The Strategy Unit.

Referral to Treatment Waiting List System Dynamics Model

Supporting Documentation

July 2020

NHS
Midlands and Lancashire
Commissioning Support Unit

Contents

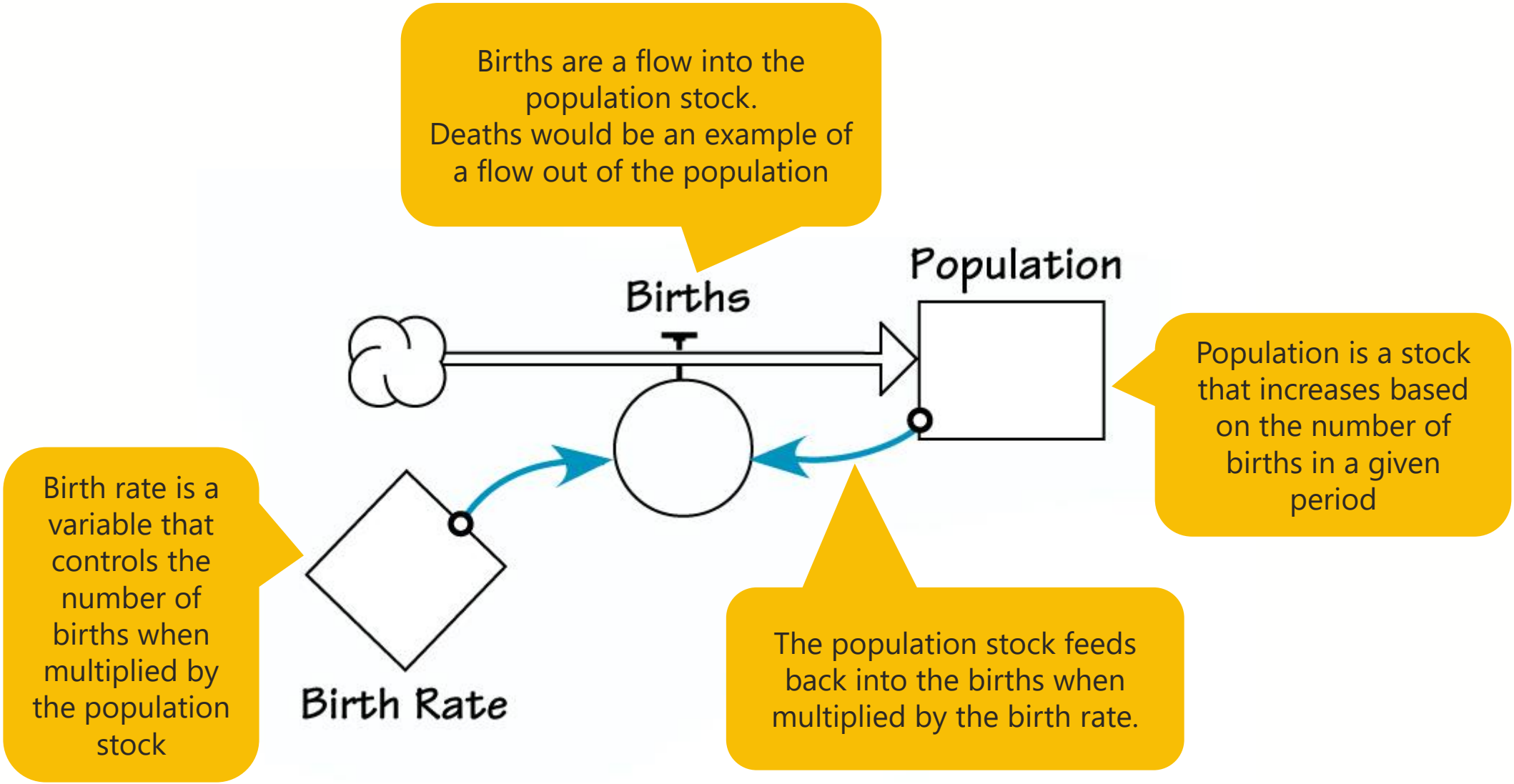
Introduction

System Dynamics (SD) Modelling

SD is an approach to understanding the nonlinear behaviour of complex systems over time using stocks, flows, internal feedback loops, table functions and time delays. Models can be developed to show visually how all the objects in a system interact with one another. SD models use aggregate level data and can be validated using historic data to ensure they accurately map to the dynamics of the system. The models can be developed to simulate the impact of changes in policy] \ [intervention, such as the impact of policies to reduce the impact of Covid 19 on Consultant-led Referral to Treatment (RTT) waiting times. They model how stocks (these variables are accumulations in the system, e.g. waiting lists) are influenced by flows (these variables tell how fast the stocks are changing, e.g. new GP referrals) in and out of them and are shown as Stock and Flow Diagrams (see below).

SD is a useful modelling tool as it visually maps the interactions across the system to make it more accessible to 'decision makers'. Sourcing data to populate the models is straightforward as they use aggregate time series datasets. Models can be built incrementally and be validated using historic data to ensure they capture the physics of the process / pathway.

Example of a Stock and Flow Diagram



Model Overview

System Dynamics Waiting List Model

The SD Waiting List Modelling is part of a wider piece of work to provide a ‘post covid-19 recovery model' for the Midlands. It has been developed to support local analysts to model the impact of the postponed referrals and activity due to Covid 19 on the overall RTT waiting list. It will also allow local health and care systems to model the impact of changes in referral patterns, patient behaviour, clinical capacity and mitigating actions during the restoration and recovery period.

The modelling has been developed at provider and specialty level and is customisable to reflect different local decisions on the postponement and restoration of elective activity. It is being made available to local systems to allow them to test different assumptions of the effect of Covid on the restoration and recovery of elective activity.

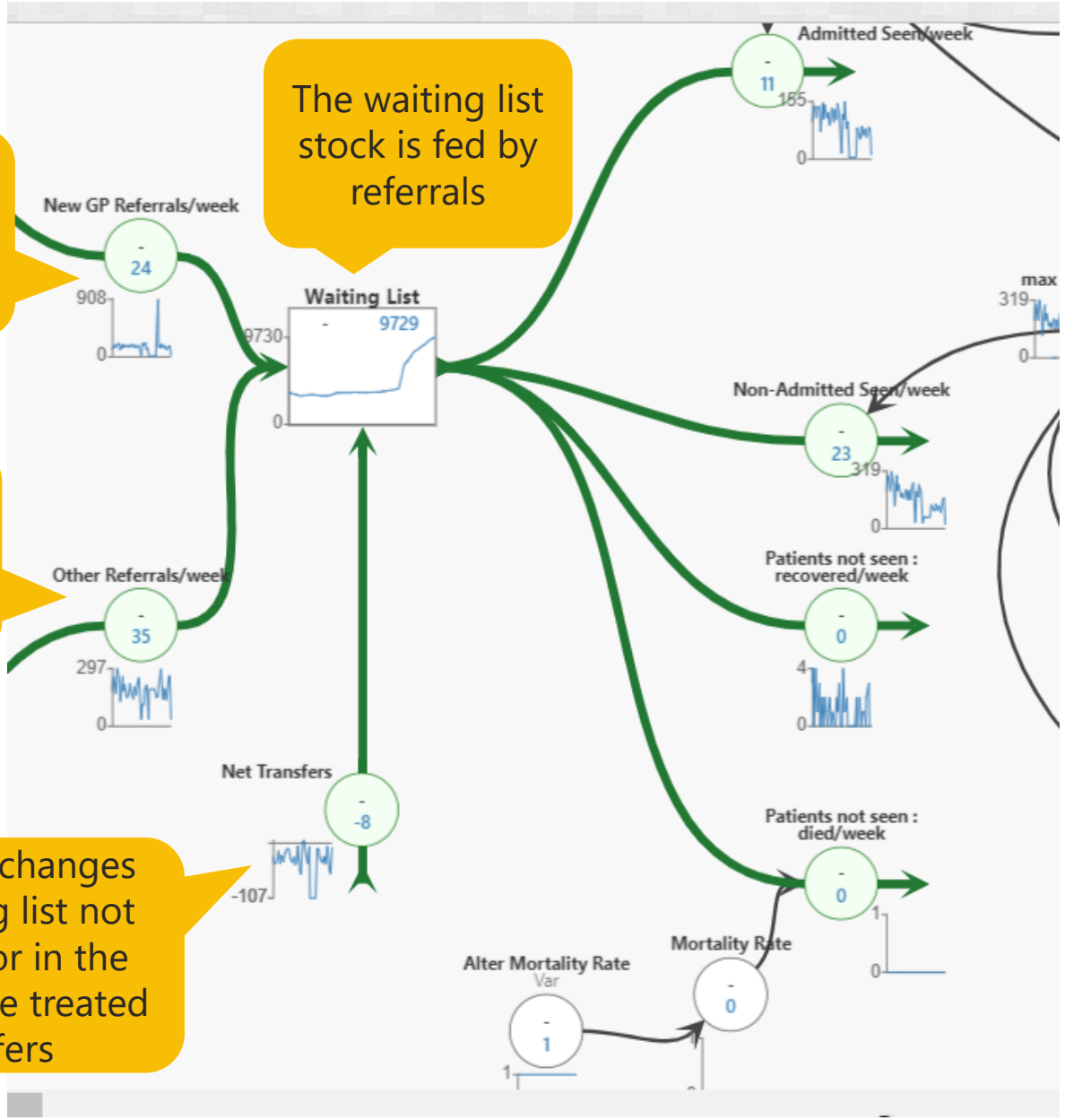
The model has been developed using online modelling software called Sheetless and local areas should be able to access a community licence for free to run the model. Additional support is available by contacting Mike Woodall at m.woodall@nhs.net.

