

A hybrid modelling approach for investigating interventions in renal care

Yiwen Hon₁, Dr Lucy E. Morgan₁, Sally Thompson₁, Professor
Mark Lambie₂, Jennifer Wood₁,

1 - The Strategy Unit, 2 - Keele University/ Midlands Renal Network



Background

Dialysis centres are struggling with demand and there are concerns about capacity to meet future needs for renal services, particularly in-hospital. There is an expectation that need is going to grow, further challenging capacity through changes in population size and health profile.

The Midlands Renal Operational Delivery Network (MRODN) identified that centres in the region required advanced methods of estimating renal replacement treatment needs in the future. There are options available to manage demand and capacity, but these require investment, and careful balancing of risk and reward.

A model will facilitate better informed decisions about the future, facilitating "left shift" and ensuring future capacity and good patient outcomes whilst supporting positive change through evidence and analysis.

Glossary: CKD – Chronic Kidney Disease KRT – Kidney Replacement Therapy

Objectives of the work

1. How might **demand** change over time?

2. What does that mean for **capacity** for renal services?

3. What difference could we make? Using **scenarios** include to model the ability to mitigate future demand

Modelling the CKD/KRT pathway

A hybrid approach

Participative modelling approach



The models have been built in partnership with a range of stakeholders, to create a validated representation of the system in a model, which answers the right questions.

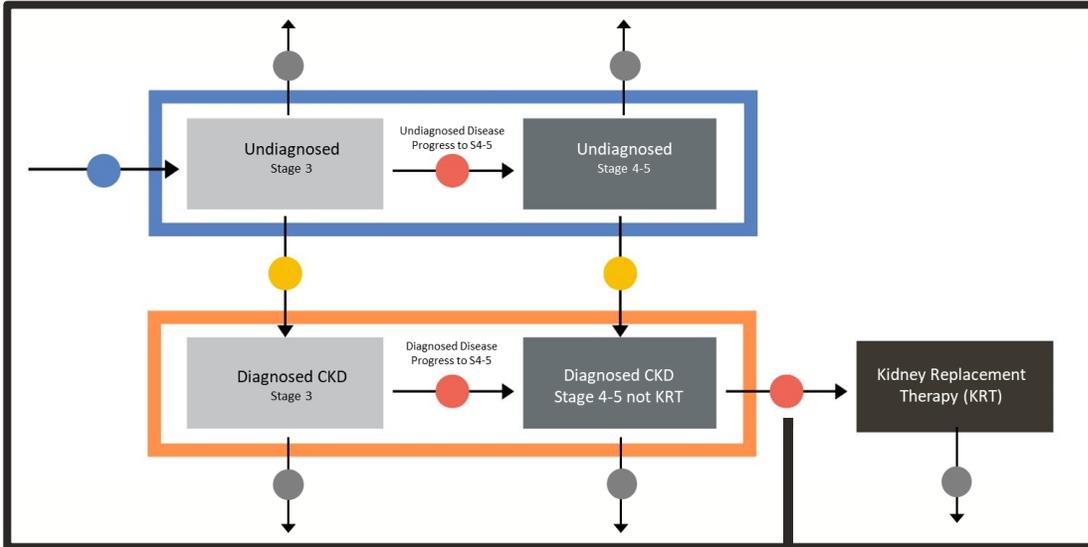
Our outputs/experience so far

We have produced an open-source sequential SD-DES hybrid model of renal care with two components:

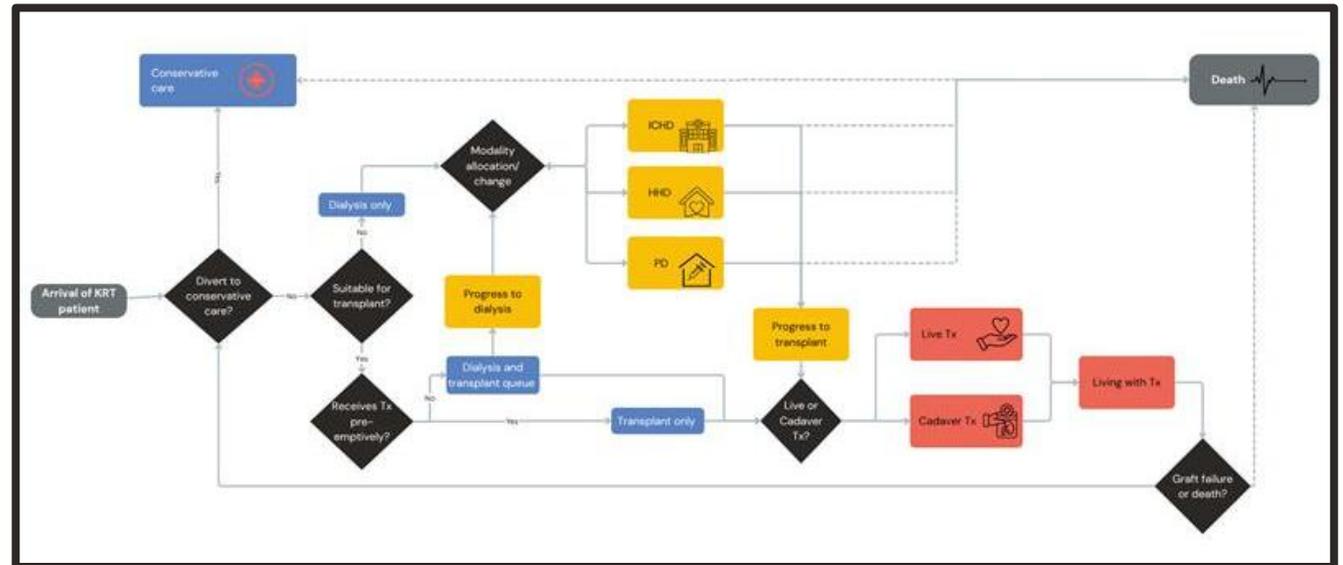
- A System Dynamics (SD) model of CKD progression
- A Discrete Event Simulation (DES) model of KRT patient pathways for capacity planning

The models allow for **risk-free** evaluation of interventions and their cost/benefit. Producing **defensible evidence** for decision making.

