

Predicting EQ-5D-5L Utility Scores from the Oswestry Disability Index and Roland-Morris Disability Questionnaire for Low Back Pain

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Background: Cost utility analysis is important for measuring the impact of chronic disease and helps clinicians and policymakers in patient management and policy decisions, but generic preference-based measures are not always considered in clinical studies.

Objective: To evaluate if health-related quality-of-life (HRQoL)-specific questionnaires used in chronic low back pain (CLBP) can predict EQ-5D-5L utility scores.

Methods: The data come from an online survey on low back pain conducted between October 2018 and January 2019. Health utility scores for EuroQol Five Dimensions Five Levels (EQ-5D-5L) were calculated with the recommended model of Xie et al. The EQ-5D-5L health states ranged from -0.148 for the worst (55555) to 0.949 for the best (11111). Univariate and multivariate linear regression were performed to predict EQ-5D-5L with Oswestry Disability Index (ODI), Roland-Morris Disability Questionnaire (RMDQ) and clinical variables.

Results: Analyses were performed in 408 subjects who completed the questionnaires EQ-5D-5L, ODI or RMDQ. Median (range) of EQ-5D-5L was 0.622 (-0.072 to 0.905). There was high correlation between EQ-5D-5L and ODI ($r = -0.78$, $p < 0.001$), while it was moderate with RMDQ ($r = -0.62$, $p < 0.001$). The multivariate model to predict EQ-5D-5L with ODI explained 67.6% of variability, and the correlation between actual and predicted EQ-5D-5L was 0.82. Principal predictors were ODI, duration of LBP, invalidity, health satisfaction (0–10 cm), life satisfaction (0–10 cm), and intensity of pain today (0–10 cm).

Conclusion: Data from this study demonstrated that individual correlation between ODI and EQ-5D-5L was high, but moderate with RMDQ. Correlations between actual and predicted EQ-5D-5L from multivariate models were higher and very high. Considering these results, the multivariate model can be used in similar studies for patient with CLBP to estimate the utility scores from the ODI when the EQ-5D-5L was not measured.

Keywords: low back pain, EQ-5D-5L, utility score, QALY, health-related quality of life

Introduction

Low back pain (LBP) is a major cause of disability. It is estimated that about 80% of people will experience at least one form of back pain (pain and disability) during their lifetime¹⁻³ and that chronic low back pain (CLBP) affects between 20% and 30% of the population according to several studies.⁴⁻⁸ Pain is considered chronic if it lasts for more than 3 to 6 months.^{7,9}

Health-related quality of life (HRQoL) is important for measuring the impact of chronic disease and help clinicians and policymakers in patient management and policy

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decisions.¹⁰ Several instruments can be used to measure HRQoL, some are specific to the disease while others are generic preference-based measures, each having its strengths and weaknesses.¹⁰ The Oswestry Disability Index (ODI) and Roland-Morris Disability Questionnaire (RMDQ) are specific instruments commonly used to measure the disability related to LBP.^{11,12} Also, there are several generic preference-based measures to evaluate the HRQoL such as the EuroQol Five Dimensions (EQ-5D) and the Short Form Six Dimensions (SF-6D). These instruments allow to calculate utility scores and belong to the family of the Quality-Adjusted Life-Year (QALY) questionnaires. The EQ-5D and SF-6D have been used and validated in different LBP populations.^{13–16} To date, it is recommended to use several instruments to measure HRQoL¹⁰ but not always done, especially in clinical studies. It is also worthwhile to note that the EQ-5D is available in two versions: EuroQol Five Dimensions Three Levels (EQ-5D-3L) and EuroQol Five Dimensions Five Levels (EQ-5D-5L). The difference is that the EQ-5D-5L uses the same dimensions as the EQ-5D-3L but allows 5 levels of answers instead of only 3. This leads the EQ-5D-5L to generate more health states and then to provide a higher level of sensitivity when evaluating HRQoL.

