

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**



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- Flexible models can help answer many policy questions
- Aim for transparency, reliability, reproducibility and **usability**
 - sensitive patient-level data often cannot be released



Motivation: how to facilitate usability?

	Transparency	Reliability	Usability
Release the code	😊	😊	😞 useRs only code mis-use
Publish equations and methods	😊	😊	😞 analysts only
Provide user-friendly interface	😞 black box	😞	😊 NB: user vs useR
Publish equations and methods and provide user-friendly interface	😊	😊	😊

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
 - treatment to be assessed
- Customising parameters in the current setting
 - population characteristics
 - duration of treatment / time horizon
 - discount rate



SHARP CKD-CVD model: Shiny interface

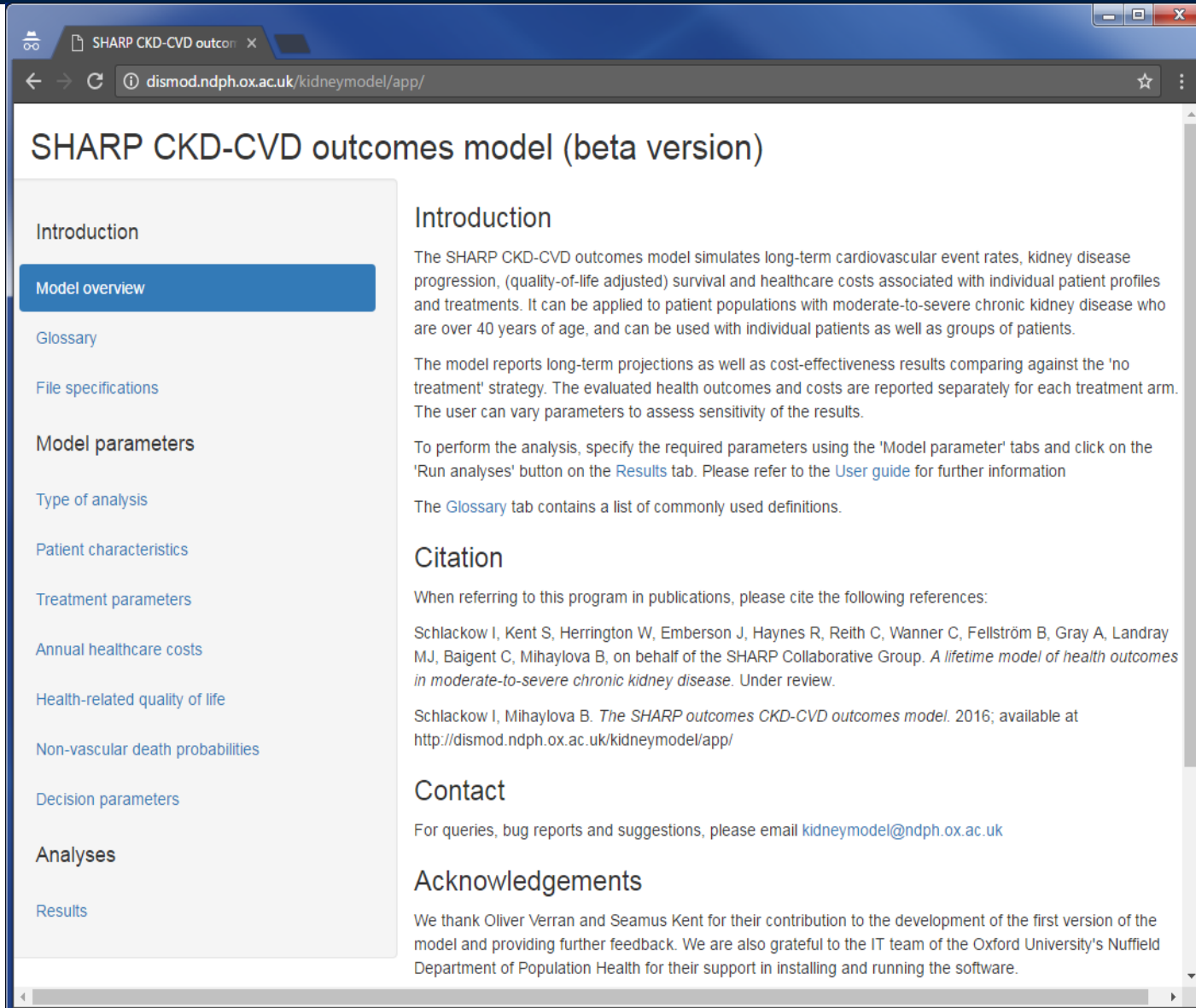


<http://one-elevenbooks.com/shiny-or-the-truth/>

- 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://dismod.ndph.ox.ac.uk/kidneymodel/app/>