A holistic view of the renal care pathway



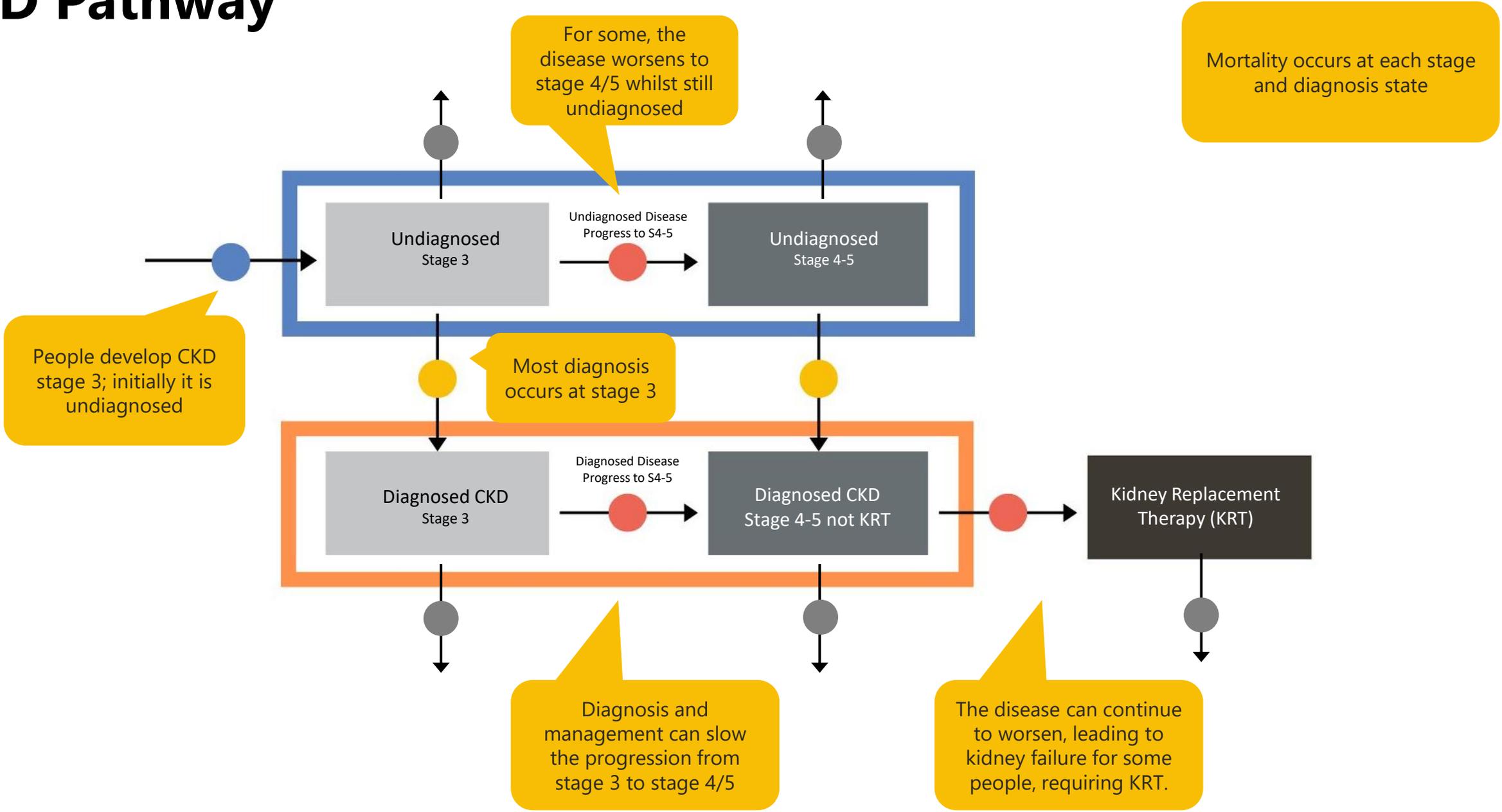
Chronic Kidney Disease (CKD) progression