The correlation between EQ-5D and ODI in the literature varies from moderate^{17–19} to high correlation.¹⁴ To our knowledge, only one study analyzed the correlation between RMDQ and EQ-5D and found a moderate correlation.²⁰ Carreon et al computed a regression model to estimate EQ-5D-3L with ODI and other measures, but they did not use EQ-5D-5L and their conclusion was that the EQ-5D cannot be accurately estimated from the ODI.¹⁸ Other authors used mapping to predict EQ-5D-3L and did not consider ODI as instrument.^{20,21} Some authors correlated EQ-5D-5L with ODI and other measures, but did not perform regression models to predict EQ-5D-5L.^{14,15}

The purpose of this study is thus to evaluate if two current specific questionnaires used in CLBP (ODI and RMDQ) can be used to predict EQ-5D-5L utility scores and EuroQol Visual Analog Scale (EQ-VAS). If so, we will define the predictors of the EQ-5D-5L and establish a predictive equation.

Methods

Data

The data come from an online survey on low back pain conducted between October 2018 and January 2019. The

Quebec Association of Chronic Pain distributed the survey by email to its members and posters were also publicized at different places in our hospital. No monetary compensation was allocated to complete the survey. The inclusion criteria were to be a Quebec resident, had at least 18 years, suffer from LBP and able to read and understand either French or English. Subject with LBP for less than 3 months or unable to complete alone or accompanied an online questionnaire were excluded.

Survey

The primary purpose of the survey was to identify patient preferences for non-surgical treatment for low back pain using a discrete choice experiment.²² Variables used in this study were mainly from the sociodemographic characteristics, the duration of participants' LBP, intensity of pain on a numerical rating scale from 0 (no pain) to 10 (worst possible pain), and health and life satisfaction scores measured with a numerical rating scale from 0 (not at all satisfied) to 10 (fully satisfied). The questionnaire ends with 4 HRQoL questionnaires administered in a random order, ie, two generic preference-based measures (EQ-5D-5L and SF-6D) and two specific questionnaires (ODI and RMDQ).

Oswestry Disability Index

The ODI is a specific instrument used to measure disability in patients with LBP.¹¹ It includes 10-item scale (pain intensity, personal care, lifting, walking, sitting, standing, sleeping, work, social life and traveling) with 6 levels from 0 to 5. A total score is calculated by adding the 10 items to obtain a partial score from 0 to 50. The score is transformed to obtain a 0–100 scale. The total score could be categorised in minimal disability (0–20), moderate disability (21–40), severe disability (41–60), crippled (61–80) and bed-bound or exaggerating their symptoms (81–100).

Roland-Morris Disability Questionnaire

The RMDQ is a specific instrument used to measure disability related to LBP. It includes 24 questions that describe some of the challenges of doing daily physical activity directly related to lower back pain.²³ All questions are yes/no and a total score is calculated from 0 to 24 by adding the number of yes responses. A higher score reflects more disability.

EQ-5D-5L

The EQ-5D-5L questionnaire includes 6 questions. The 5 first questions correspond to 5 dimensions (mobility, self-care,

usual activities, pain/discomfort, and anxiety/depression) with 5 levels each from no problem to extreme problem. The last question is a vertical visual analog scale (VAS) with 100 on the top representing the “best imaginable health state” and 0 at the bottom representing the “worst imaginable health state.” Health utility scores were calculated with the value set developed by Xie et al²⁴ and using their recommended model. The health utilities elicited ranged from −0.148 for the worst (55555) to 0.949 for the best (11111) EQ-5D-5L health states. Indeed, since health utility scores were calculated with a linear model, worst and best states were different than 0 and 1.

Statistical Analysis

Sociodemographic and clinical characteristics were presented with frequency and percentage for categorical variables and mean, standard deviation and range for continuous variables. Histograms were used to evaluate normality distributions. Results are presented with median (interquartile range (IQR)) for EQ-5D-5L and with mean (95% confidence interval (CI)) for EQ-VAS, ODI and RMDQ. Ceiling and floor effect were calculated for each utility instrument. Ceiling effect was the proportion of respondents reporting “no problems” for all dimensions and floor effect was the proportion of respondents reporting the worst level for all dimensions. Specific and generic preference-based measures were compared according to ODI categories with ANOVA or Kruskal–Wallis. Spearman correlations were computed with EQ-5D-5L and Pearson correlations with other variables. Univariate and Multivariate linear regression models were performed to predict EQ-5D-5L and EQ-VAS. One first model was performed with clinical variables easily available (gender, age, duration of LBP, invalidity yes/no). Other models performed with other significant variables in univariate analysis (health satisfaction, life satisfaction and intensity of pain). Since the EQ-5D-5L was not normally distributed, the model was applied on inverse logarithm utility score transformation ($\log(x-1)$), the best transformation among the ones tested to obtain normal distribution. Therefore, the estimates of the models must be interpreted in the opposite direction. Pearson correlations were computed to evaluate the association between transformed EQ-5D-5L and predicted values from multivariate linear regressions. The interpretation of correlation coefficient was very high between 0.9 and 1, high between 0.7 and 0.9, moderate between 0.5 and 0.7, and low between 0.3 and 0.5.^{25,26} As the EQ-5D-5L and specific questionnaires were at the end of the survey, and as the subjects were obliged to answer the questions to go on to