Waiting List Model - Core

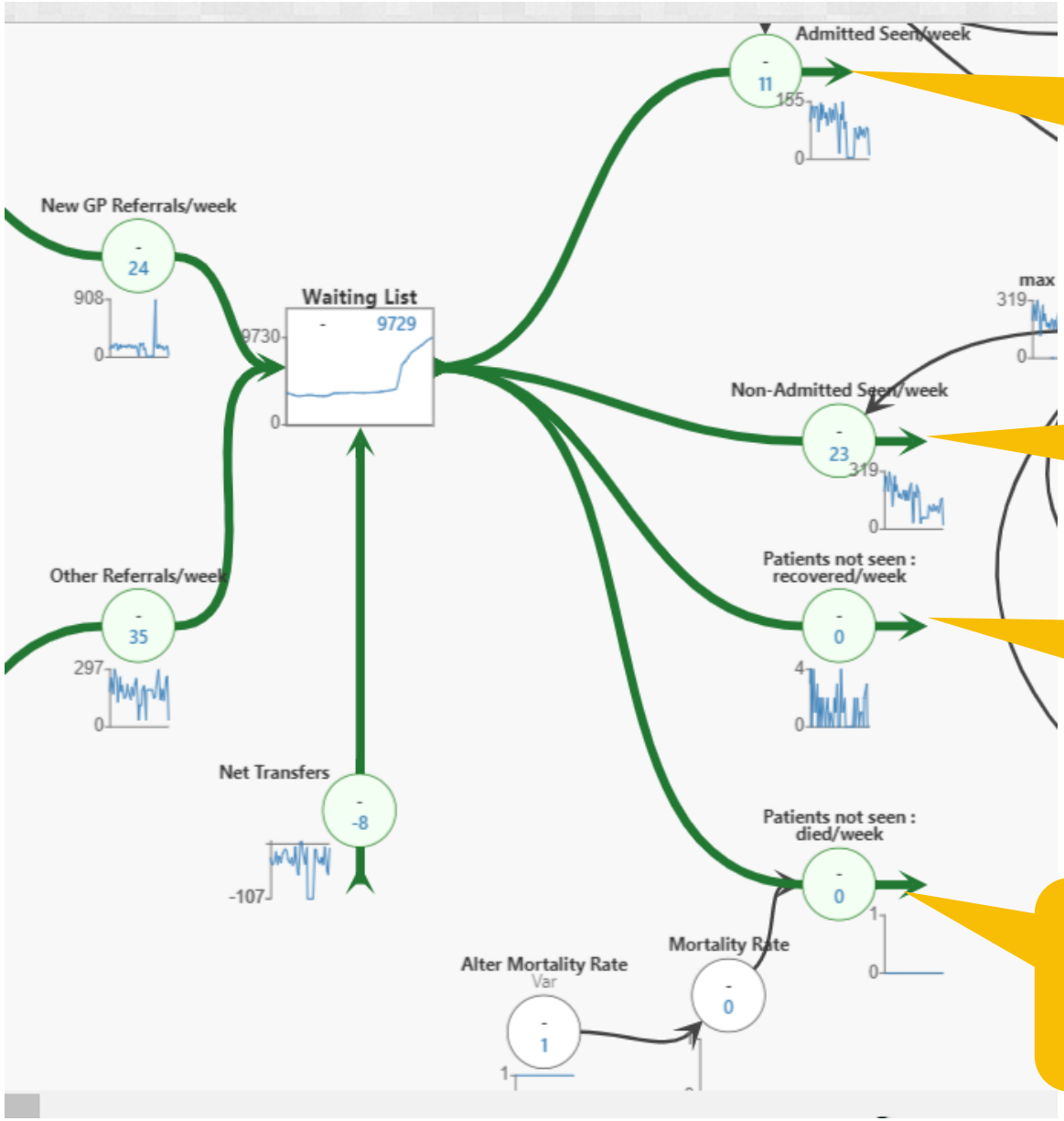
The waiting list stock is fed by GP referrals

…or by referrals from other sources

Any residual changes in the waiting list not accounted for in the other flows are treated as transfers



