

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

Iryna Schlackow and **Borislava Mihaylova**  
on behalf of the **SHARP Collaborative Group**

useR! 2019

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# Motivation: what is a health policy model?

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 (eg 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?

	Transparency	Reliability	Usability
Release the code	yes	yes	no useRs only code mis-use
Publish equations and methods	yes (sort of)	yes (sort of)	no analysts only
Provide user-friendly interface	no black box	no	yes NB: user vs useR
Publish equations and methods and provide user-friendly interface	yes (sort of)	yes (sort of)	yes



# SHARP CKD-CVD model: Shiny interface

← → ↻ ⓘ dismod.ndph.ox.ac.uk/kidneymodel/app/



## SHARP CKD-CVD outcomes model

Introduction

Model overview

Glossary

File specifications

Model parameters

Type of analysis

Patient characteristics

Treatment parameters

Annual healthcare costs

### 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



# 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 model: Shiny interface

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, Kent S, Herrington W, Emberson J, Haynes R, Reith C, Wanner C, Fellström B, Gray A, Landray MJ, Baigent C, Mihaylova B, on behalf of the SHARP Collaborative Group. *A lifetime model of health outcomes in moderate-to-severe chronic kidney disease*. Under review.

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](mailto:kidneymodel@ndph.ox.ac.uk)

**Acknowledgements**

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# SHARP CKD-CVD model: Shiny interface

SHARP CKD-CVD outcomes model (beta version)

The following example files are provided to help with the model use, see [User guide](#) for detailed file descriptions.

Input file with patient characteristics: [default values \(one patient\)](#) and [several patients](#)

Non-vascular death probabilities: [2014 UK non-vascular death probabilities](#)

Output analysis files: long-term projections (deterministic) [summary](#) and [patient-level](#)

Output analysis files: long-term projections (probabilistic) [summary](#) and [patient-level](#)

Output analysis files: cost-effectiveness analysis (deterministic) [summary](#) and [patient-level](#)

Output analysis files: cost-effectiveness analysis (probabilistic) [summary](#) and [patient-level](#)