Table 1 Sociodemographic and Clinical Characteristics

	All Subject (n=408)
Age (years), Mean \pm SD Range	55 \pm 12.3 (20–87)
Gender	
Men	83 (20.3)
Women	323 (79.2)
Intersex	2 (0.5)
Body mass index (kg/m ²), Mean \pm SD Range	29.3 \pm 6.8 (13.7–62.7)
Smoking	53 (13.0)
Marital Status	
Married/living with a partner	248 (60.8)
Single	71 (17.4)
Divorced/separated	77 (18.9)
Widowed	12 (2.9)
Occupational Status	
Employed or student	117 (28.7)
Retired	141 (34.6)
Unemployed	35 (40.2)
On sick leave, parental leave	57 (14.0)
Invalid	58 (14.2)
Education	
Secondary or less	57 (14.0)
Diploma of professional Studies	61 (15.0)
CEGEP	116 (28.4)
University	174 (42.7)
Annual household income (K\$ CAN), Mean \pm SD Range	57.7 \pm 37.4 (2.5–165)
Living with an adult	275 (67.4)
Have a child	66 (16.2)
Urban area	290 (71.1)
Owning a home	261 (64.0)
Health Status	
Excellent/Very good	51 (12.5)
Good	153 (37.5)
Fair	141 (34.6)
Poor	63 (15.4)
How long have they had lower-back pain	
From three months to a year	8 (2.0)
More than a year	400 (98.0)
Satisfaction on his/her health, Mean \pm SD	4.0 \pm 2.4
Satisfaction on his/her life, Mean \pm SD	5.4 \pm 2.5
Intensity of pain today (0–10 cm), Mean \pm SD	5.5 \pm 2.0
Worst level of pain in the last two weeks (0–10 cm), Mean \pm SD	7.6 \pm 1.8
Average level of pain in the last two weeks (0–10 cm), Mean \pm SD	5.6 \pm 1.8

Abbreviation: SD, standard deviation.

the next question, the subjects with values for EQ-5D-5L, ODI and RMDQ answered all the previous questions. So no imputation was done for missing data. Normality of residues was validated. Analyses were computed with SAS software (version 9.4; SAS Institute Inc., Cary, NC, USA) and graph with GraphPad Prism version 7.00 for Windows. A p-value less than 0.05 was considered significant.

Ethical Approval

This project was approved by the institutional ethics committee (Comité d'éthique de la recherche of the CIUSSS de l'Estrie – CHUS #2019-2929). The subject's consent was obtained by clicking on the start button at the end of the explanatory letter. All questionnaires were anonym and the data were stored on a protected network at our institution to ensure confidentiality and protection of the respondents.

Results

Sample Characteristics

Between October 2018 and January 2019, 610 subjects responded to the survey. Reasons of exclusion were low

back pain for less than 3 months (n=8) and do not begin the survey (n=33). Analyses were performed only in 408 subjects who completed the questionnaires EQ-5D-5L, ODI or RMDQ. Subjects who did not complete the EQ-5D-5L and the specific HRQoL questionnaires were older, had a slightly lower BMI, were more widowers, more retired, had more osteoporosis, and did less aerobic activity. No difference was observed for education, income, pain, treatments, health status, life or health satisfaction ([Supplementary Table 1](#)). For subjects who went to the end of the survey, the median time to complete the questionnaire was 34 mins. Subject's characteristics are presented in [Table 1](#). The mean (range) age was 55 (20–87) years and majority was women (79.3%). The pain intensity was not so high, but their health and life satisfaction were low.

