Rasch Rating Scale Model (RSM) Analysis of the EQ-5D Using the 2003 Medical Expenditure Panel Survey (MEPS)

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Introduction

- The EQ-5D is a widely used generic preference-based instrument quantifying health-related quality-of-life (HRQoL) in health outcome assessments, clinical trials, cost-effectiveness analysis (CEA) and burden of disease studies.

**EQ-5D**
- 5 items (domains)
  - mobility (MO), self-care (SC), usual activities (UA), pain/discomfort (PD) and anxiety/depression (AD)
- Each item has 3 responses
  - No problem (=1), some problem (=2), extreme problem (=3)
- \(3^5 = 243\) health states
- Visual Analogue Scale (VAS)
- Single index score

- The validity and the item properties, in a U.S. sample have yet to be explored.
Fundamental Assumptions

- EQ-5D describes and quantifies HRQoL
- Fewer problems endorsed indicates better HRQoL
- Lower severity of problems also indicates better HRQoL

By these assumptions…

- Item endorsement should be a function of respondent HRQoL, the difficulty of endorsing the item and the severity level of the response category
The Rasch Model (RM)

\[ P(X_{ni} = x) = f(\beta_n - \delta_{ix}) \]  \hspace{1cm} (1)

- The probability of endorsing an item is a function of the persons HRQoL \( \beta \) and the severity of the EQ-5D item \( \delta \) at category \( x \)
The Rasch Rating Scale Model (RSM)

\[ P(X_{ni} = x) = \frac{\exp \sum_{j=0}^{x} \left[ \beta_n - (\delta_i + \tau_j) \right]}{\sum_{k=0}^{m} \exp \sum_{j=0}^{\delta_k - (\delta_i + \tau_j)}}, \]  
\[ x = 0, 1, \ldots, m \quad (2) \]

- Where \( P(X_{ni} = x) \) is the probability that a person \( n \) is assigned to rating scale category \( x \) on item \( i \), each item has \( m + 1 \) rating scale categories.

- And
\[ \sum_{j=0}^{0} \left[ \beta_n - (\delta_i + \tau_j) \right] = 0 \quad (3) \]
Hypotheses Tested

- $H1$: All EQ-5D items contribute to a single underlying construct of HRQoL in all populations

- $H2$: Departure from $H1$ occurs in one or more sub-populations (gender or disease groups)
METHODS
Data Source

- The 2003 Household Component Full-Year Files from the Medical Expenditure Panel Survey (MEPS), conducted by the US Agency for Healthcare Research and Quality (AHRQ)

Inclusion criteria
- positive person weights
- 18 years or older
- complete EQ-5D responses
- no extreme scores demonstrating ceiling or floor effect
- Primary ICD-9-CM codes for the top 10 most prevalent chronic diseases in MEPS

Participants

<table>
<thead>
<tr>
<th>Chronic Disease</th>
<th>ICD-9</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>401</td>
<td>797 (19.4)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>250</td>
<td>484 (11.8)</td>
</tr>
<tr>
<td>Depression</td>
<td>311</td>
<td>468 (11.4)</td>
</tr>
<tr>
<td>Back Disorder</td>
<td>724</td>
<td>417 (10.2)</td>
</tr>
<tr>
<td>Arthropathy</td>
<td>716</td>
<td>383 (9.3)</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>272</td>
<td>182 (4.4)</td>
</tr>
<tr>
<td>Asthma</td>
<td>493</td>
<td>172 (4.2)</td>
</tr>
<tr>
<td>Sinusitis</td>
<td>473</td>
<td>133 (3.2)</td>
</tr>
<tr>
<td>Anxiety</td>
<td>300</td>
<td>191 (4.7)</td>
</tr>
<tr>
<td>Joint Disorder</td>
<td>719</td>
<td>164 (4.0)</td>
</tr>
<tr>
<td>Healthy</td>
<td>No ICD-9</td>
<td>716 (17.4)</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>4107 (100%)</td>
</tr>
</tbody>
</table>
Analysis Plan

- Create linear measures using RSM
- Item infit/outfit standardized z score ($Z$)
  - Underfit if $Z > +2 \rightarrow$ noisy/erratic
  - Overfit if $Z < -2 \rightarrow$ muted/Guttman
- Principal component analysis (PCA) of Rasch residuals
  - Amount of variance explained after the Rasch measure is accounted for
- Differential Item Functioning (DIF)
  - DIF if individuals with the same level of HRQoL respond systematically different to the EQ-5D items
- Report using log-odd units (logits)
- *A priori* significance level 0.05
  - Bonferroni adjustment to control for Type I error
RESULTS
Category Probability Curves

- $P(X_{ni} = 1)$: No problem
- $P(X_{ni} = 2)$: Some problem
- $P(X_{ni} = 3)$: Extreme problem

Values:
- $\tau_1 = -2.63$
- $\tau_2 = 2.63$
Principal Component Analysis of Rasch Residuals

- About 75% ~ 94% of the variance explained by the EQ-5D items within different disease groups, after the Rasch measure was accounted for
- Small amount of variance unexplained
Infit Z

- Mobility
- Self-Care
- Usual Activities
- Pain/Discomfort
- Anxiety/Depression

Underfit, > +2 (noisy/erratic)

"Anxiety/depression"
Outfit Z

“Anxiety/depression”

Underfit, > +2 (noisy/erratic)
## Gender-Related Differential Item Function (DIF)

<table>
<thead>
<tr>
<th>Item</th>
<th>Female</th>
<th>Male</th>
<th>DIF Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DIF Measure</td>
<td>DIF S.E.</td>
<td>DIF Measure</td>
</tr>
<tr>
<td>Mobility</td>
<td>0.36</td>
<td>0.05</td>
<td>0.21</td>
</tr>
<tr>
<td>Self-Care</td>
<td>3.00</td>
<td>0.08</td>
<td>3.00</td>
</tr>
<tr>
<td>Usual Activities</td>
<td>-0.05</td>
<td>0.05</td>
<td>0.13</td>
</tr>
<tr>
<td>Pain/Discomfort</td>
<td>-2.22</td>
<td>0.05</td>
<td>-2.50</td>
</tr>
<tr>
<td>Anxiety/Depression</td>
<td>-1.06</td>
<td>0.05</td>
<td>-0.80</td>
</tr>
</tbody>
</table>

* Significant after Bonferroni adjustment of Type I error
Infit Z on PD & AD with Gender-Split

“Anxiety/depression” _ Male
“Anxiety/depression” _ Female

Underfit, > +2 (noisy/erratic)

Abbreviation: PD = Pain/Discomfort; AD = Anxiety/Depression
Outfit Z on PD & AD with Gender-Split

Underfit, > +2 (noisy/erratic)

Abbreviation: PD = Pain/Discomfort; AD = Anxiety/Depression
Limitations and Future Studies

- In this study, we did not investigate:
  - ethnicity or socioeconomic status (SES) related DIF
  - interactions between disease and item within subgroups
  - the inclusion of the EQ-5D VAS into the Rasch model analysis
  - the validity of the findings by using different Rasch models
Conclusions

- We reject our null hypothesis
- EQ-5D items function similarly in different disease groups
- Unidimensionality is not achieved across all disease groups
- Item “anxiety/depression” consistently showed misfit irrespective of gender in most cases
- DIF found on the items “anxiety/depression” & “pain/discomfort” attributes, perhaps, to potential statistical artifacts
- It’s important to diagnose the potential causes of the misfit using the Rasch models by taking the confounding factors into consideration
Acknowledgments

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References

Thank You!