**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

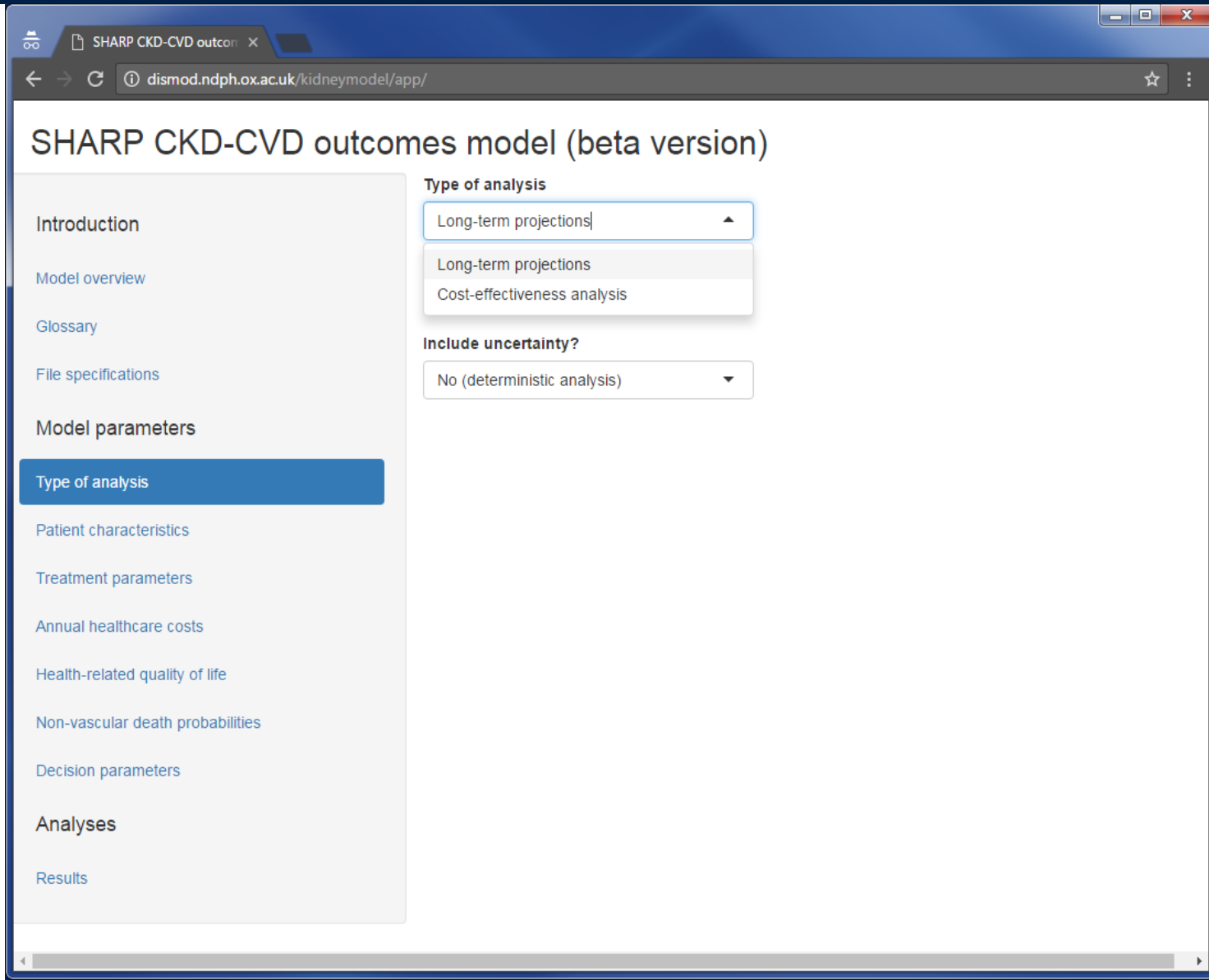
Decision parameters

**Analyses**

Results



# SHARP CKD-CVD model: Shiny interface



The screenshot shows a web browser window displaying the SHARP CKD-CVD outcomes model (beta version) Shiny interface. The browser address bar shows the URL `dismod.ndph.ox.ac.uk/kidneymodel/app/`. The page title is "SHARP CKD-CVD outcomes model (beta version)".

The interface features a left-hand navigation menu with the following items:

- Introduction
- Model overview
- Glossary
- File specifications
- Model parameters
  - Type of analysis (highlighted)
  - Patient characteristics
  - Treatment parameters
  - Annual healthcare costs
  - Health-related quality of life
  - Non-vascular death probabilities
  - Decision parameters
- Analyses
- Results

The main content area displays two dropdown menus:

- Type of analysis:** A dropdown menu with "Long-term projections" selected. The menu is open, showing options: "Long-term projections" and "Cost-effectiveness analysis".
- Include uncertainty?:** A dropdown menu with "No (deterministic analysis)" selected.