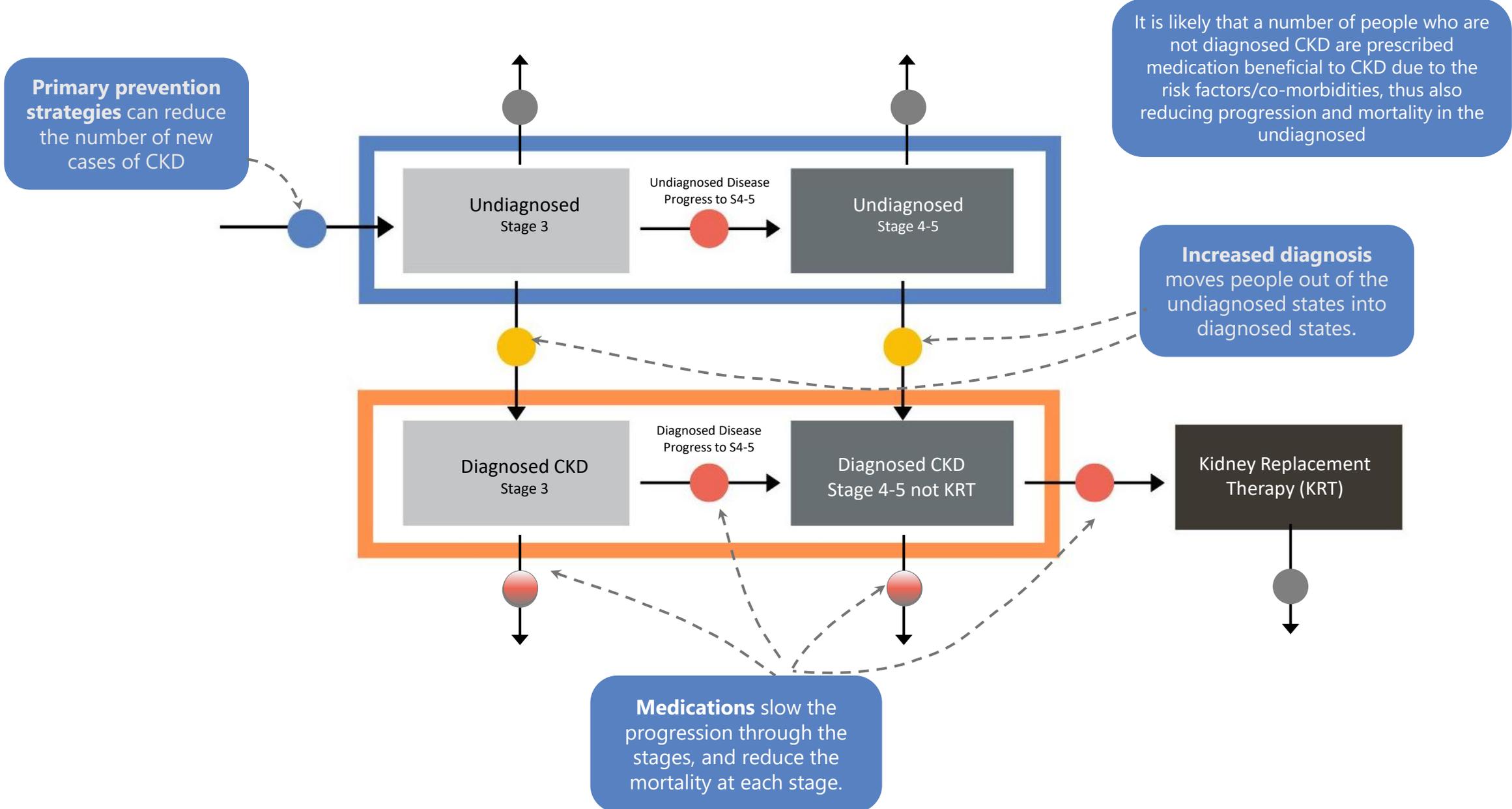
Kidney Replacement Therapy (KRT) services