Waiting List Model - Core



Patients can leave the waiting by being Admitted seen

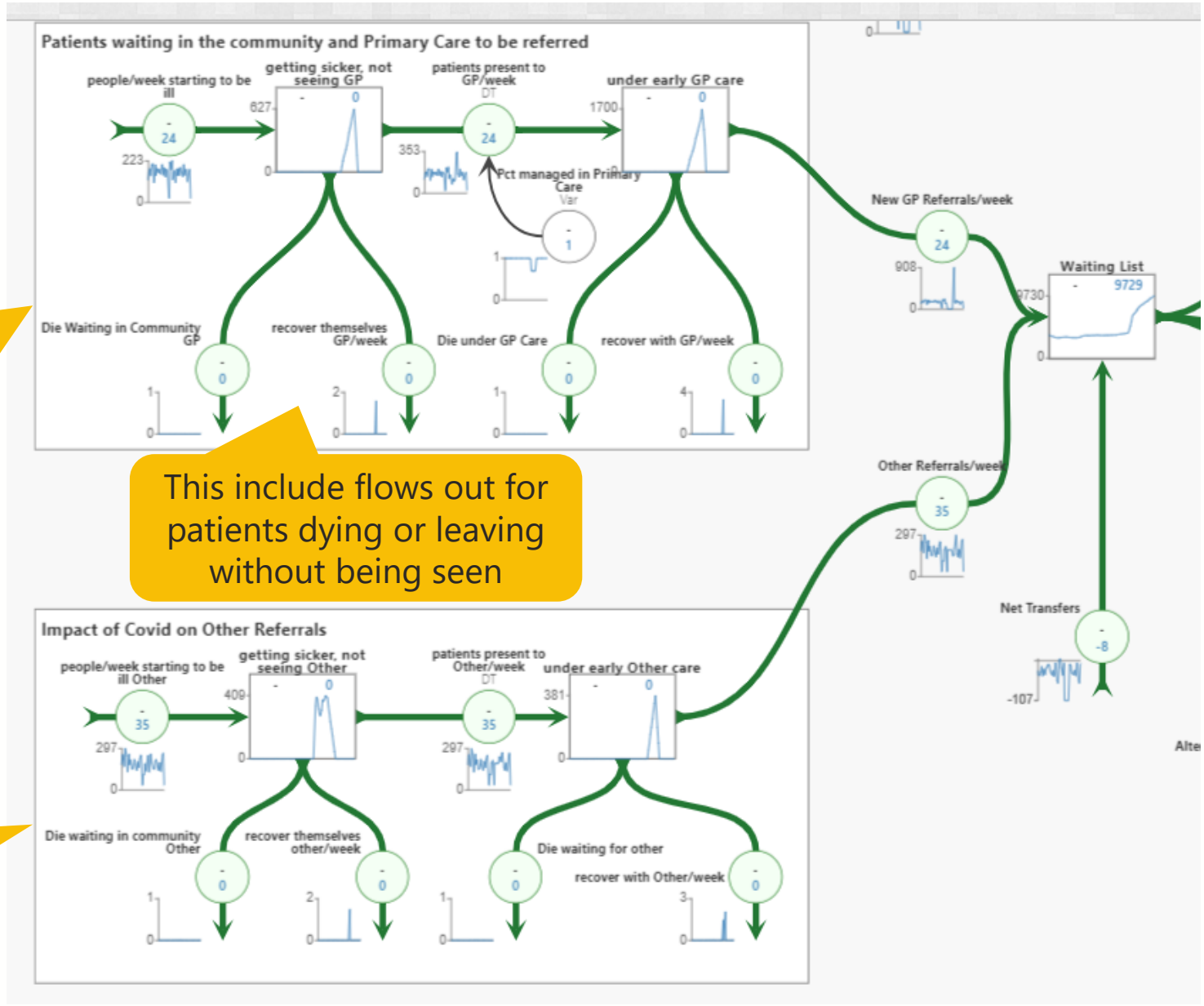
...by being Non-admitted seen

...by leaving without being seen

...or by dying before being seen

Waiting List Model - Referrals

A referral pathway includes stocks for excess patients waiting in the community and excess patients managed in primary care