SHARP CKD-CVD model: Shiny interface



The screenshot shows a web browser window with the address bar displaying `dismod.ndph.ox.ac.uk/kidneymodel/app/`. The page title is "SHARP CKD-CVD outcomes model (beta version)". On the left, a sidebar contains a list of navigation links: "Introduction", "Model overview" (highlighted in blue), "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", and "Results". The main content area is titled "Introduction" and contains the following text:

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](#) 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:

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

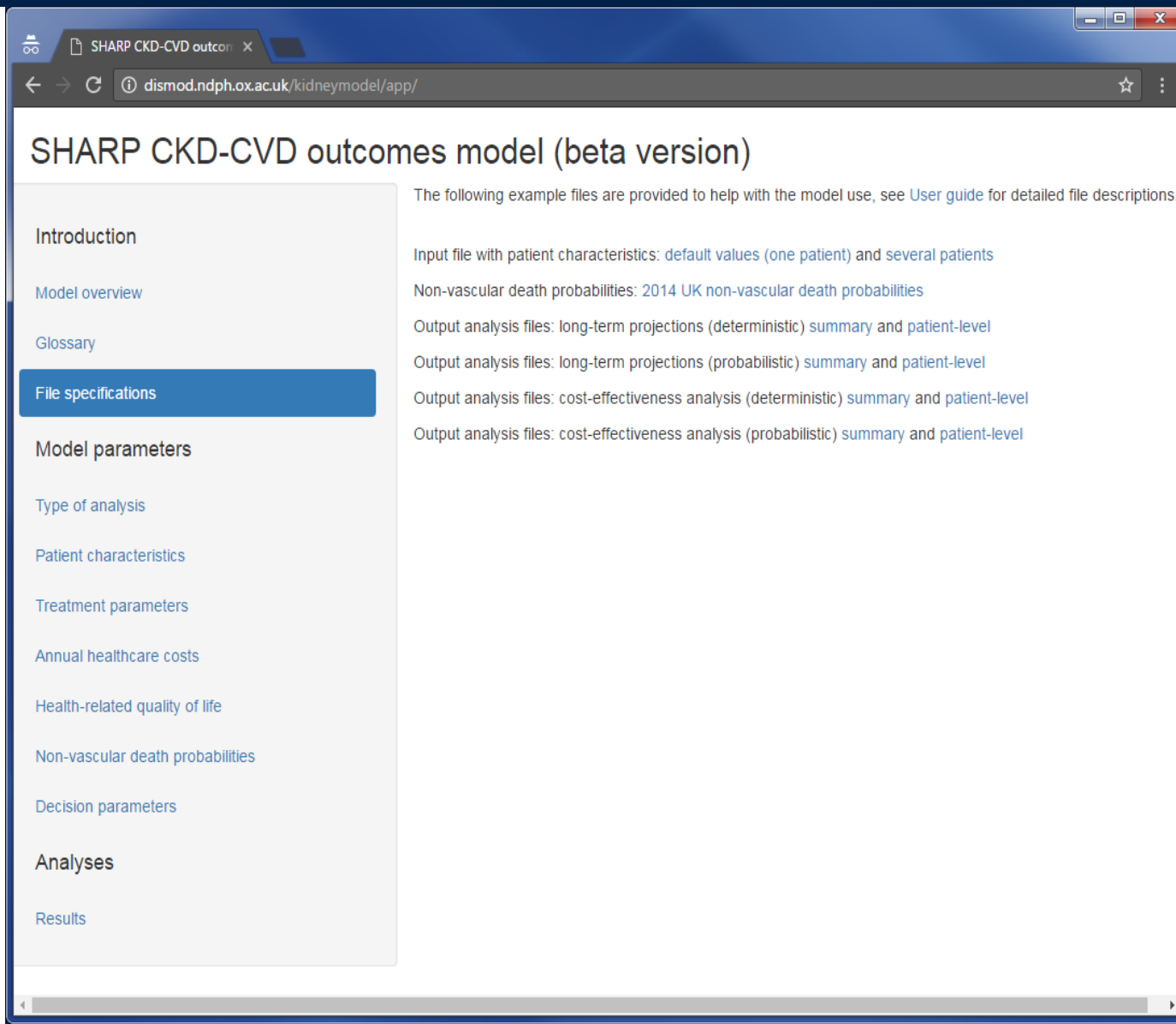
For queries, bug reports and suggestions, please email kidneymodel@ndph.ox.ac.uk