Descriptive Statistics and Correlations

Between QALY and HRQoL Questionnaires

Only the EQ-5D-5L was not normally distributed ([Figure 1](#)). No ceiling and floor effect was observed for EQ-5D-5L. For EQ-VAS, only one ceiling effect and 4 floor effects were

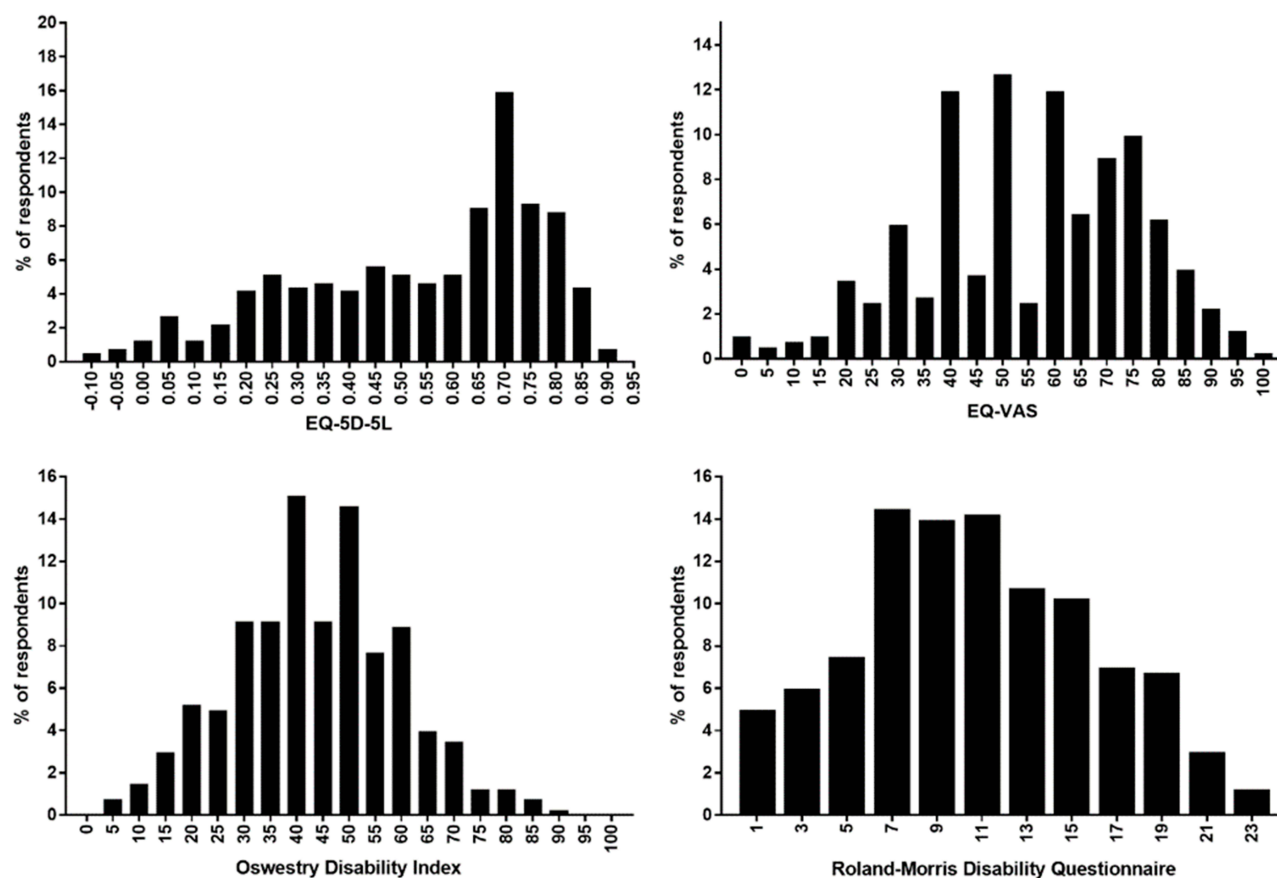


Figure 1 Distribution of EQ-5D-5L, EQ-VAS, Oswestry Disability Index and Roland-Morris Disability Questionnaire.