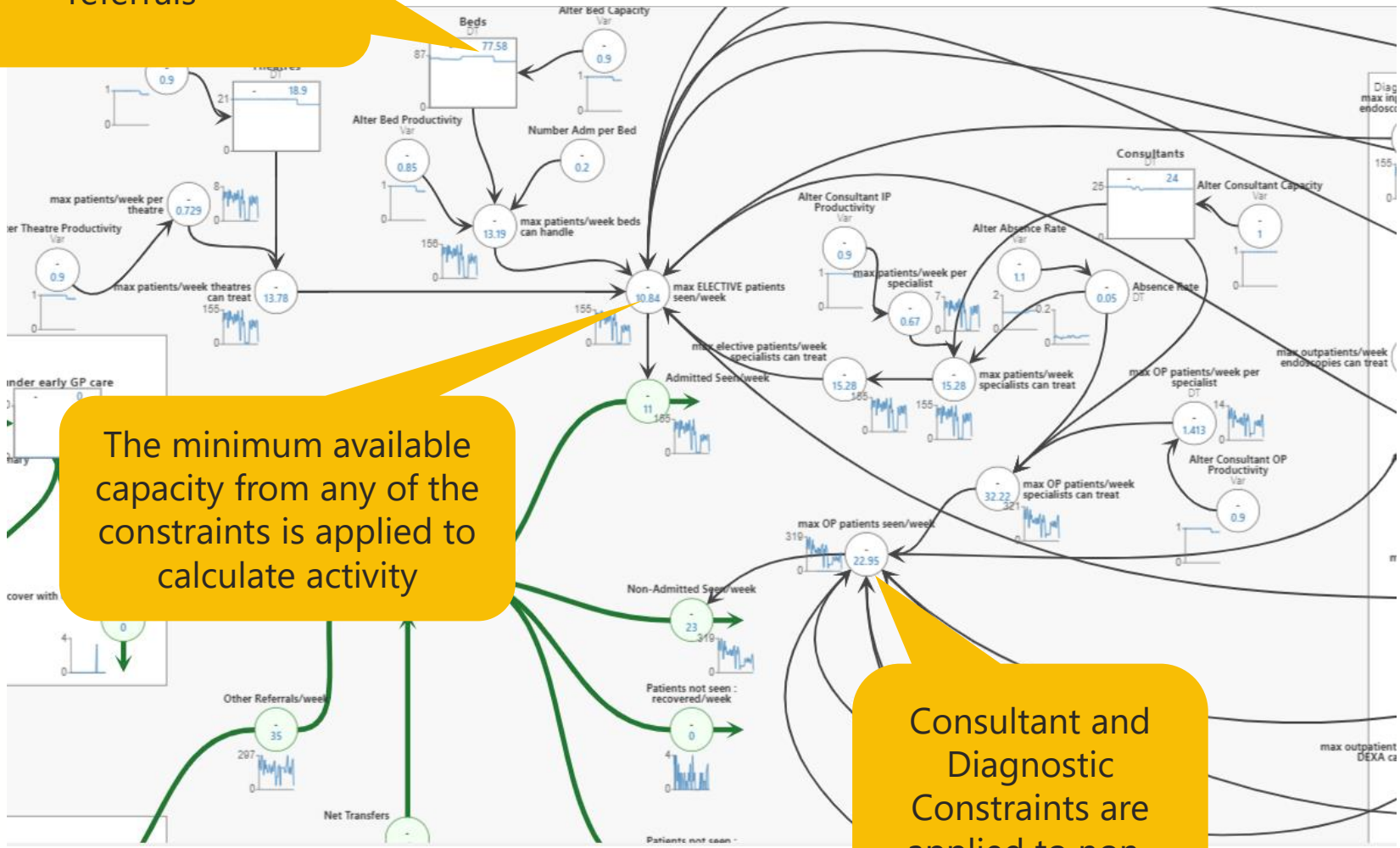


This include flows out for patients dying or leaving without being seen

This is repeated for other referrals

Waiting List Model – Resource Constraints

This is repeated for other referrals

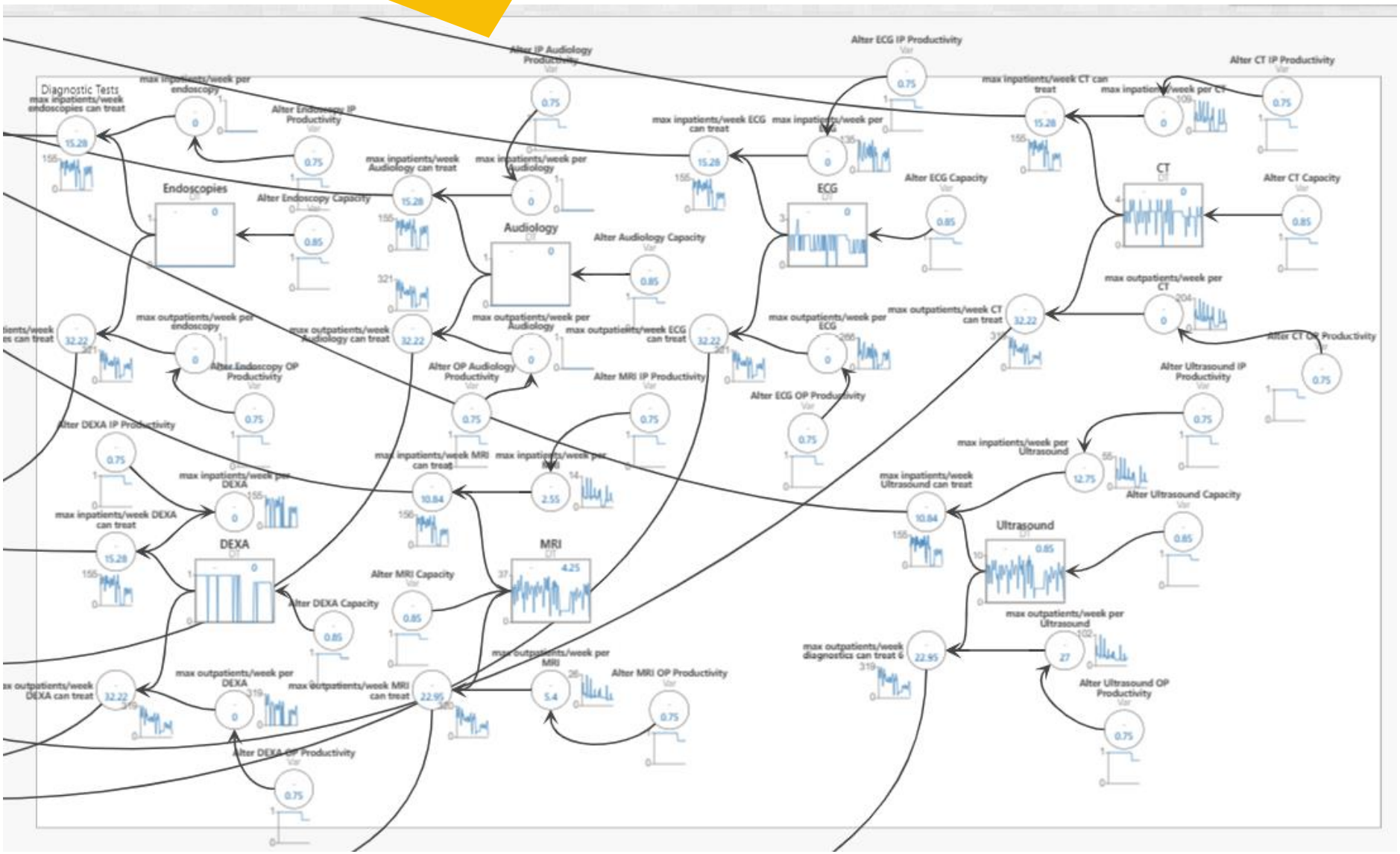


The minimum available capacity from any of the constraints is applied to calculate activity

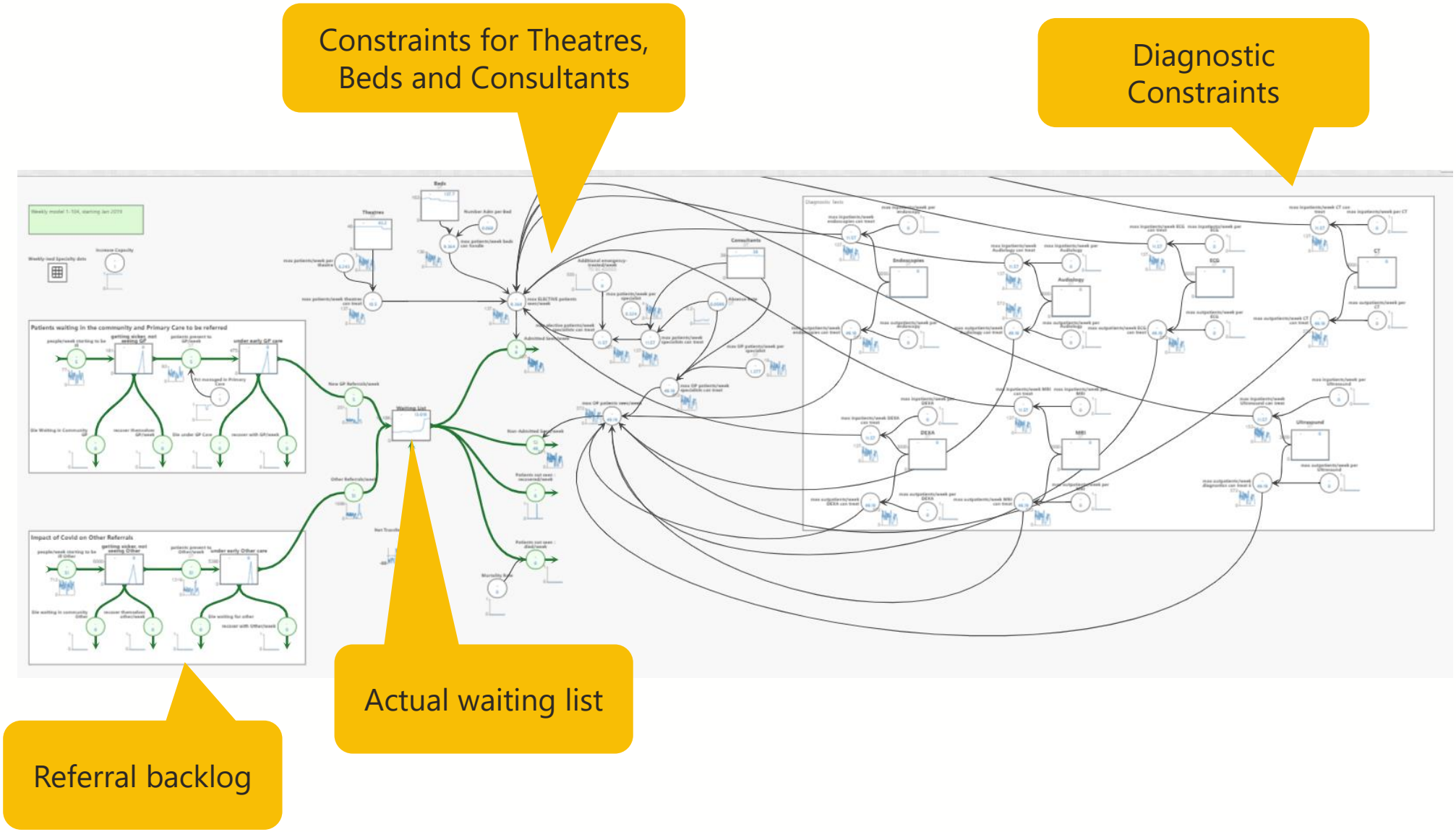
Consultant and Diagnostic Constraints are applied to non-admitted seen

Waiting List Model – Diagnostic Constraints

Additional Constraints are applied for each of the diagnostic tests



Waiting List Model



Creating the dataset

Creating the Dataset

A data table is used in sheetless to input the historic data required in the model. It also includes projections of future referrals, resource availability and resource productivity that are calculated outside the model.

Initial datasets for trusts have been created by the Strategy Unit by using readily available datasets. Most of the data is from national datasets so can be replicated for all trusts but data on GP referrals and the number of people who die or leave the waiting whilst waiting are from the ERS and SUS datasets

It is not possible to manually check all datasets therefore local analysts should check the datasets to ensure they and any assumptions used to create them are correct for their trust before they copy the data into the model. They may also want to replace some data with locally available data if available.

The tables on the following pages detail each data item, their source and where they are used in the model.

