Facilitating external use with user-friendly interfaces: a health policy model case study

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on behalf of the SHARP Collaborative Group

useR! 2019
Toulouse, July 11, 2019
A health policy model is a tool to inform policy decisions by projecting people’s life courses. Predictions include

- disease events
- life expectancy
- quality of life
- healthcare costs
- effects of treatments
  - positive (disease risk reduction) and negative (adverse effects)

Projections made over long time periods (e.g., lifetime)
Motivation: why are health policy models needed?

Healthcare budgets are limited and not all treatments can be recommended even if effective

- Models show whether treatments are good value for money
- Health policy models are increasingly used by policy makers and clinicians
- In UK, cost-effectiveness analyses are required by NICE
  - Good-value-for-money: £20-30K per extra quality-adjusted life-year (QALY)
- Flexible models can help answer many policy questions
- Aim for transparency, reliability, reproducibility and usability
## Motivation: how to facilitate usability?

<table>
<thead>
<tr>
<th></th>
<th>Transparency</th>
<th>Reliability</th>
<th>Usability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release the code</td>
<td>yes</td>
<td>yes</td>
<td>no useRs only code mis-use</td>
</tr>
<tr>
<td>Publish equations and methods</td>
<td>yes (sort of)</td>
<td>yes (sort of)</td>
<td>no analysts only</td>
</tr>
<tr>
<td>Provide user-friendly interface</td>
<td>no black box</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Publish equations and methods and provide user-friendly interface</td>
<td>yes (sort of)</td>
<td>yes (sort of)</td>
<td>yes</td>
</tr>
</tbody>
</table>

NB: user vs useR
Introduction

The SHARP CKD-CVD outcomes model simulates long-term cardiovascular event rates, kidney disease progression, (quality-of-life adjusted) survival and healthcare costs associated with individual patient profiles and treatments. It can be applied to patient populations with moderate-to-severe chronic kidney disease who are over 40 years of age, and can be used with individual patients as well as groups of patients.

The model reports long-term projections as well as cost-effectiveness results comparing against the 'no treatment' strategy. The evaluated health outcomes and costs are reported separately for each treatment arm. The user can vary parameters to assess sensitivity of the results.

To perform the analysis, specify the required parameters using the 'Model parameter' tabs and click on the 'Run analyses' button on the Results tab. Please refer to the User guide and the published manuscript for further information.

The Glossary tab contains a list of commonly used definitions.

Citation

When referring to this program in publications, please cite the following references:
Case study: SHARP CKD-CVD model

Background

- Chronic kidney disease (CKD) increases cardiovascular (CV) risk
- Want to project long-term outcomes in CKD
  - cardiovascular events, CKD progression, life expectancy, quality of life, healthcare costs;
  - enable implementation of treatments to reduce cardiovascular risk
    - assess long-term effects and cost-effectiveness.
- Patient-level data from a trial
  - baseline characteristics, within-trial events
- Risk equations derived from the data
- Combined into a Markov model to do lifelong projections
  - validated internally and externally
The SHARP CKD-CVD model: need for a user-friendly interface

- The model to be useful for NICE, other analysts, clinicians...
- User-friendly interface accessible from anywhere
- No need for knowledge / installation of R
- Adaptation to other scenarios/countries
  - national mortality rates
  - national healthcare costs
- Customising parameters in the current setting
  - treatment to be assessed
  - population characteristics
  - duration of treatment / time horizon
  - discount rate
SHARP CKD-CVD model: Shiny interface

- Application accessed via a link
- The user only sees the front end
- All programs/data stored externally
- The front end can be modified using CSS themes, htmlwidgets, and JavaScript actions
  - fancy fonts, links, email addresses etc
  - error checking on data entry

http://one-elevenbooks.com/shiny-or-the-truth/

http://dismod.ndph.ox.ac.uk/kidneymodel/app/
SHARP CKD-CVD outcomes model (beta version)

Introduction

The SHARP CKD-CVD outcomes model simulates long-term cardiovascular event rates, kidney disease progression, (quality-of-life adjusted) survival and healthcare costs associated with individual patient profiles and treatments. It can be applied to patient populations with moderate-to-severe chronic kidney disease who are over 40 years of age, and can be used with individual patients as well as groups of patients.