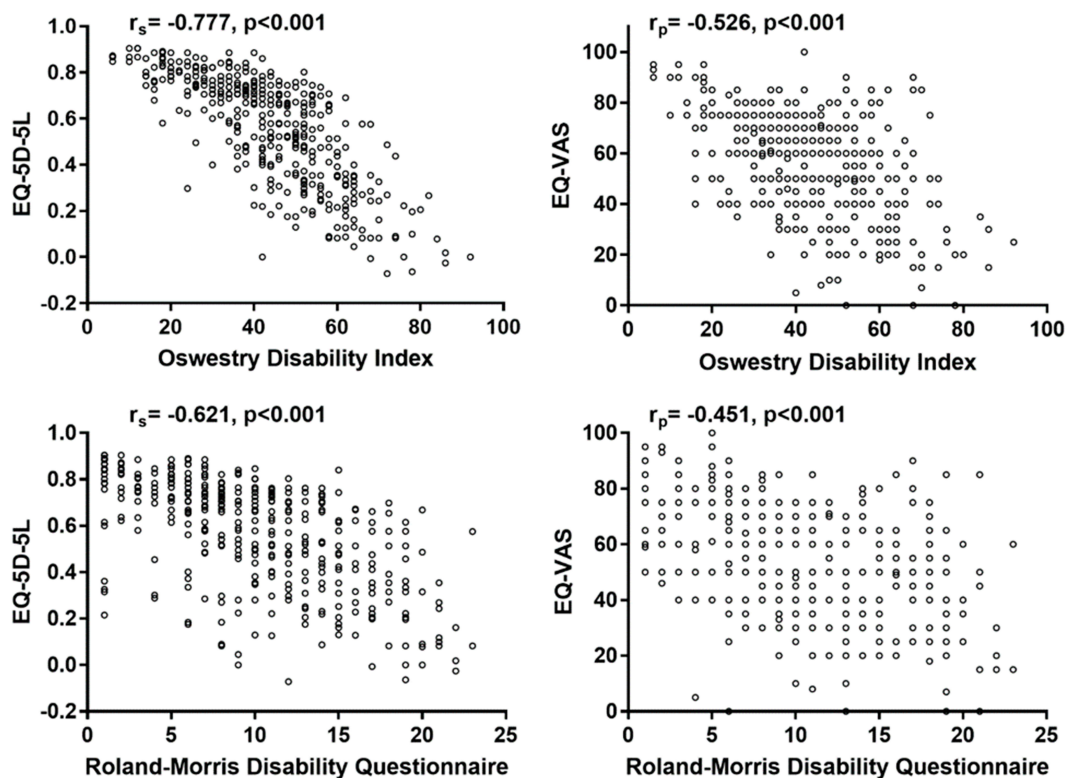
Table 2 Descriptive Statistics of EQ-5D-5L, EQ-VAS and Specific HRQoL Questionnaires

		EQ-5D-5L (n=408)	EQ-VAS (n=402)	RMDQ (n=401)	ODI (n=404)
Global					
Mean (95% CI)		0.558 (0.535–0.581)	55.3 (53.3–57.3)	10.3 (9.8–10.8)	43.7 (42.1–45.2)
Median (IQR)		0.622 (0.369–0.745)	60 (40–70)	10 (6–14)	44 (34–54)
Minimum		–0.072	0	1	6
Maximum		0.905	100	23	92
Oswestry Disability Index					
	N	Median (IQR)	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)
Minimal Disability (0–20)	38	0.834 (0.782–0.867)	77.6 (72.9–82.3)	3.8 (2.9–4.7)	15.4 (14.1–16.8)
Moderate Disability (21–40)	134	0.736 (0.668–0.782)	60.9 (58.1–63.6)	7.7 (7.1–8.3)	32.9 (32.0–33.8)
Severe Disability (41–60)	173	0.513 (0.355–0.661)	51.5 (48.7–54.2)	11.8 (11.2–12.5)	49.9 (49.1–50.7)
Crippled (61–80)	53	0.243 (0.126–0.335)	38.5 (32.3–44.7)	15.7 (14.4–17.1)	67.2 (65.7–68.6)
Bed-bound (81–100)	5	0.019 (0–0.079)	26.3 (12.7–39.8)	21.0 (19.2–22.8)	86.0 (81.4–90.6)