Model Data Sources

Field Name	Description	Source	Where used in the model (name of object)
wait list	Number of people on the waiting list at the start of the month	Consultant-led Referral To Treatment (RTT) waiting times	Waiting List
PopNeed_GP	The number of GP referrals to the trust and specialty during the week projected from the start of the covid period using last years data	Consultant-led Referral To Treatment (RTT) waiting times	People/week starting to be ill, Patients present to GP/week
PopNeed_Other	[RTT_Referrals] – [GP Referrals]	Consultant-led Referral To Treatment (RTT) waiting times	people/week starting to be ill Other, patients present to Other/week
GP Referrals	The number of GP referrals to the trust and specialty during the week projected from the start of the covid period using Aprils data to the end of June and last years data from July onwards	e-Referral System	New GP Referrals/week
Other Referrals	[RTT_Referrals] – [GP Referrals]	Calculated	Other Referrals/week
RTT_Referrals	The number of RTT referrals to the trust and specialty during the week	Consultant-led Referral To Treatment (RTT) waiting times	Not used in the model. Used to calculate other fields.
Adm seen	The number of people leaving the waiting list following a hospital admission	Consultant-led Referral To Treatment (RTT) waiting times	Not used in the model. Used to calculate other fields.
Non-Adm seen	The number of people leaving the waiting list without a hospital admission	Consultant-led Referral To Treatment (RTT) waiting times	Not used in the model. Used to calculate other fields.
not seen	[recover while on wait list] + [die while on wait list]	Calculated	Not used in the model. Used to calculate other fields.

Model Data Sources

Field Name	Description	Source	Where used in the model
recover while on wait list	Number of people who left the pathway without being seen	SUS	Patients not seen : recovered/week
die while on wait list	Number of people who died whilst waiting to be seen	SUS	Not used in the model. Used to calculate other fields.
Beds	Number of available elective and day beds per trust and specialty	NHS England Bed Availability and Occupancy	Beds
Consultants	Number of FTE Consultants per trust and specialty	NHS Workforce data	Consultants
Theatres	Number of available Theatres per trust	NHS England Supporting Services data	Theatres
Absence Rate	Trust level staff absence rate per month	NHS Workforce data	Absence Rate
Medics	Number of FTE Medics per trust and specialty	NHS Workforce data	Not used in model. Included if local areas want to use rather than Consultants
Mortality Rate	Percentage of patients who died whilst on the waiting list	Calculated	Mortality Rate
Number Adm per bed	[Adm seen] \ [Beds]	Calculated	Number Adm per Bed
Number Adm per consultant	[Adm seen] \ [Consultants]	Calculated	Patients/week per specialist
Number Adm per theatre	[Adm seen] \ [Theatres]	Calculated	Patients/week per theatre

Model Data Sources

Field Name	Description	Source	Where used in the model
Endoscopies	Number of endoscopy (Colonoscopy, Flexi Sigmoidoscopy, Cystoscopy, Gastroscopy) appointments per month apportioned by specialty using national data	NHS England Diagnostic Activity Data	Endoscopies
Number Adm per Endoscopy	[Adm seen] \ [Endoscopies]	Calculated	max inpatients/week per Endoscopy
Number seen per consultant	[Non-Adm seen] \ [Consultants]	Calculated	max OP patients/week per specialist
Number seen per Endoscopy	[Non-Adm seen] \ [Endoscopies]	Calculated	max outpatients/week per Endoscopy
PCT_Recover	Percentage of patients who recover whilst on the waiting list	Calculated	Not used in the model
Transfers	Net number of transfers from another trust \ specialty	Calculated	Net Transfers
Audiology	Number of Audiology appointments per month apportioned by specialty using national data	NHS England Diagnostic Activity Data	Audiology
Number Adm per Audiology	[Adm seen] \ [Audiology]	Calculated	max inpatients/week per Audiology
Number Seen per Audiology	[Non-Adm seen] \ [Audiology]	Calculated	max inpatients/week per Audiology
ECG	Number of ECG appointments per month apportioned by specialty using national data	NHS England Diagnostic Activity Data	ECG
Number Adm per ECG	[Adm seen] \ [ECG]	Calculated	max inpatients/week per ECG

Model Data Sources

Field Name	Description	Source	Where used in the model
Number seen per Ultrasound	[Non-Adm seen] \ [Ultrasound]	Calculated	max outpatients/week per Ultrasound
CT	Number of CT appointments per month apportioned by specialty using national data	NHS England Diagnostic Activity Data	CT
Number Adm per CT	[Adm seen] \ [CT]	Calculated	max inpatients/week per CT
Number seen per CT	[Non-Adm seen] \ [CT]	Calculated	max outpatients/week per CT
DEXA	Number of DEXA appointments per month apportioned by specialty using national data	NHS England Diagnostic Activity Data	DEXA
Number Adm per DEXA	[Adm seen] \ [DEXA]	Calculated	max inpatients/week per DEXA
Number seen per DEXA	[Non-Adm seen] \ [DEXA]	Calculated	max outpatients/week per DEXA
MRI	Number of MRI appointments per month apportioned by specialty using national data	NHS England Diagnostic Activity Data	MRI
Number Adm per MRI	[Adm seen] \ [MRI]	Calculated	max inpatients/week per MRI
Number seen per MRI	[Non-Adm seen] \ [MRI]	Calculated	max outpatients/week per MRI
Ultrasound	Number of Ultrasound appointments per month apportioned by specialty using national data	NHS England Diagnostic Activity Data	Ultrasound
Number Adm per Ultrasound	[Adm seen] \ [Ultrasound]	Calculated	max inpatients/week per Ultrasound
Number seen per Ultrasound	[Non-Adm seen] \ [Ultrasound]	Calculated	max outpatients/week per Ultrasound

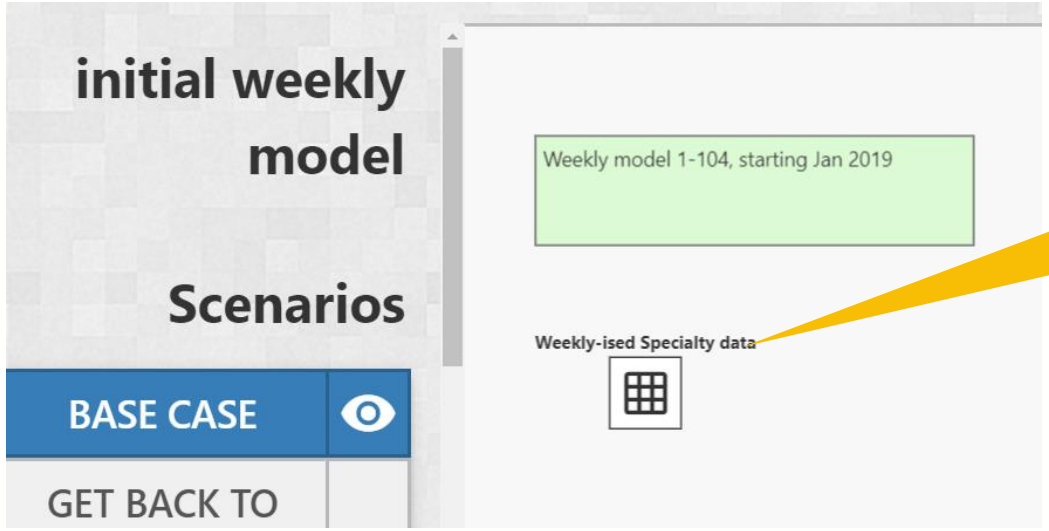
Using the model

Using the Model

In order to use the Waiting List model locally you will need to follow these steps:

- Create a Community Account for Sheetless at https://sheetless.io/pricing and then log in to the software
- Open the Waiting List model at https://sheetless.io/@mikewoodall/nhs-waiting-list-post-covid-v10?s=8_2CT77sQaOIXNBv-scU0Q
- Check the dataset for each specialty and update the data sources where better local data is available. The R code used to create the dataset is available at https://github.com/The-Strategy-Unit/covid_outpatients_pulling/blob/master/custom_pull_loop.R
- Copy in the data for the trust and specialty you are modelling (see pages 22, 23 and 24)
- Check the waiting list at the end of March is similar to the actual waiting list. If it is not similar then recheck each of the flows in (New GP Referrals/week, Other Referrals/week, Net Transfers) and out (Admitted Seen/week, Non-admitted Seen/week, Patients not seen : recovered/week, Patients not seen : died/week) of the waiting list stock are correct. Once you have identified which is wrong then work back from that flow to identify the issue.
- Adjust any variables in the base model or the pre-loaded scenarios (see pages 30, 31 and 32)
- Create a new scenario to model (see pages 37 and 38)
- Adjust any variables in the new scenario (see pages 30, 31 and 32)