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Schlackow I, Mihaylova B. The SHARP outcomes CKD-CVD outcomes model. 2016; available at http://dismod.ndph.ox.ac.uk/kidneymodel/app/

Contact

For queries, bug reports and suggestions, please email kidneymodel@ndph.ox.ac.uk

Acknowledgements

We thank Oliver Verran and Seamus Kent for their contribution to the development of the first version of the model and providing further feedback. We are also grateful to the IT team of the Oxford University’s Nuffield Department of Population Health for their support in installing and running the software.
SHARP CKD-CVD model: Shiny interface
SHARP CKD-CVD model: Shiny interface
SHARP CKD-CVD model: Shiny interface

![SHARP CKD-CVD outcomes model](image)

**Introduction**
- Model overview
- Glossary
- File specifications

**Model parameters**
- Type of analysis
  - Patient characteristics
  - Treatment parameters
  - Annual healthcare costs
  - Health-related quality of life
  - Non-vascular death probabilities

**Analyses**
- Results

**SHARP CKD-CVD outcomes model (beta version)**

Select characteristics for a single patient or import a text file with these characteristics for one or more patients.

- Import a file with patient characteristics

**Demographic and socio-economic characteristics**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>65</td>
</tr>
<tr>
<td>Gender</td>
<td>Female</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>White</td>
</tr>
<tr>
<td>Smoking status</td>
<td>Never smoked</td>
</tr>
</tbody>
</table>

**Highest educational attainment**

- Any post-secondary education

**Clinical factors**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diastolic blood pressure</td>
<td>75-84 mmHg</td>
</tr>
<tr>
<td>Systolic blood pressure</td>
<td>130-149 mmHg</td>
</tr>
<tr>
<td>HDL cholesterol</td>
<td>0.9-1.1 mmol/L</td>
</tr>
<tr>
<td>Albinium</td>
<td>3.9-4.1 g/dL</td>
</tr>
<tr>
<td>Haemoglobin</td>
<td>11.6-12.9 g/dL</td>
</tr>
<tr>
<td>Phosphate</td>
<td>1.2-1.4 mmol/L</td>
</tr>
<tr>
<td>Urinary albumin:creatinine ratio</td>
<td>30-300 mg/g</td>
</tr>
</tbody>
</table>
SHARP CKD-CVD model: Shiny interface

SHARP CKD-CVD outcomes model

Select characteristics for a single patient or import a text file with these characteristics for one or more patients.

- Import a file with patient characteristics

![Browse... example_input_data_error.csv](example_input_data_error.csv)

Upload complete

The model cannot be executed. Please check the following conditions:
- The following columns are missing: ethnicity
- The following columns are in the wrong format: smoker (needs to be numeric)
- The following columns contain disallowed values: age (age column can only take values between 40 and 90); sex (sex column can only take values 0, 1); DM (DM column can only take values 0, 1. Participants with diabetic nephropathy should be marked as having diabetes); CKDDuration (CKDDuration column values should be between 0 and the participant's age)
SHARP CKD-CVD model: Shiny interface
SHARP CKD-CVD model: Shiny interface

SHARP CKD-CVD outcomes model (beta version)

The default values are based on SHARP data and UK 2014 prices.

Annual cost of CKD

<table>
<thead>
<tr>
<th>CKD stage 3B</th>
<th>mean estimate</th>
<th>standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>427</td>
<td>32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CKD stage 4</th>
<th>mean estimate</th>
<th>standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>417</td>
<td>27</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CKD stage 5</th>
<th>mean estimate</th>
<th>standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>656</td>
<td>41</td>
</tr>
</tbody>
</table>

On dialysis, for year of dialysis initiation

<table>
<thead>
<tr>
<th>mean estimate</th>
<th>standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>20112</td>
<td>198</td>
</tr>
</tbody>
</table>

On dialysis, not for year of dialysis initiation

<table>
<thead>
<tr>
<th>mean estimate</th>
<th>standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>24709</td>
<td>51</td>
</tr>
</tbody>
</table>
SHARP CKD-CVD outcomes model (beta version)

The default values are UK quality of life (QoL) utilities estimates derived from the SHARP data.
Baseline QoL is the quality of life utility of a 60 year old female, non-smoker, with above secondary education, with BMI 25-30 kg/m², pre-RRT CKD and without diabetic nephropathy or vascular disease.

Baseline QoL

0.86

Additional effects

Demographic and socio-economic characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per 10 years)</td>
<td>-0.048</td>
</tr>
<tr>
<td>Completed secondary education</td>
<td>-0.017</td>
</tr>
<tr>
<td>Ex-smoker</td>
<td>-0.009</td>
</tr>
<tr>
<td>Male</td>
<td>0.059</td>
</tr>
<tr>
<td>Below secondary education</td>
<td>-0.036</td>
</tr>
<tr>
<td>Current smoker</td>
<td>-0.037</td>
</tr>
<tr>
<td>BMI &lt;25 kg/m²</td>
<td>0.011</td>
</tr>
<tr>
<td>BMI ≥30 kg/m²</td>
<td>-0.043</td>
</tr>
</tbody>
</table>

