our observed median WTP is much higher than those observed in the American study, patients in the latter study were willing to pay a much higher amount ($1162) for the complete elimination of the risk of restenosis. Second, given that patient healthcare costs are already covered by taxes in Canada, it is possible that patients would be willing to pay a much higher out-of-pocket amount because they are only directly paying for the treatment that eliminates the risk of restenosis compared to US patients who would be required to pay for the whole procedure as well as the hypothetical treatment.

Our analysis does not refer to a specific technology aimed at reducing the risk of restenosis, such as DES, but to a hypothetical treatment that can completely eliminate resteno-
sis. No treatment currently can achieve such a health benefit. Most cost-effectiveness analyses have indicated that the best “bang for the buck” with DES may be limited to patients with higher risk profiles, although the widespread implantation of DES in the unselected population may not be cost-effective.\textsuperscript{5,21–23} Such evaluations usually were based on a disease-specific cost-effectiveness ratio: cost per RR avoided.\textsuperscript{21–25} Although this metric has intuitive appeal and is straightforward to calculate, the proper threshold value to declare that an intervention is cost-effective was derived from available literature and believed to be \$10 000 per RR avoided.\textsuperscript{20–22} Compared with societal thresholds in cost-effectiveness analyses, the amount patients are willing to pay to attain a preferred health state may substantially differ from society’s WTP for the same outcome. Therefore, our results should not be used to set a threshold to declare a treatment as cost-effective when using the cost per RR avoided metric. We can only conclude that patients would be willing to pay a substantial amount (\$2802 out of their pocket), which amounts to close to 3 times the incremental cost of a DES over a BMS (currently \$1000), for a treatment that completely abolishes the risk of this detrimental health condition (a goal that has yet to be realized with current therapies).

Our study has limitations that we need to acknowledge. First, our selected range of value underestimated patients’ WTP for the intervention, and as such, we needed to linearly extrapolate our population’s median WTP. Although the selected range was based on the incremental cost of DES over BMS, a wider or higher range of bids would have yielded a more-precise answer. Additionally, WTP using an out-of-pocket amount already has been shown to overestimate patients’ real WTP.\textsuperscript{9} Despite attempting to palliate this issue, patients may still have stated an increased WTP due to the virtual exercise of the survey. Second, we used an ex post approach that involved asking a sample population of patients undergoing cardiac catheterization with ad hoc PCI about their WTP for a treatment that would eliminate the risk of restenosis. The ex post approach estimates the amount a user would be willing to pay for the treatment at the point of consumption.\textsuperscript{11} In contrast, the ex ante approach estimates the amount an individual would be willing to pay, through increased taxes or insurance fees, for the treatment to be covered by an insurance plan.\textsuperscript{11} Although the ex post approach is more commonly used in contingent valuations, some have argued that the ex ante approach should be favored due to its theoretical foundation.\textsuperscript{26} However, the ex post approach offers several advantages, including better understanding by actual patients of risk and benefits associated with the proposed treatment.\textsuperscript{27,28} Third, we used a closed-ended format to elicit our patients’ WTP. Evidence shows that different formats can yield different estimates of WTP; however, there is no consensus on which format should be used.\textsuperscript{12} There is at least some concern that closed-ended formats can overestimate the real WTP.\textsuperscript{29,30} Fourth, our study was performed in a small single teaching hospital. Although this center provides services to patients in and beyond the greater Montreal region, our study sample comprised essentially French-Canadians whose values may possibly differ from patients outside our province or country. Finally, as acknowledged earlier, we attempted to assess patients’ WTP for a hypothetical treatment that would completely eliminate restenosis with no additional risk. This assumption diverges from the current outcome of DES, which remains limited by a residual risk of restenosis, although the residual risk appears lower than 5% to 7% in most cases.\textsuperscript{6} Therefore, the WTP we assessed cannot be considered equivalent to the WTP for the incremental cost of DES versus BMS, and determining such a WTP would require an additional contingent valuation specifically comparing the benefits of DES to BMS. Furthermore, conventional decision theory would suggest that the probability of a positive answer to the WTP question should be proportional to the baseline risk.\textsuperscript{31,32} Accordingly, in our study, the group presented with the 20% risk of restenosis should have a twice-higher probability of a positive answer than the 10% group. Our point estimate of the adjusted OR for the higher (20%) versus lower (10%) baseline risk (OR, 1.78; 95% CI, 1.07 to 2.97) is slightly below the expected value of 2.0, but the latter value is well within the estimated 95% CI, suggesting that the discrepancy may be due to sampling error. Whereas our questionnaire was designed to assess WTP for only a 10% or 20% risk of restenosis, it would be interesting to estimate the WTP corresponding to other risk levels. Finally, it is possible that the actual increase in the probability of the patient willing to pay in the situation with the higher baseline risk of restenosis is lower than expected because of concerns about the incremental risk of other associated complications.

In conclusion, despite being informed that restenosis is a non-life-threatening condition, our results indicate that patients would be willing to pay a substantial amount to eliminate the risk of this complication after PCI. Although our results provide additional information on the benefits provided by technologies that reduce restenosis rates, a complete cost-benefit analysis specifically examining DES would be required to assess the entire benefits provided by DES over BMS.

Sources of Funding
This study was funded by the Fonds de la recherche en Santé du Québec (FRSQ). Drs Rin fret and Brophy are clinician-scientists of the FRSQ. Dr Abrahamowicz is a James McGill Professor of Biostatistics at McGill University.

Disclosures
Dr Cohen has received grant support from Cordis and Boston Scientific and consulting fees from Medtronic. Dr Rin fret has received grant support from Cordis Canada and consulting fees from Cordis and Abbott Vascular Canada. No other potential conflict of interest relevant to this article was reported.

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Circ Cardiovasc Qual Outcomes. 2011;4:46-52; originally published online December 14, 2010; doi: 10.1161/CIRCOUTCOMES.109.915421

Circulation: Cardiovascular Quality and Outcomes is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2010 American Heart Association, Inc. All rights reserved.
Print ISSN: 1941-7705. Online ISSN: 1941-7713

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