Abbreviations: HRQoL, health-related quality of life; EQ-5D-5L, EuroQol Five Dimensions, RMDQ, Roland-Morris Disability questionnaire; ODI, Oswestry Disability Index; CI, Confidence Interval.

observed. Table 2 presents the descriptive statistics of the outcomes. More detailed information about the ODI is also presented in [Supplementary Table 2](#). It is clear that EQ-5D-5L and EQ-VAS decreased when ODI increased (all $p < 0.001$). ODI and RMDQ were correlated at various degrees (from high to low) with EQ-5D-5L and EQ-VAS, but more with EQ-5D-5L ($r = -0.777$, $p < 0.001$ and $r = -0.621$,

$p < 0.001$, respectively) than EQ-VAS ($r = -0.526$, $p < 0.001$ and $r = -0.451$, $p < 0.001$, respectively) (Figure 2). Similar results were observed in univariate linear regression. Although both specific questionnaires were very significant in predicting the utility score and EQ-VAS, the variability explained by ODI was higher than RMDQ to predict EQ-5D-5L ($R^2 = 0.603$ vs 0.387 , respectively) and

**Figure 2** Correlations between EQ-5D-5L and EQ-VAS with Oswestry Disability Index and Roland-Morris Disability Questionnaire.

EQ-VAS ($R^2=0.276$ vs 0.204 , respectively) (Table 3 and Supplementary Tables 3 and 4). In addition, as shown earlier, ODI was better to predict the EQ-5D-5L than EQ-VAS.

Predictors of Utility Score

Multivariate linear regression models by outcome were performed to evaluate predictors of utility score (Table 3 and Supplementary Tables 3 and 4). Since EQ-5D-5L values were transformed with inverse logarithm to obtain a normal distribution of residues, the estimates must be interpreted in the opposite. In all models, ODI or RMDQ were the highest predictor and were significantly associated with lower EQ-5D-5L and lower EQ-VAS, but the variability explained by the models was always higher with ODI than RMDQ. In all full models, health or life satisfaction increased the health utility score and pain reduced the health utility score. Subjects with invalidity decreased the EQ-5D-5L, but had no impact on EQ-VAS. When each item of ODI was included separately in EQ-5D-5L models, a majority were significantly associated with lower health utility score except lifting, sitting and standing

(Supplementary Table 3). A fewer number of ODI sections were significantly associated with EQ-VAS (Supplementary Table 4). For EQ-5D-5L and EQ-VAS, the highest ODI predictor was pain intensity. In model 3, the intensity of pain today (0–10 cm) was not significant, but the effect was probably captured by the pain item of ODI. When each item of RMDQ was analysed, only items with $p<0.1$ in model 1 were presented and used in models 2 and 3 (Supplementary Table 3). The RMDQ items with the highest coefficients negatively associated with EQ-5D-5L were staying at home most of the time, not doing any jobs that I usually do around the house, painful almost all of the time, and can only walk short distances. Other predictors were invalidity, health and life satisfaction, and intensity of pain today. In model 3 for EQ-VAS, no items of RMDQ stayed significant. Only health and life satisfaction, and intensity of pain today predicted EQ-VAS.

The correlation between actual and predicted EQ-5D-5L using the univariate model with ODI was 0.78. The correlation stayed at 0.79 in model 2 and increased to 0.82 with model 3 including ODI (Figure 3). For EQ-5D-5L