Disease history

Health-related quality of life

Introduction

Model overview

Glossary

File specifications

Model parameters

Type of analysis

Patient characteristics

Treatment parameters

Annual healthcare costs

Analyses

Results
Discount cost-effectiveness results

Long-term projections in the control group (cumulative probabilities per 1,000 participants)

<table>
<thead>
<tr>
<th></th>
<th>MVE or VD</th>
<th>RRT</th>
<th>Vascular deaths</th>
<th>All deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 5 years</td>
<td>184 (159, 213)</td>
<td>409 (357, 444)</td>
<td>57 (44, 76)</td>
<td>205 (194, 222)</td>
</tr>
<tr>
<td>At 10 years</td>
<td>281 (244, 319)</td>
<td>843 (504, 883)</td>
<td>118 (92, 155)</td>
<td>415 (398, 438)</td>
</tr>
<tr>
<td>Over simulation duration</td>
<td>419 (358, 501)</td>
<td>884 (826, 935)</td>
<td>202 (225, 379)</td>
<td>907 (897, 918)</td>
</tr>
</tbody>
</table>

Long-term projections in the treatment group (cumulative probabilities per 1,000 participants)

<table>
<thead>
<tr>
<th></th>
<th>MVE or VD</th>
<th>RRT</th>
<th>Vascular deaths</th>
<th>All deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 5 years</td>
<td>169 (138, 193)</td>
<td>407 (355, 439)</td>
<td>51 (37, 70)</td>
<td>200 (189, 218)</td>
</tr>
<tr>
<td>At 10 years</td>
<td>263 (214, 299)</td>
<td>838 (593, 875)</td>
<td>106 (81, 140)</td>
<td>407 (389, 429)</td>
</tr>
<tr>
<td>Over simulation duration</td>
<td>397 (328, 477)</td>
<td>877 (813, 927)</td>
<td>271 (207, 371)</td>
<td>905 (898, 915)</td>
</tr>
</tbody>
</table>

Incremental cost-effectiveness over the simulation duration (results per 1,000 participants)

<table>
<thead>
<tr>
<th>LYs gained</th>
<th>QALYs gained</th>
<th>Incremental hospital costs</th>
<th>Treatment costs</th>
<th>Cost per LY gained</th>
<th>Cost per QALY gained</th>
</tr>
</thead>
<tbody>
<tr>
<td>135 (-4, 279)</td>
<td>107 (22, 227)</td>
<td>598,152 (-410,384, 1,308,000)</td>
<td>5,074,512 (4,904,776, 5,201,336)</td>
<td>42,646 (20,617, 304,068)</td>
<td>54,085 (27,412, 179,555)</td>
</tr>
</tbody>
</table>

![Graph showing probability cost-effective](image-url)
User-friendly interface: help with debugging and transparency
User-friendly interface: help with debugging and transparency

• Face validity debugging
  - Easier to do on a user-friendly interface (even for the developers!)

• Feedback from external users

• Running several models against a reference simulation
  - Mount Hood diabetes challenge: models predicting long-term outcomes in diabetes patients
    • everyone gets the same tasks (eg change in life expectancy after statin initiation)
    • core assumptions same for everyone
    • additional assumptions must be documented in a pre-defined template
    • the results are presented, compared and (usually) published
    • user-friendly interface enables replication
SHARP CKD-CVD model: conclusions

• SHARP CKD-CVD model is a novel resource for evaluating health outcomes and cost-effectiveness of interventions in CKD

• User-friendly web-based freely available interface aids model use

• Together with the published equations / methods helps ensure reliability of the underlying code and methods transparency

• The user can enter with their own parameter values and perform calculations in different settings

• User’s perspective taken into account:
  - simple menus, straightforward navigation, pretty looks
  - detailed user-guide
  - example input/output files, file descriptions and default values
  - error checking at data entry could (partially) prevent inappropriate use
  - which parameters should be modifiable?
SHARP CKD-CVD model: challenges and discussion points

- **Day-to-day support**
  - Replying to queries, fixing bugs
  - R/package updates may break everything!
  - Not updating is not an option (according to our IT team)

- **Is R the best option for such an interface?**
  - Might Python be faster and/or have better visualisation capabilities?
  - C++?

- **Do the benefits of releasing the code outweigh the risks?**
Acknowledgements


- SHARP participants, study staff and collaborators!

- The SHARP study was funded by Merck/Schering-Plough Pharmaceuticals (North Wales, PA, USA), with additional support from the Australian National Health Medical Research Council, the British Heart Foundation, and the UK Medical Research Council
SHARP CKD-CVD model

http://dismod.ndph.ox.ac.uk/kidneymodel/app/

iryna.schlackow@ndph.ox.ac.uk