Modelling CKD progression using System Dynamics

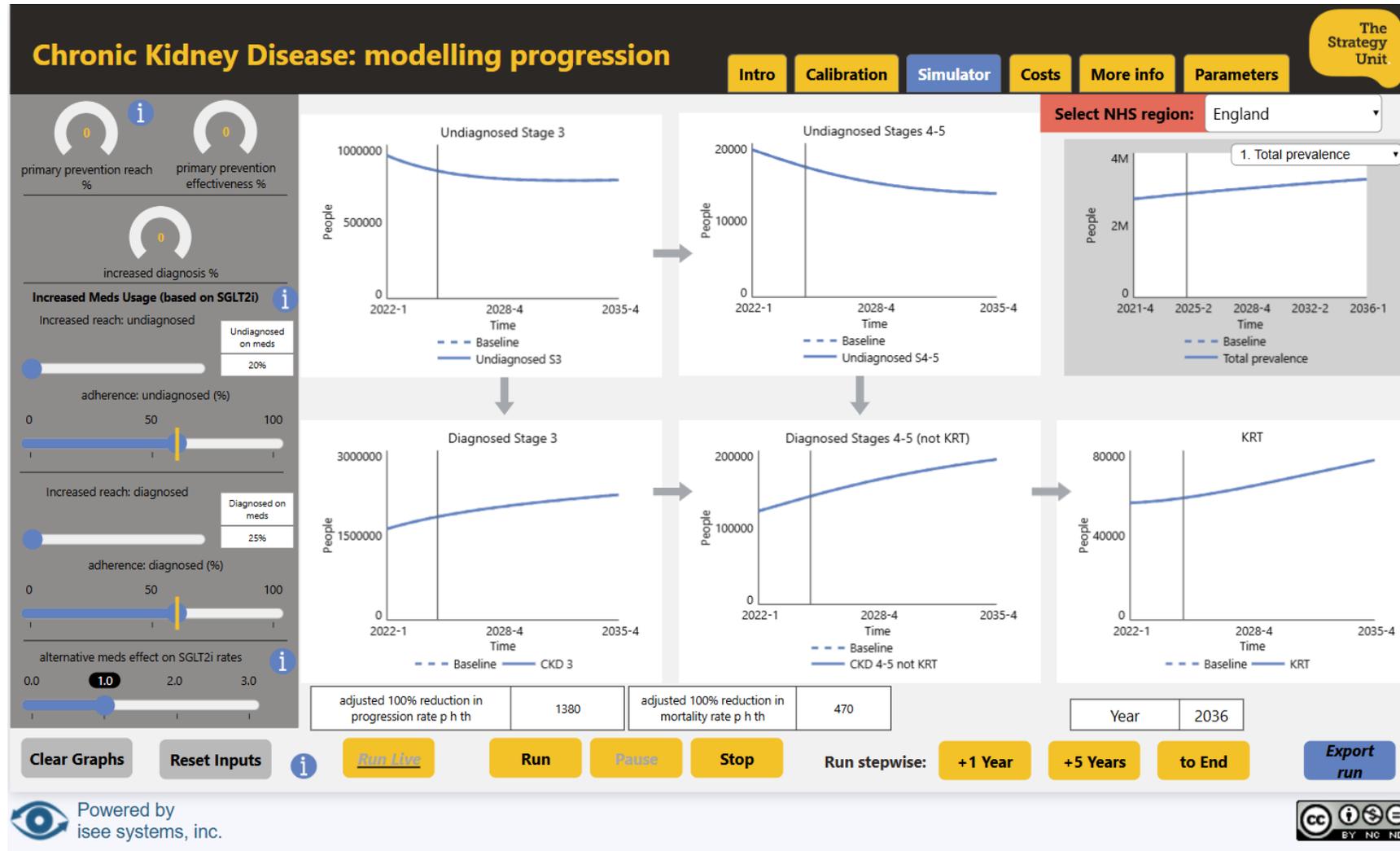
CKD Pathway



Interventions

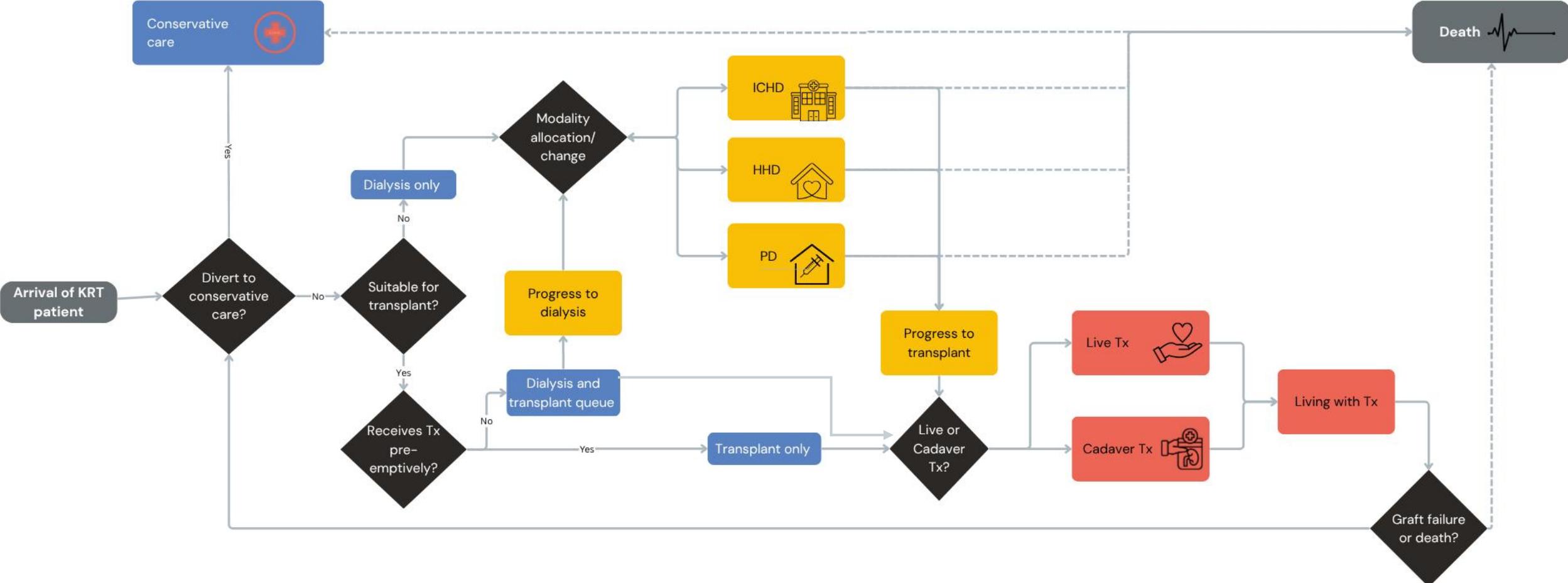


Model showcase – running the model



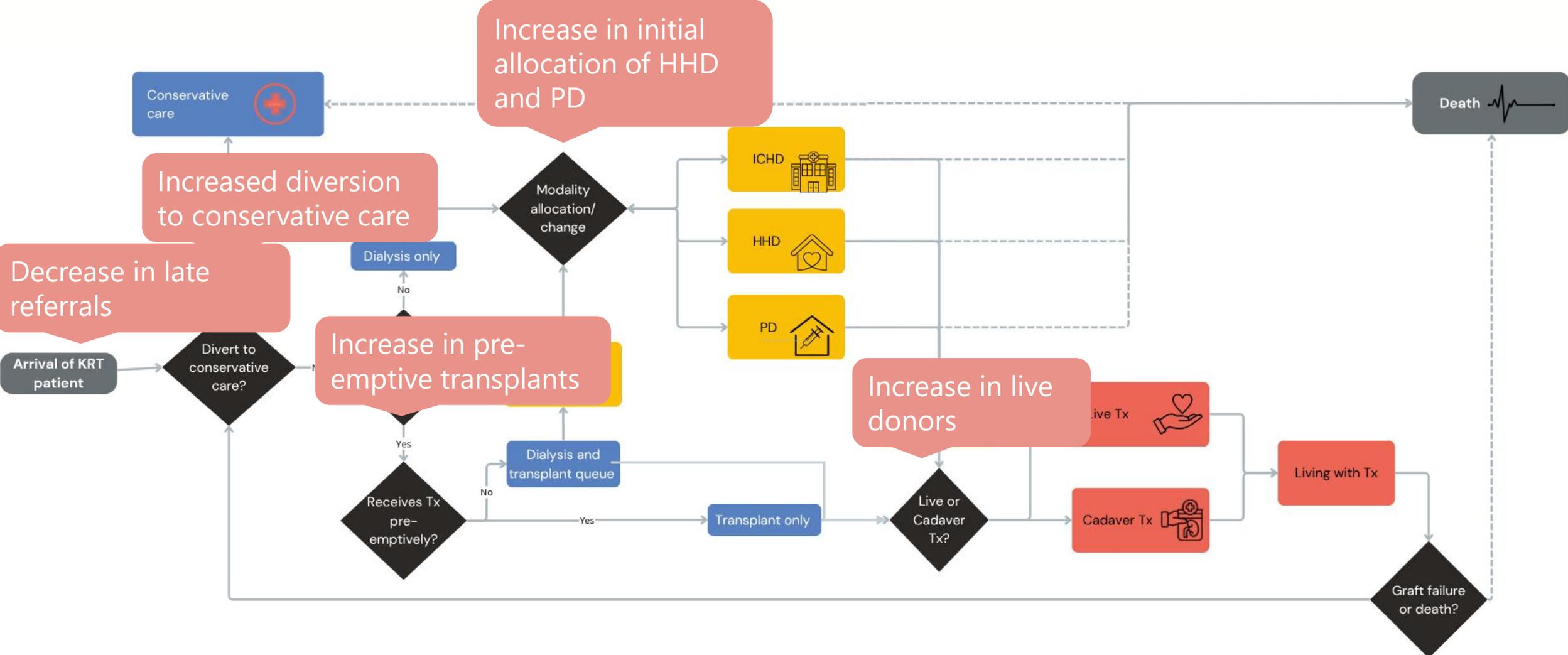
Modelling KRT using Discrete Event Simulation

KRT Patient Treatment Pathways



Allows us to build a national, regional and centre level picture of renal demand and capacity requirements