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



The screenshot shows a web browser window with the title "SHARP CKD-CVD outcomes model (beta version)". The browser's address bar shows the URL "dismod.ndph.ox.ac.uk/kidneymodel/app/". The page has a sidebar on the left with a list of navigation links: "Introduction", "Model overview", "Glossary", "File specifications" (which is highlighted in blue), "Model parameters", "Type of analysis", "Patient characteristics", "Treatment parameters", "Annual healthcare costs", "Health-related quality of life", "Non-vascular death probabilities", "Decision parameters", "Analyses", and "Results". The main content area on the right contains the following text:

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](#)

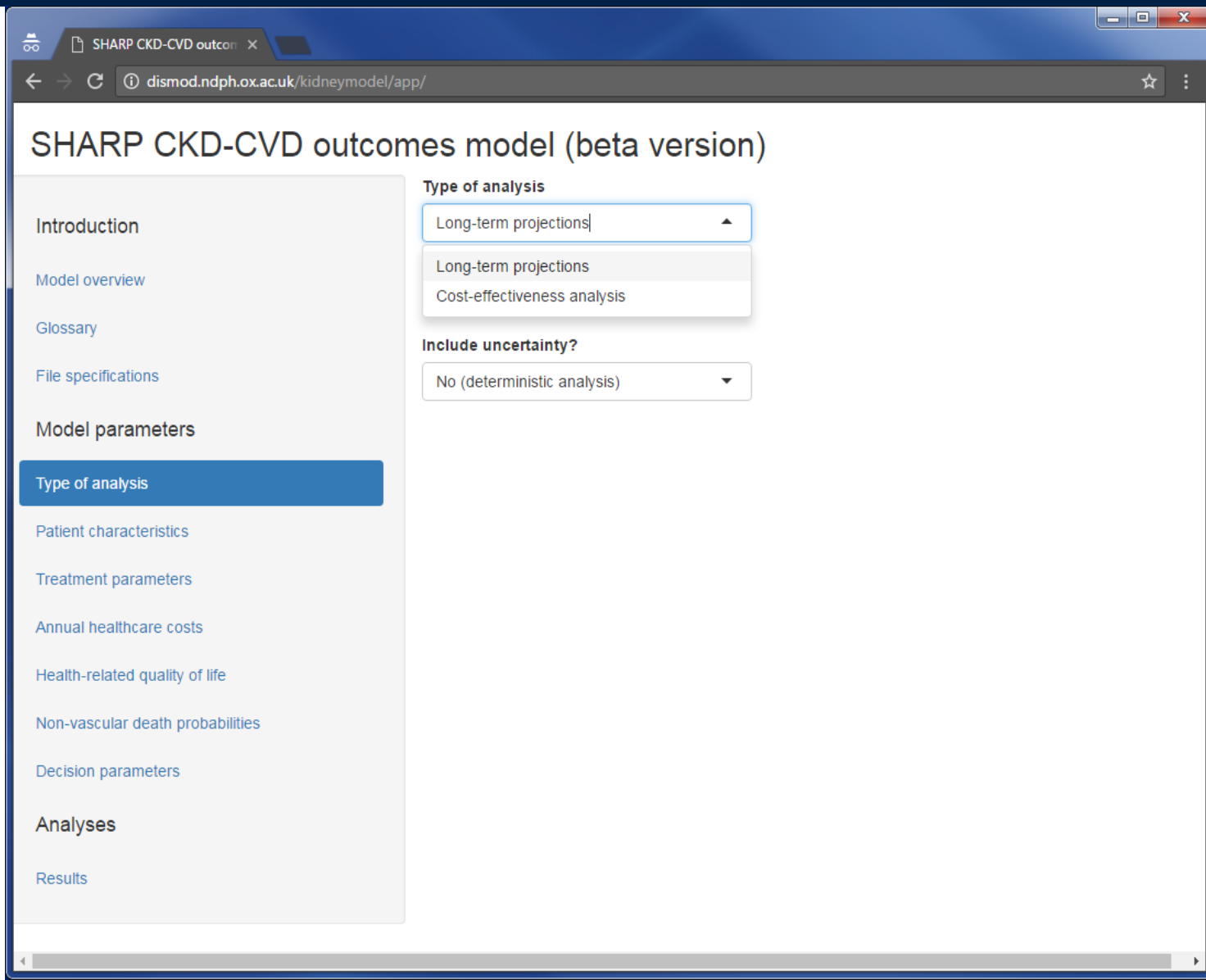
Output analysis files: long-term projections (deterministic) [summary](#) and [patient-level](#)