Table 3 Univariate and Multivariate Linear Regression Models to Predict EQ-5D-5L

	Model 1	Model 2	Model 3
	Estimate (SE)	Estimate (SE)	Estimate (SE)
Oswestry Disability Index Score	$R^2 = 0.603$	$R^2 = 0.628$	$R^2 = 0.676$
	RMSE = 0.154	RMSE = 0.149	RMSE = 0.140
Intercept	−0.9431 (0.0225) ***	−0.488 (0.2145) *	−0.2617 (0.2032)
Oswestry	0.0120 (0.0005) ***	0.0116 (0.0005) ***	0.0091 (0.0006) ***
Age (years)		−0.001 (0.0006)	−0.0004 (0.0006)
Women		−0.041 (0.0189) *	−0.0346 (0.0178) †
Time LBP (> 1 year vs 3 months to 1 year)		−0.0811 (0.054)	−0.1105 (0.0509) *
Invalid		0.0658 (0.0219) **	0.0555 (0.0205) **
Health satisfaction (0–10 cm)			−0.0127 (0.0039) **
Life satisfaction (0–10 cm)			−0.0122 (0.0039) **
Intensity of pain today (0–10 cm)			0.0136 (0.0042) **
Roland-Morris Disability Questionnaire	$R^2 = 0.387$	$R^2 = 0.417$	$R^2 = 0.567$
	RMSE = 0.192	RMSE = 0.187	RMSE = 0.162
Intercept	−0.7178 (0.021) ***	−0.1862 (0.2683)	0.0545 (0.2333)
Roland Morris	0.0288 (0.0018) ***	0.0279 (0.0019) ***	0.0176 (0.0018) ***
Age (years)		−0.00001 (0.0008)	0.0002 (0.0007)
Women		−0.0308 (0.0239)	−0.0283 (0.0208)
Time LBP (> 1 year vs 3 months to 1 year)		−0.1208 (0.068) †	−0.1563 (0.059) **
Invalid		0.0895 (0.0278) **	0.0642 (0.0242) **
Health satisfaction (0–10 cm)			−0.0139 (0.0045) **
Life satisfaction (0–10 cm)			−0.0206 (0.0044) ***
Intensity of pain today (0–10 cm)			0.0301 (0.0046) ***

Notes: 0.05 † $p<0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Abbreviations: SE, standard error; RMSE, root-mean-square deviation; R^2 , R-squared; LBP, low back pain.

predicted by RMDQ, correlations were 0.62, 0.65 and 0.75 for model 1 to 3, respectively (Figure 3). Adding health and life satisfaction, and intensity of pain today increased the predictive capacity of the model. Similar results were observed for EQ-VAS (Supplementary Table 4). On the other hand, the variability explained by the models was lower, being invalid is not a predictor of EQ-VAS and many fewer ODI items were significant.

Discussion

The main purpose of this study was to evaluate if ODI and RMDQ can be used to predict utility scores. Data from this study demonstrate that EQ-5D-5L is highly correlated with ODI and only moderately with RMDQ. Correlations with the EQ-VAS were also significant but lower than with the EQ-5D-5L. Since correlations generated interesting results, we constructed regression models to predict these outcomes. The correlation was high between the EQ-5D-5L and the predicted values from the full model (model 3), which shows that the regression model predicts the EQ-5D-5L very well. Indeed, in all models with ODI the correlations between actual and predicted EQ-5D-5L were high (0.7–0.9), while they were moderate (0.5–0.7) with RMDQ in models 1 and 2, and high in model 3.

Consequently, we recommend using the full model to convert answers to ODI and RMDQ questionnaires into utility scores. However, if some variables used in the full model are not available, it should be better to use only answers from the ODI than from the RMDQ to predict utility scores. The lower correlation we observed between the EQ-5D-5L and RMDQ may be explained by the lower range of values generated by the RMDQ despite it has more questions than the ODI. Since the EQ-5D-5L describes 3125 possible health states it may better correlate with a questionnaire using a higher range of values (0–24 vs 0–100). Also, the dimensions described in the ODI may be considered as closer to that of the EQ-5D-5L.

This finding is consistent with two studies that found similar correlation between EQ-5D-5L and ODI.^{14,15} Ye et al found a higher correlation ($r=-0.828$) and Cheung et al found exactly the same correlation ($r=-0.770$). On the other hand, we have a better correlation than other studies that had only moderate correlations around 0.5.^{17,19} For the studies that had moderate correlations, they mainly used the EQ-5D-3L, which may explain the lower correlation since the EQ-5D-3L has less sensitivity than the EQ-5D-5L. This indicates that the EQ-5D-5L is potentially better correlated with HRQoL questionnaires in patients with LBP.