Planned interventions

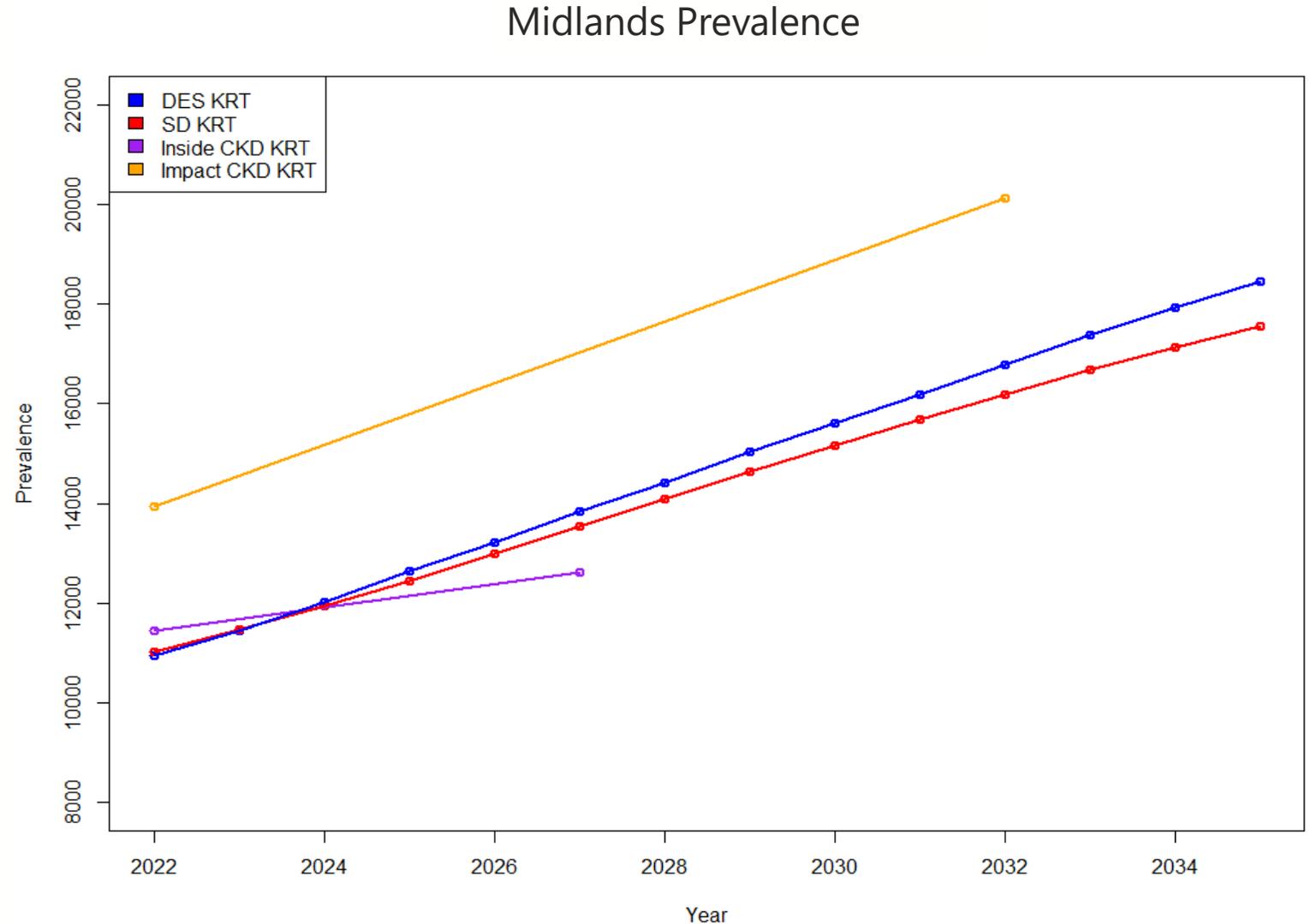


Validating against External Models

We've considered KRT projections from Inside CKD and Impact CKD before when observing the output from the SD CKD model.

Here we show the output from the DES capacity model for comparison*

The relative error between the SD and KRT models is <5% across all time points.



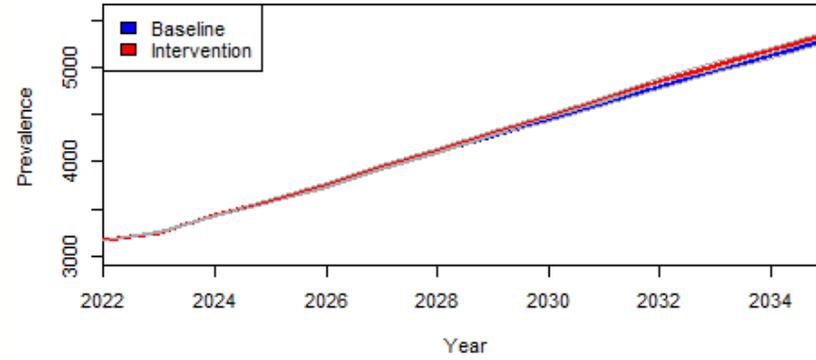
*all model outputs are scaled to Midlands level.

Scenario:

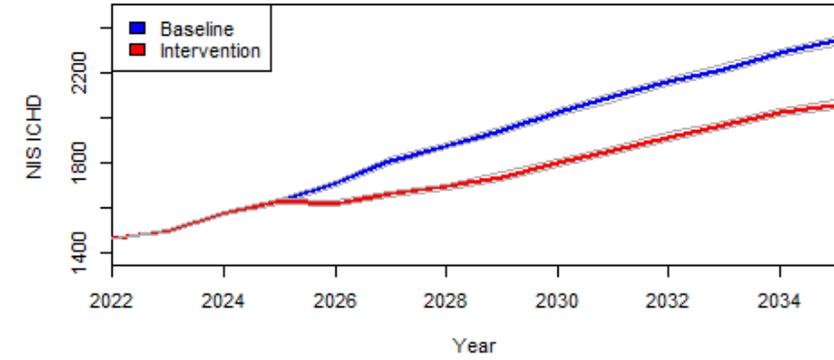
Initial allocation to PD risen to 50%

*baseline allocation probability was ~25%

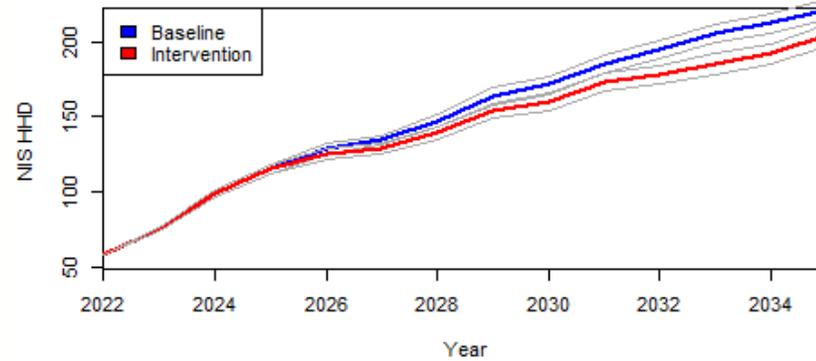
Prevalence



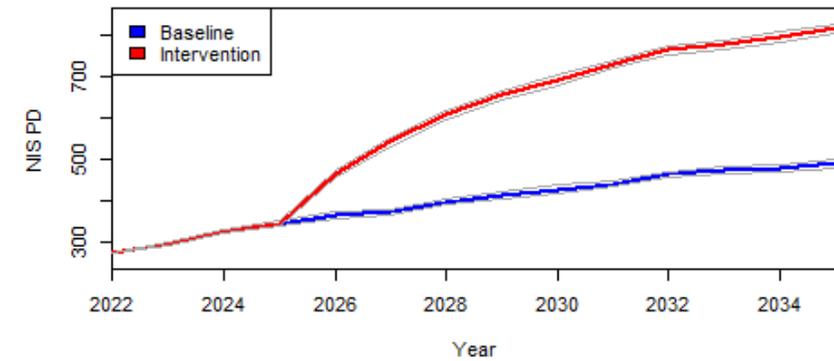
Prevalence ICHD



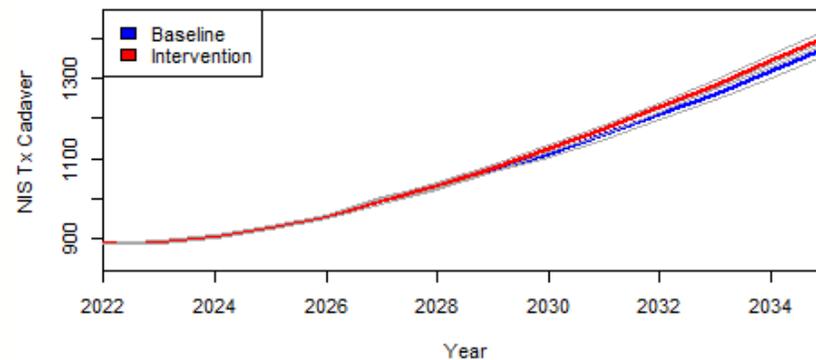
Prevalence HHD



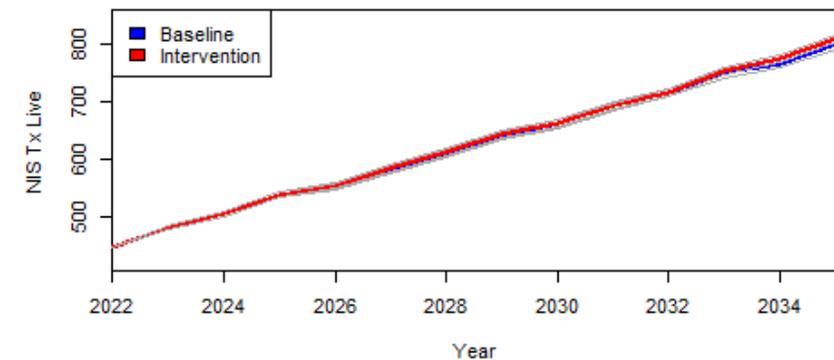
Prevalence PD



Prevalence Living with Cadaver Donor Tx



Prevalence Living with Live Donor Tx



Across model experimentation

The impact of increased roll out of SGLT2i medication