# SHARP CKD-CVD model: Shiny interface

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

Reset inputs

*Demographic and socio-economic characteristics*

**Age (years)**  
65

**Gender**  
Female

**Ethnicity**  
White

**Highest educational attainment**  
Any post-secondary education

**Adult dependants**  
No

**Smoking status**  
Never smoked

**Alcohol drinker**  
No

**Body mass index**  
25-29 kg/m<sup>2</sup>

*Clinical factors*

**Diastolic blood pressure**  
75-84 mmHg

**Systolic blood pressure**  
130-149 mmHg

**HDL cholesterol**  
0.9-1.1 mmol/L

**Albumin**  
3.9-4.1 g/dL

**Haemoglobin**  
11.6-12.9 g/dL

**Phosphate**  
1.2-1.4 mmol/L

**Urinary albumin:creatinine ratio**  
30-300 mg/g



# SHARP CKD-CVD model: Shiny interface

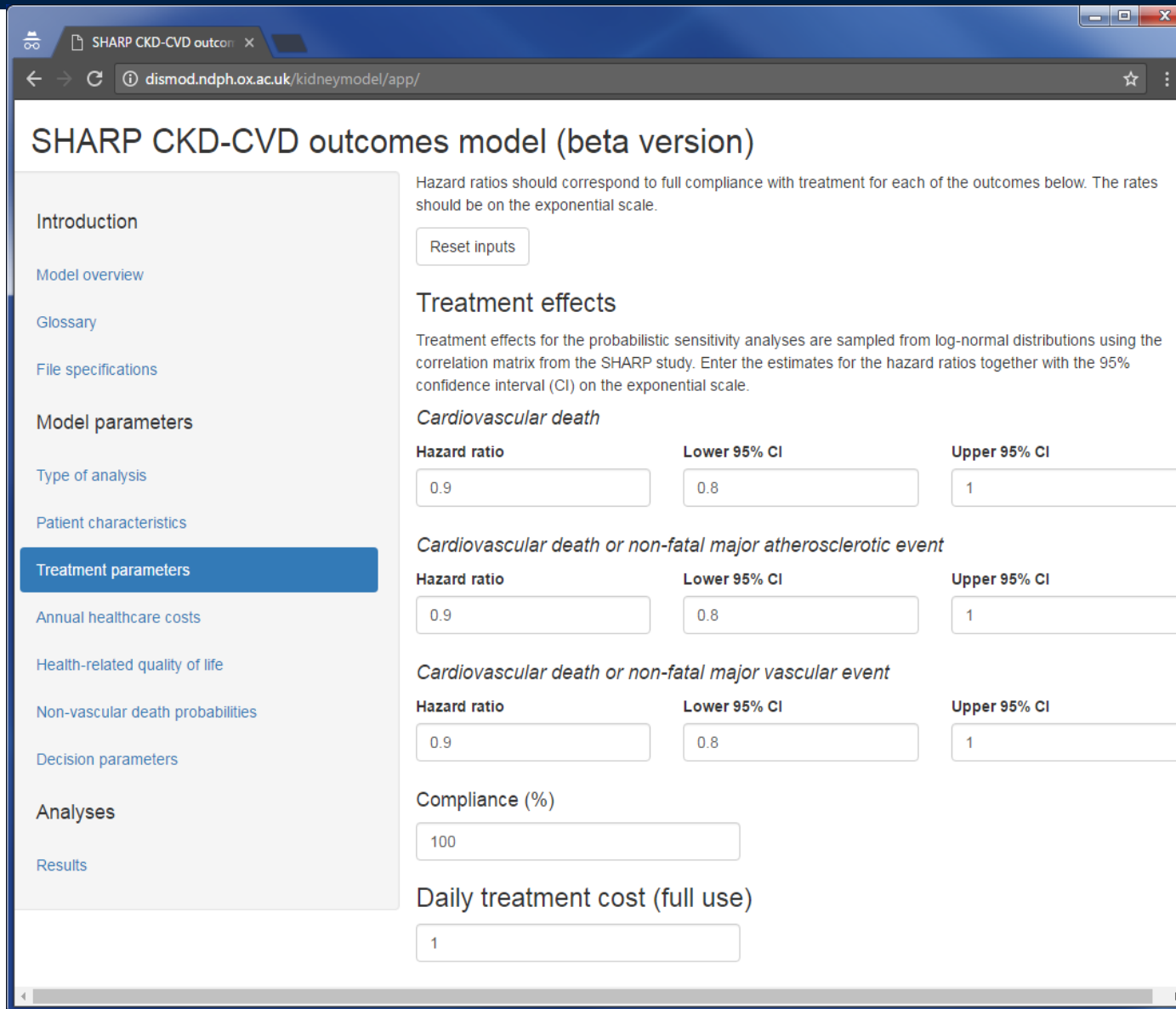
The screenshot shows a web browser window with the URL `dismod.ndph.ox.ac.uk/kidneymodel/app/`. The page title is "SHARP CKD-CVD outcomes model". On the left is a navigation sidebar with the following items: Introduction, Model overview, Glossary, File specifications, Model parameters, Type of analysis, Patient characteristics (highlighted), Treatment parameters, Annual healthcare costs, Health-related quality of life, Non-vascular death probabilities, Decision parameters, Analyses, and Results.