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](#)

SHARP CKD-CVD model: Shiny interface



The screenshot displays the SHARP CKD-CVD outcomes model (beta version) Shiny interface within a web browser. The browser's address bar shows the URL `dismod.ndph.ox.ac.uk/kidneymodel/app/`. The interface features a sidebar on the left with a navigation menu containing the following items: Introduction, Model overview, Glossary, File specifications, Model parameters, Type of analysis (highlighted in blue), Patient characteristics, Treatment parameters, Annual healthcare costs, Health-related quality of life, Non-vascular death probabilities, Decision parameters, Analyses, and Results. The main content area is titled "SHARP CKD-CVD outcomes model (beta version)" and contains two interactive sections. The "Type of analysis" section has a dropdown menu currently showing "Long-term projections|", with a list of options including "Long-term projections" and "Cost-effectiveness analysis". The "Include uncertainty?" section has a dropdown menu showing "No (deterministic analysis)".

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) <input type="text" value="65"/>	Gender <input type="text" value="Female"/>	Ethnicity <input type="text" value="White"/>
Highest educational attainment <input type="text" value="Any post-secondary education"/>	Adult dependants <input type="text" value="No"/>	Smoking status <input type="text" value="Never smoked"/>
Alcohol drinker <input type="text" value="No"/>	Body mass index <input type="text" value="25-29 kg/m²"/>	

Clinical factors

Diastolic blood pressure <input type="text" value="75-84 mmHg"/>	Systolic blood pressure <input type="text" value="130-149 mmHg"/>	HDL cholesterol <input type="text" value="0.9-1.1 mmol/L"/>
Albumin <input type="text" value="3.9-4.1 g/dL"/>	Haemoglobin <input type="text" value="11.6-12.9 g/dL"/>	Phosphate <input type="text" value="1.2-1.4 mmol/L"/>
Urinary albumin:creatinine ratio <input type="text" value="30-300 mg/g"/>		

SHARP CKD-CVD model: Shiny interface

← → ↻ ⓘ Not secure | dismod.ndph.ox.ac.uk/kidneymodel/app/ 🔍 ☆ ⋮

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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

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

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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
0.9	0.8	1

Cardiovascular death or non-fatal major atherosclerotic event

Hazard ratio	Lower 95% CI	Upper 95% CI
0.9	0.8	1

Cardiovascular death or non-fatal major vascular event

Hazard ratio	Lower 95% CI	Upper 95% CI
0.9	0.8	1

Compliance (%)

100

Daily treatment cost (full use)

1

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 3B

mean estimate	standard error
<input type="text" value="427"/>	<input type="text" value="32"/>

CKD stage 4

mean estimate	standard error
<input type="text" value="417"/>	<input type="text" value="27"/>

CKD stage 5


mean estimate	standard error
<input type="text" value="556"/>	<input type="text" value="41"/>

On dialysis, for year of dialysis initiation

mean estimate	standard error
<input type="text" value="20112"/>	<input type="text" value="198"/>

On dialysis, not for year of dialysis initiation

mean estimate	standard error
<input type="text" value="24709"/>	<input type="text" value="51"/>



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/m², pre-RRT CKD and without diabetic nephropathy or vascular disease.