Scenario:

80% of the eligible population accessing SGLT2i medication

*in 2025 20% of the eligible population are on SGLT2i meds

Here we're considering the impact of an intervention in the CKD population on the capacity needed for KRT.

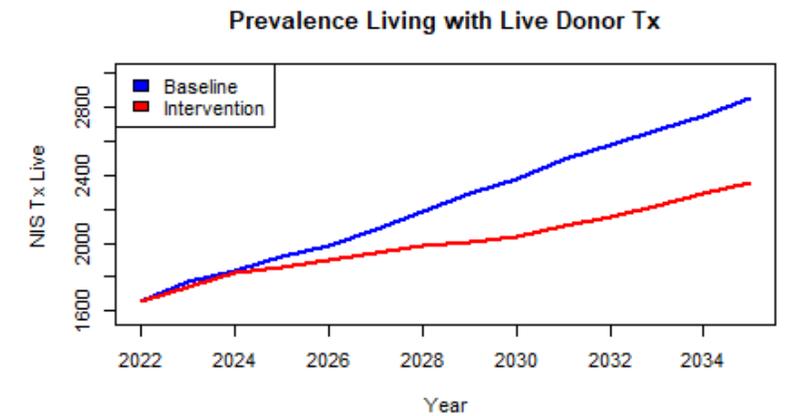
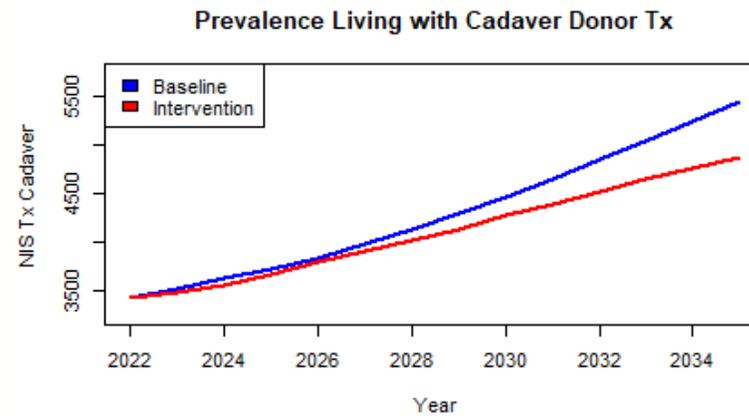
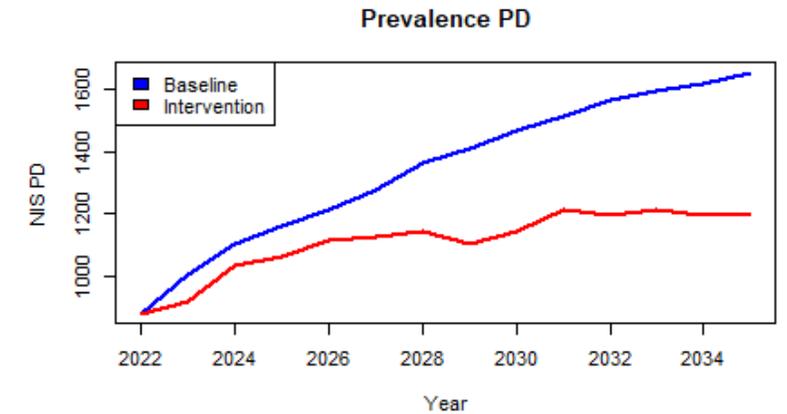
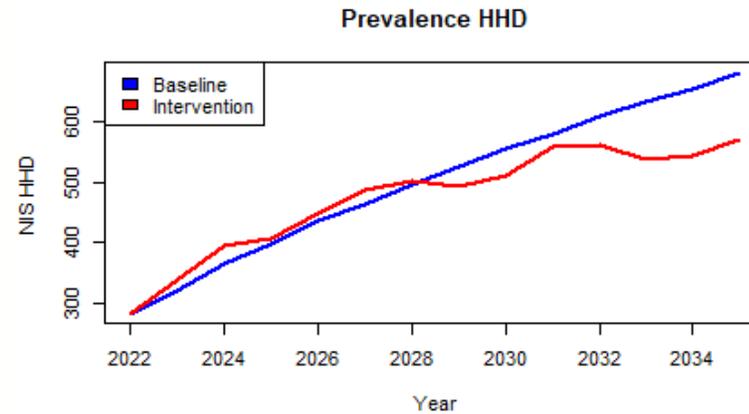
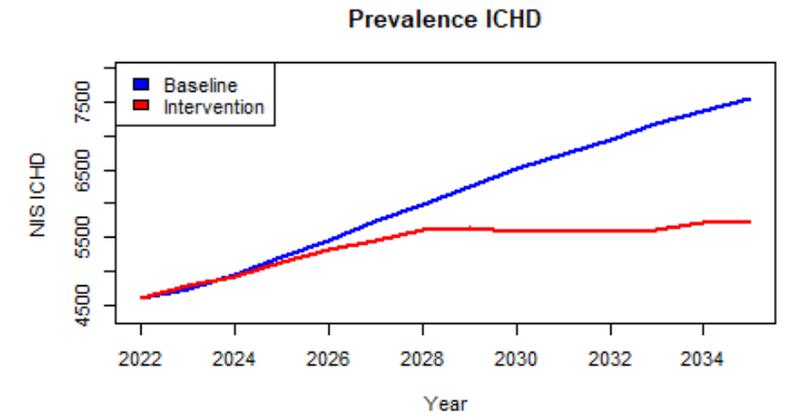
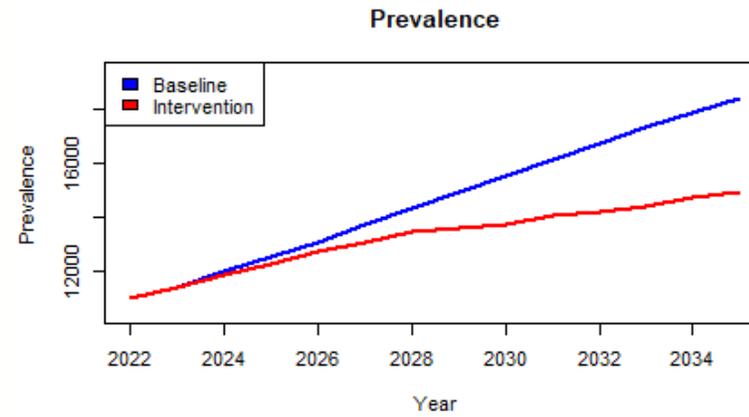
Steps:

- 1) Using the CKD app increase the reach of SGLT2i from 20% in 2025 to 80% by 2030 (linear increase year on year). Constant 60% adherence assumed.
- 2) Export KRT incidence from the CKD model and feed it into the KRT capacity model
- 3) Run the model – without additional interventions

Scenario:

80% of the eligible population accessing SGLT2i medication

*in 2025 20% of the eligible population are on SGLT2i meds



Sharing our experience of open-sourcing the DES model

Getting started

- We wanted to be able to share the model with our clients and let them run their own scenarios. This wasn't possible whilst the model remained in commercial software

My path to open-source looked a little like this:

1. Look at open-source simulation packages and software to get a range of options
2. Enter Yiwen – data scientist
3. We chose SimPy because of its flexibility and the helpful resources available from [HSMA](#)* including [The Little Book of DES](#)
4. Application for internal funding to make the change

Technical aspects

Aiming for  [higher levels of RAP](#) (Reproducible Analytical Pipelines):

-  Coding standards, checked with formatting/linting tools like **pyright** and **ruff**
-  Use of **uv** as a package manager and installer
-  Documentation
-  Testing framework, with Continuous Integration (CI): **pytest**

Want to do more RAP? Join us at our fortnightly [RAP Drop-ins](#)

See also the [DES RAP book](#) for simulation-specific guidance

How we worked together

GitHub: more than just a place to put code

- Project management using repository issues
- Quality assurance through code review
- We use a free organisation account
- Data remains secure – only code is open

[Our team's GitHub guidelines](#)



Successes

- Already being used in business cases
- Clients running their own scenario with minimal support
- Better control over model design
- Built once for multiple potential users

Compromises

- Excel as input and output files – not ideal
- Technically challenging to download the code and run the model locally
- Testing coverage not at 100%

What's next

Where funding allows, we would like to continue to work with this model to:

- Add the code to *ATLAS* a directory of open-source tools, packages, and projects for analytics and decision science in healthcare [ATLAS](#)
- Seamlessly connect the CKD and KRT model components under one model interface that allows for better user experience
- Continue to roll out to other regional networks
- Create the tools required to hand the model over to UKRR in the coming years.

Acknowledgements and Thanks...

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All the model group participants

UK Renal Registry

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The CKD disease progression model



The KRT
GitHub repository



The
Strategy
Unit.



Thank you any questions?

Contact

Dr Lucy E. Morgan

Lucy.morgan48@nhs.net

With comments and questions