Adding the data to the model



Double click on he “Weekly-ised Specialty data” icon to open the data table

Click on “wait list” to highlight the column and then paste the data copied from the spreadsheet template into the table

initial weekly model

INITIAL WEEKLY MODEL

	wait list	PopNeed_GP	PopNeed_Other	GP Referrals	Other Referrals	RTT_Referrals
Jan 1st	5125	45	390	45	390	435
Jan 8th	5135	55	476	55	476	531
Jan 15th	5147	62	538	62	538	600
Jan 22nd	5160	52	450	52	450	502
Jan 29th	5172	42	384	42	384	426

Adding the Data to the Model

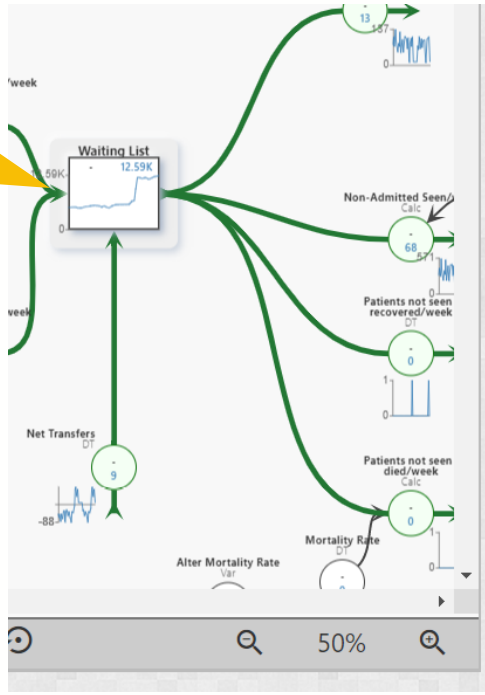
Copy the first value in the wait list column

initial weekly model

INITIAL WEEKLY MODEL

	wait list	PopNeed_GP	PopNeed_Other	GP Referrals	Other Referrals	RTT_Referrals	A
Jan 1st	5125	45	390	45	390	435	
Jan 8th	5135	55	476	55	476	531	
Jan 15th	5147	62	538	62	538	600	
Jan 22nd	5160	52	450	52	450	502	
Jan 29th	5172	42	384	42	384	426	

Click on the Waiting List Stock to open the panel on the right side of the screen



Data

	Simulated	Sketched
Jan 1st	5125	5125
Jan 8th	5135	-
Jan 15th	5147	-
Jan 22nd	5160	-
Jan 29th	5172	-
Feb 5th	5185	-
Feb 12th	5204	-
Feb 19th	5218	-
Feb 26th	5235	-

Paste the waiting list value into the first cell of the Simulated column in the wait list stock

Adding the Data to the Model Video

A video of a data being added to the model can be found at:

https://www.youtube.com/watch?v=9HW0Pj2JNOY&feature=youtu.be

Model Elements that can be Customised

A number of elements within the model can be adjusted to test different local scenarios. The variables and how these can be changed are shown on the next page. The elements that can be changed are:

- Number of people waiting to be referred in the population
- Percentage of people waiting to be referred who will no longer need to be seen
- Number of GP and Other Referrals
- Number of patients who die whilst on the waiting list
- Number of patients who leave the waiting list without being seen
- Net impact of transfers
- Delays in patients being referred and seen as services are resumed
- Total number of:
  - Theatres
  - Beds
  - Staff
  - Diagnostics
- Productivity levels of:
  - Theatres
  - Beds
  - Staff
  - Diagnostics

Variables that can be Changed in the Model

Variable Name	Description
Alter Theatre Capacity	Percentage change in the number of theatres available
Alter Theatre Productivity	Percentage change in the productivity of available theatres
Alter Beds Capacity	Percentage change in the number of beds available
Alter Beds Productivity	Percentage change in the productivity of available beds
Alter Consultant Capacity	Percentage change in the number of Consultants available
Alter Consultant IP Productivity	Percentage change in the productivity to undertake inpatient activity of available Consultants
Alter Consultant OP Productivity	Percentage change in the productivity to undertake outpatient activity of available Consultants
Alter Absence Rate	Percentage change in the staff absence rate.
Alter Endoscopy Capacity	Percentage change in the number of endoscopy tests available
Alter Endoscopy IP Productivity	Percentage change in the productivity to undertake inpatient activity of available endoscopy tests
Alter Endoscopy OP Productivity	Percentage change in the productivity to undertake outpatient activity of available endoscopy tests
Alter Audiology Capacity	Percentage change in the number of Audiology tests available

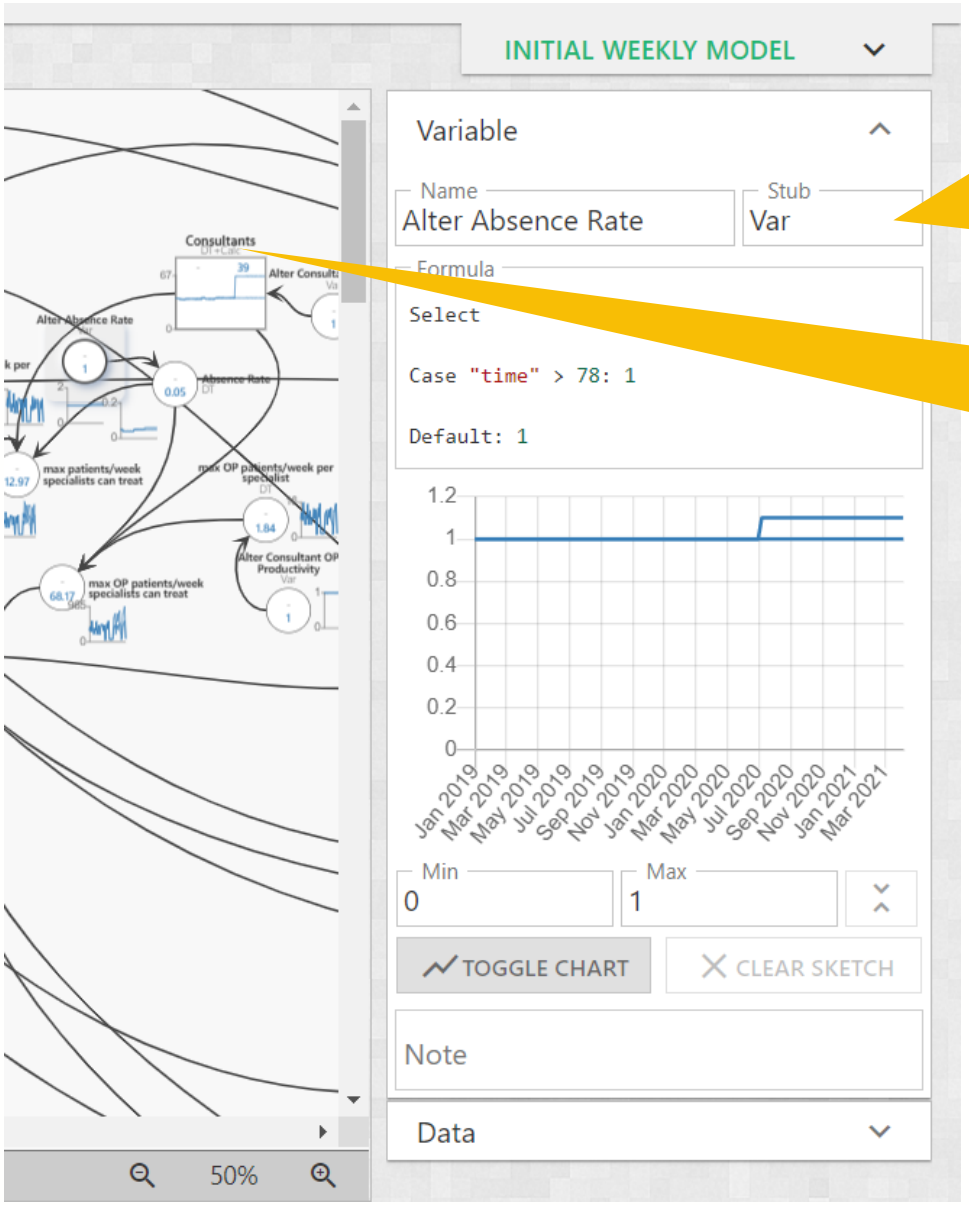
Variables that can be Changed in the Model