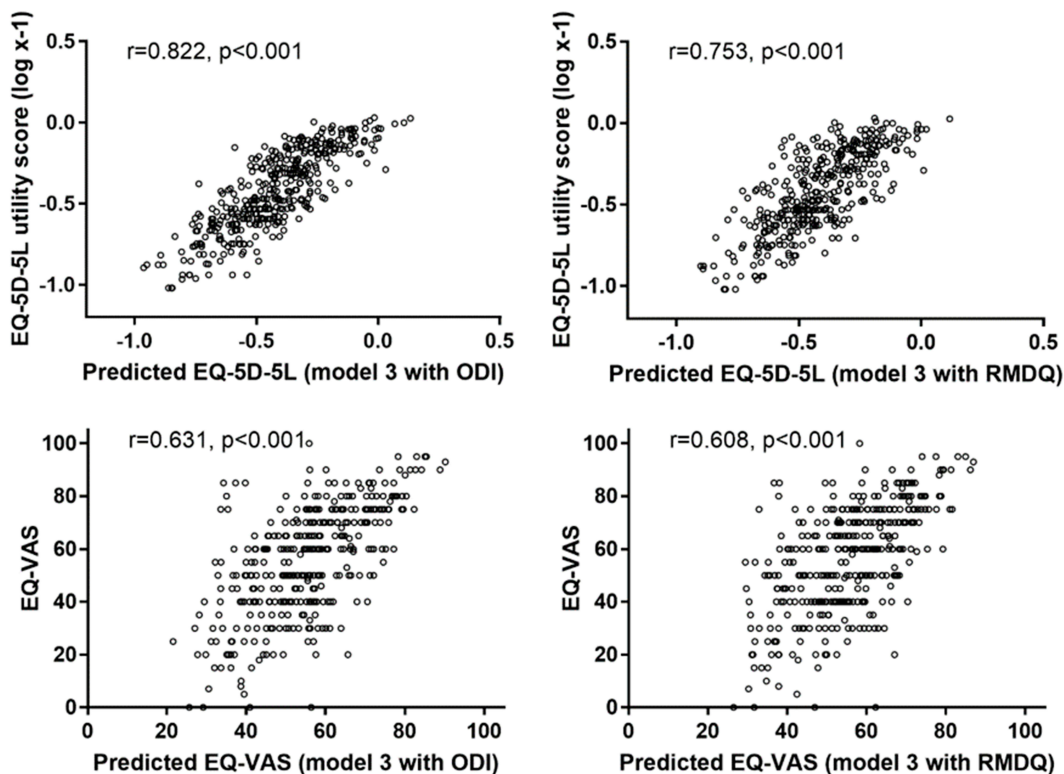


Figure 3 Predicted and actual EQ-5D-5L and EQ-VAS considering the model 3 with Oswestry Disability Index (ODI) and Roland-Morris Disability Questionnaire (RMDQ).

A strength of our study is that, to our knowledge, no study has built a prediction model for the EQ-5D-5L, but some were created for EQ-5D-3L.^{18,20,21} Ye et al and Cheung et al used the EQ-5D-5L, but did not construct predictive models.^{14,15} In addition, the variability explained by our model is very high and our results and distribution of utility scores and specific questionnaires are similar than other cohorts with the same problematic, even if it is in other regions.^{14,15} Another strength is that no ceiling effect was observed in our cohort for EQ-5D-5L as in the study by Ye et al where the ceiling effect is very small (0.4%)¹⁴ but different from Cheung et al study who have 14% for EQ-5D-5L.¹⁵

One limitation for calculating EQ-5D-5L utility scores is that there no value set for the Quebec population, so that we used a value set from Canada where other provinces were disproportionately represented. Another limitation is that women are over-represented in our cohort, although it is recognized that LBP is more prevalent among women. However, women generally represent two-third of LBP^{8,27,28} and not the three quarters as in our survey, this indicating that women may be more inclined to respond to such surveys. The number of subjects for a survey is quite high and is more than other study analyzing the EQ-5D-5L, but it is maybe not enough to have a representative cohort of the Quebec population with LBP. This may limit the generalization of the results. Another limitation is that the subjects who did not complete the survey until the EQ-5D-5L and the HRQoL-specific questionnaire were older which may underrepresent this population in utility scores. It is also possible that this clientele had more difficulty to complete the online questionnaire and left it before the end.

Conclusion

Despite the high correlation between ODI and EQ-5D-5L, these ones are not interchangeable, as well as for the RMDQ where the correlation was only moderate. Given the high correlation between the values predicted by the regression model and the utility scores, the full model can be used in similar studies for patients with CLBP to estimate the EQ-5D-5L scores from the ODI.

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Disclosure

The authors report no conflicts of interest in this work.

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