Reset inputs

Baseline QoL

0.86

Additional effects

Demographic and socio-economic characteristics

Age (per 10 years)	Male
-0.048	0.059
Completed secondary education	Below secondary education
-0.017	-0.036
Ex-smoker	Current smoker
-0.009	-0.037
BMI <25 kg/m²	BMI ≥30 kg/m²
0.011	-0.043

Disease history

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Discount cost-effectiveness results

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

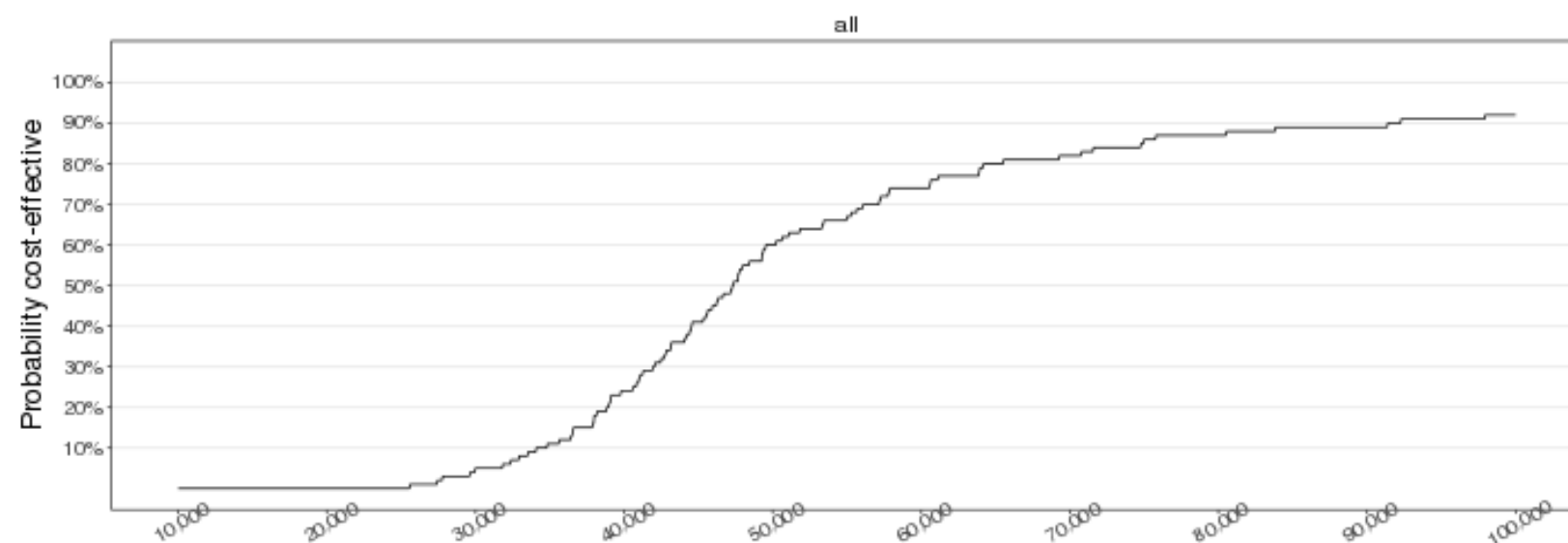
	MVE or VD	RRT	Vascular deaths	All deaths
At 5 years	184 (159, 213)	409 (357, 444)	57 (44, 76)	205 (194, 222)
At 10 years	281 (244, 319)	643 (594, 683)	118 (92, 155)	415 (398, 438)
Over simulation duration	419 (358, 501)	884 (826, 935)	292 (225, 379)	907 (897, 918)

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

	MVE or VD	RRT	Vascular deaths	All deaths
At 5 years	169 (138, 193)	407 (355, 439)	51 (37, 70)	200 (189, 216)
At 10 years	263 (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, 1,308,000)	5,074,512 (4,904,776, 5,201,338)	42,646 (20,617, 304,088)	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 should be 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

- Seamus Kent, Richard Haynes, Jonathan Emberson, Will Herrington, Colin Baigent, Alastair Gray, Jingky Lozano-Kuehne, Martin Craig, Martin Landray, Kirsty Reith
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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