Variable Name	Description
Alter Audiology IP Productivity	Percentage change in the productivity to undertake inpatient activity of available Audiology tests
Alter Audiology OP Productivity	Percentage change in the productivity to undertake outpatient activity of available Audiology tests
Alter ECG Capacity	Percentage change in the number of ECG scans available
Alter ECG IP Productivity	Percentage change in the productivity to undertake inpatient activity of available ECG scans
Alter ECG OP Productivity	Percentage change in the productivity to undertake outpatient activity of available ECG scans
Alter CT Capacity	Percentage change in the number of CT scans available
Alter CT IP Productivity	Percentage change in the productivity to undertake inpatient activity of available CT scans
Alter CT OP Productivity	Percentage change in the productivity to undertake outpatient activity of available CT scans
Alter DEXA Capacity	Percentage change in the number of DEXA scans available
Alter DEXA IP Productivity	Percentage change in the productivity to undertake inpatient activity of available DEXA scans
Alter DEXA OP Productivity	Percentage change in the productivity to undertake outpatient activity of available DEXA scans

Variables that can be Changed in the Model

Variable Name	Description
Alter MRI Capacity	Percentage change in the number of MRI scans available
Alter MRI IP Productivity	Percentage change in the productivity to undertake inpatient activity of available MRI scans
Alter MRI OP Productivity	Percentage change in the productivity to undertake outpatient activity of available MRI scans
Alter Ultrasound Capacity	Percentage change in the number of Ultrasound scans available
Alter Ultrasound IP Productivity	Percentage change in the productivity to undertake inpatient activity of available Ultrasound scans
Alter Ultrasound OP Productivity	Percentage change in the productivity to undertake outpatient activity of available Ultrasound scans
Pct managed in Primary Care	Percentage of patients managed in primary care rather than the community during the Covid lockdown period
Alter Mortality Rate	Percentage change in the mortality rate of patients whilst on the RTT waiting list

Identifying the Variables that can be Changed



Each object in the model has a stub that describes the type of object

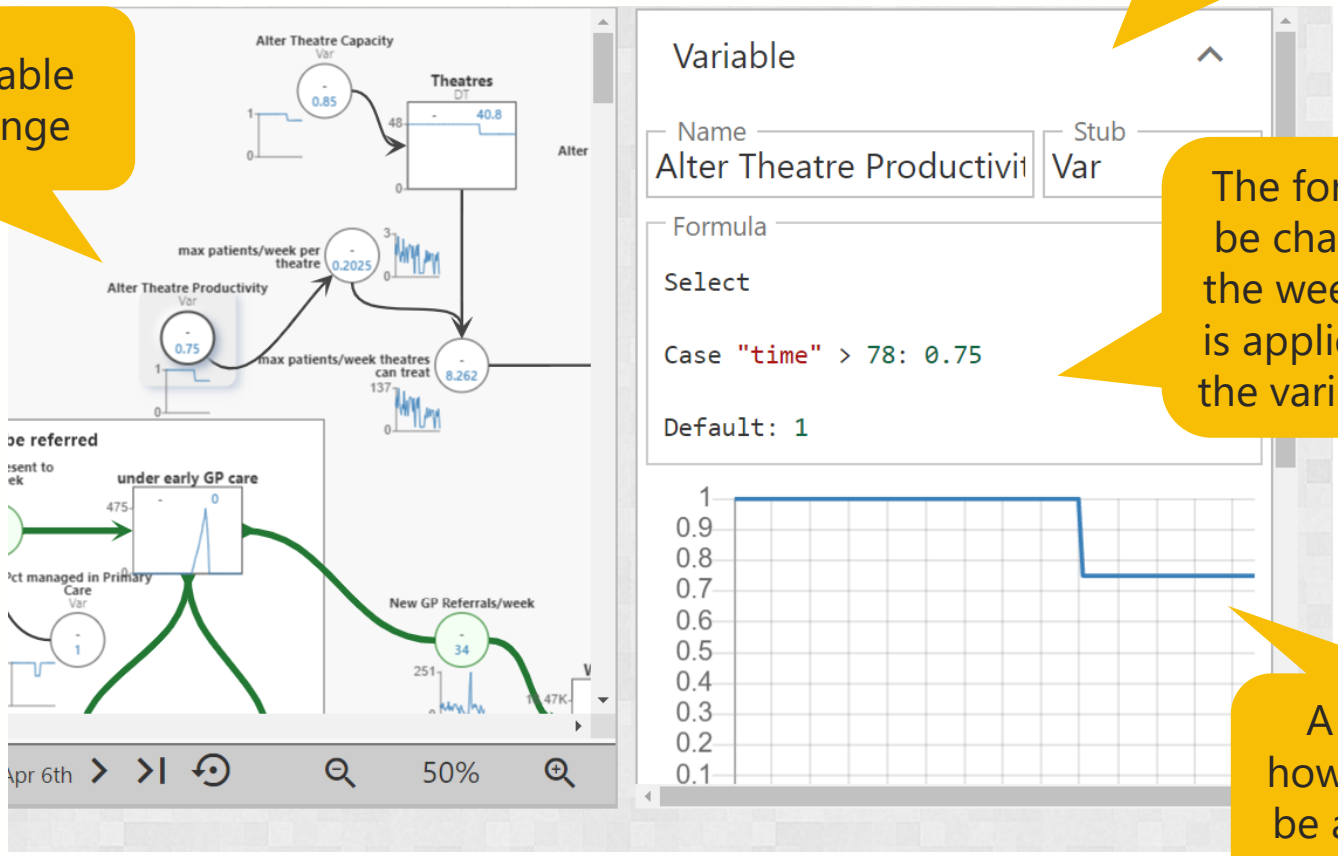
This is also shown under the title of each object

The types of object available are:
DT – Contains a value from the data table
Var – A variable that can be changed
Calc- A calculated field that is not a changeable variable
DT + Var – A variable that can be changed linked to a value from the data table
DT + Calc - A calculated field that is not a changeable variable linked to a value from the data table