The main content area contains the following text and elements:

- Text: "Select characteristics for a single patient or import a text file with these characteristics for one or more patients."
- Form: A checked checkbox labeled "Import a file with patient characteristics".
- File selection: A "Browse..." button next to the filename "example\_input\_data\_error.csv".
- Action: An "Upload complete" button.
- Error message (in red text):  
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 outcomes model (beta version)

Introduction

Model overview

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Model parameters

Type of analysis

Patient characteristics

**Treatment parameters**

Annual healthcare costs

Health-related quality of life

Non-vascular death probabilities

Decision parameters

Analyses

Results

Hazard ratios should correspond to full compliance with treatment for each of the outcomes below. The rates should be on the exponential scale.

Reset inputs

### Treatment effects

Treatment effects for the probabilistic sensitivity analyses are sampled from log-normal distributions using the correlation matrix from the SHARP study. Enter the estimates for the hazard ratios together with the 95% confidence interval (CI) on the exponential scale.

*Cardiovascular death*

Hazard ratio	Lower 95% CI	Upper 95% CI
<input type="text" value="0.9"/>	<input type="text" value="0.8"/>	<input type="text" value="1"/>

*Cardiovascular death or non-fatal major atherosclerotic event*

Hazard ratio	Lower 95% CI	Upper 95% CI
<input type="text" value="0.9"/>	<input type="text" value="0.8"/>	<input type="text" value="1"/>

*Cardiovascular death or non-fatal major vascular event*

Hazard ratio	Lower 95% CI	Upper 95% CI
<input type="text" value="0.9"/>	<input type="text" value="0.8"/>	<input type="text" value="1"/>

Compliance (%)

Daily treatment cost (full use)



# 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.

[Reset inputs](#)

The default costs for the probabilistic sensitivity analyses are derived from the SHARP data using the bootstrap method. To provide alternative costs, enter the means and the standard errors below, and the costs will be sampled from gamma distributions. The displayed values are based on SHARP data and UK 2014 prices [1].

### Annual cost of CKD

CKD stage	mean estimate	standard error
CKD stage 3B	<input type="text" value="427"/>	<input type="text" value="32"/>
CKD stage 4	<input type="text" value="417"/>	<input type="text" value="27"/>
CKD stage 5	<input type="text" value="556"/>	<input type="text" value="41"/>
On dialysis, for year of dialysis initiation	<input type="text" value="20112"/>	<input type="text" value="198"/>
On dialysis, not for year of dialysis initiation	<input type="text" value="24709"/>	<input type="text" value="51"/>

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

- Introduction
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  - Annual healthcare costs**
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# SHARP CKD-CVD model: Shiny interface

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/m<sup>2</sup>, pre-RRT CKD and without diabetic nephropathy or vascular disease.

Reset inputs

### Baseline QoL

0.86

### Additional effects

*Demographic and socio-economic characteristics*

<b>Age (per 10 years)</b>	<b>Male</b>
-0.048	0.059
<b>Completed secondary education</b>	<b>Below secondary education</b>
-0.017	-0.036
<b>Ex-smoker</b>	<b>Current smoker</b>
-0.009	-0.037
<b>BMI &lt;25 kg/m<sup>2</sup></b>	<b>BMI ≥30 kg/m<sup>2</sup></b>
0.011	-0.043

*Disease history*





Discount cost-effectiveness results

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

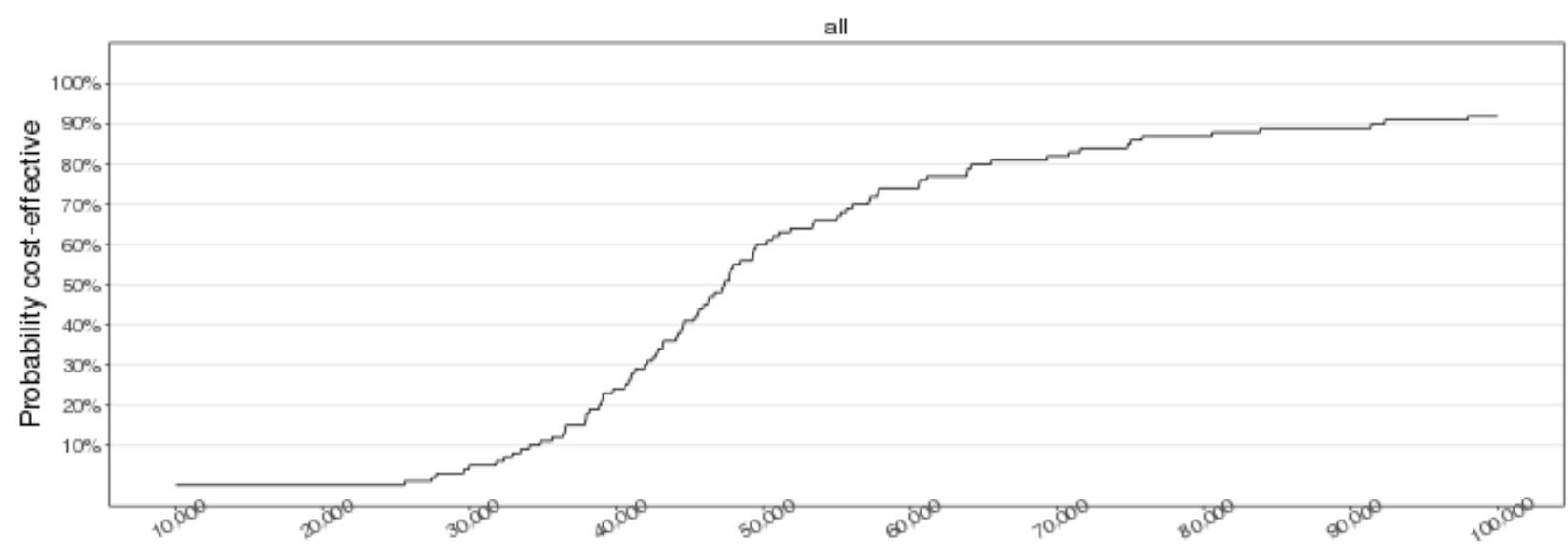
	MVE or VD	RRT	Vascular deaths	All deaths
At 5 years	184 (159, 213)	409 (357, 444)	57 (44, 76)	205 (194, 222)
At 10 years	281 (244, 319)	643 (594, 683)	118 (92, 155)	415 (398, 438)
Over simulation duration	419 (358, 501)	884 (826, 935)	292 (225, 379)	907 (897, 918)

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

	MVE or VD	RRT	Vascular deaths	All deaths
At 5 years	189 (138, 193)	407 (355, 439)	51 (37, 70)	200 (189, 216)
At 10 years	283 (214, 299)	638 (593, 675)	106 (81, 140)	407 (389, 429)
Over simulation duration	397 (328, 477)	877 (813, 927)	271 (207, 371)	905 (896, 915)

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

LYs gained	QALYs gained	Incremental hospital costs	Treatment costs	Cost per LY gained	Cost per QALY gained
135 (-4, 279)	107 (22, 227)	698,152 (-416,384, 1,306,000)	5,074,512 (4,904,776, 5,201,336)	42,646 (20,617, 304,068)	54,085 (27,412, 179,555)



# 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

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# SHARP CKD-CVD model



essentially,  
all models are wrong,  
but some are useful

George E. P. Box

freshspectrum.com

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

[iryna.schlackow@ndph.ox.ac.uk](mailto:iryna.schlackow@ndph.ox.ac.uk)