Adjusting the Model Variables

A dialog box will open on the far right of the model

Click on the variable you want to change

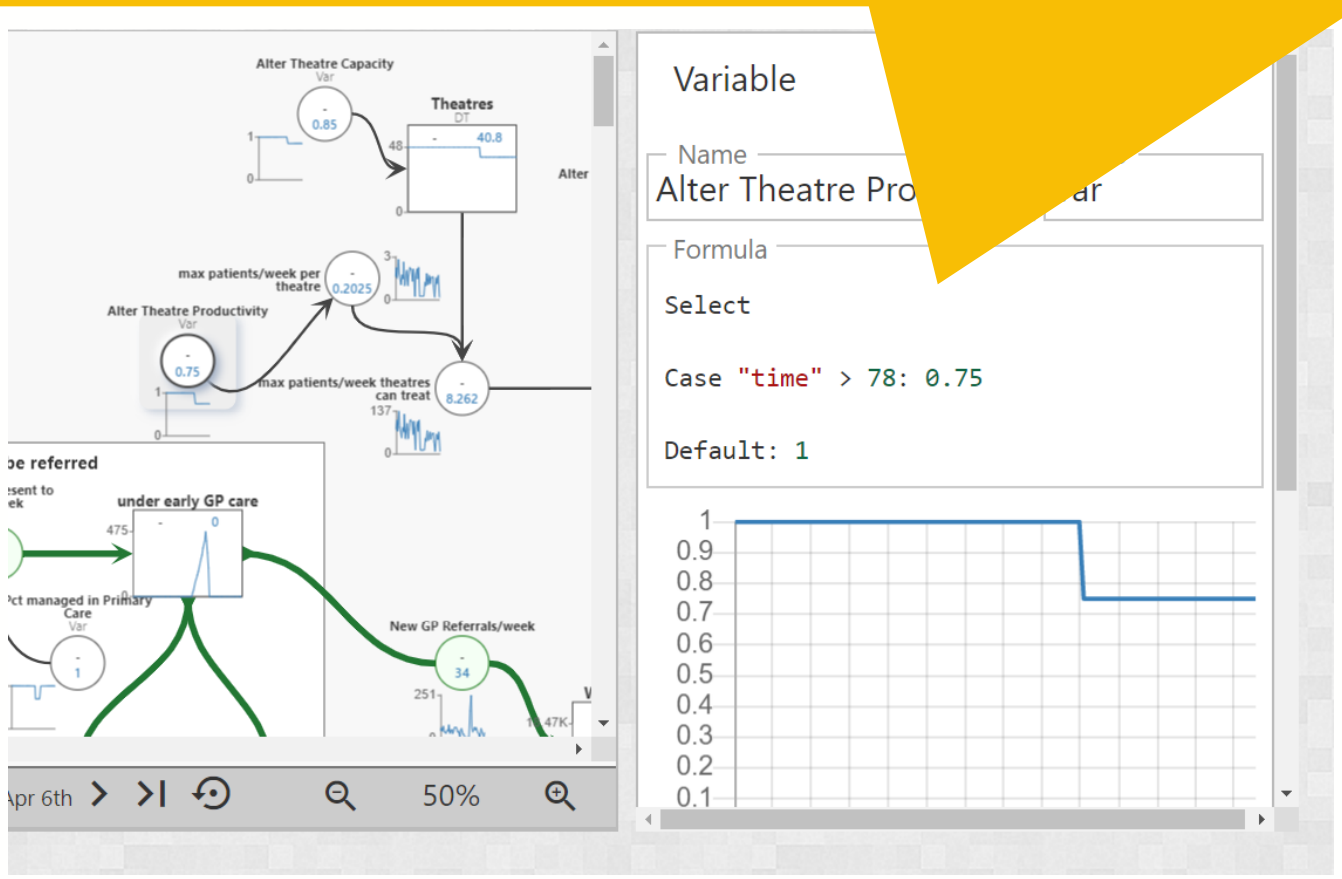


The formula can then be changed to adjust the weeks the variable is applied to as well as the variable value itself

A chart showing how the variable will be applied is shown below

Adjusting the Model Variables

The format of the variables is similar to SQL starting with where Case is the same as SQL : replaces THEN and Default: replaces ELSE. The variable “time” is the week number (Starting at week 0 on the 1st January 2019) which you want to change the value and should always with a low case “t”.
Select
Case “time” operator (e.g. <, >, =, etc.) [week number]: [variable value]
Default: [default variable value]



Adjusting the Model Variables Video

A video of a variable being adjusted can be found at:

https://www.youtube.com/watch?v=voA_vFAQ3tk

Covid Period Modelling Assumptions

A set of assumptions have been developed to show the impact of Covid on closing down elective services. These are applied in the base model and any changes would need to be calculated outside the model and fed in through the data table. The assumptions are:

- The modelling period is between April and June 2020
- All the capacity available in the system was utilised pre-covid
- Background need is based on RTT referrals from the same period in 2019
- New RTT Referrals in May and June are based on April referrals
- RTT Seen (Admitted and Non-Admitted) in May and June are based on April data
- Capacity constraints assume that all available capacity was used pre-Covid
- Number who die or choose to leave in May and June are based on April data from SUS
- Net transfers rates in May and June are based on April data

Recovery Period Modelling Assumptions

These are applied in the "Initial Capacity Constraint Assumptions" scenario and can be changed within the scenario or by creating a new scenario. The assumptions are:

- The modelling period will run from July to December 2020
- The proportion of people waiting in primary care, rather than the community, will be calculated based on changes in GP appointment rates from the NHS Digital data collection (https://digital.nhs.uk/data-and-information/publications/statistical/appointments-in-general-practice)
- All patients waiting in primary care, due to Covid, are referred in July, evenly distributed across the 4 weeks
- All patients waiting in the community, due to Covid, to see primary care will be seen in Primary Care within 4 weeks and then take a further week to be referred to acute provider (i.e. all patients will be referred before the end of August)
- All patients waiting in the community, due to Covid, to be referred by another source will be referred within 9 weeks to the acute provider (i.e. all patients will be referred before the end of September)
- These assumptions will create a community and primary care waiting list

Recovery Period Modelling Assumptions

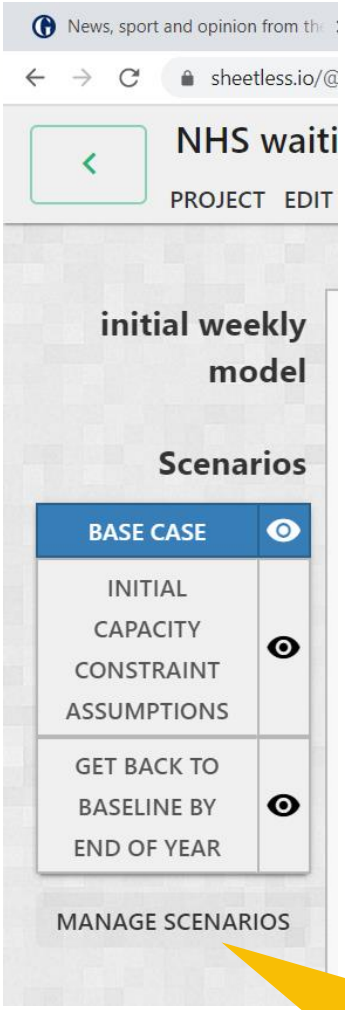
- The number of patients who leave the primary care and community waiting lists without being seen will be assumed to be 5% per week. This is higher than the usual rate due to concerns around Covid.
- Changes in the excess deaths due to Covid will be used to model the impact on the number of patients who die whilst on the waiting list.
- Transfers will remain the same as there is no evidence this has changed due to Covid
- Use the data on changes in elective activity that Steven has done using more up to date data to identify which specialties have been prioritised
- Use the percentage changes (rounded to the nearest 10%) that were collected at the last meeting for the number of each of the resources and their productivity. The changes for staffing numbers will be applied to the absence rate as it is unlikely overall staffing levels will be reduced between the July and December 2020. These are:
    - Beds. Numbers – 10% reduction, Productivity 15% reduction
    - Theatres. Numbers – 15% reduction, Productivity 25% reduction
    - Staffing. Absence rate - 10% increase, Productivity 10% reduction
    - Diagnostics. Numbers – 15% reduction, Productivity 25% reduction

Recovery Period Modelling Assumptions

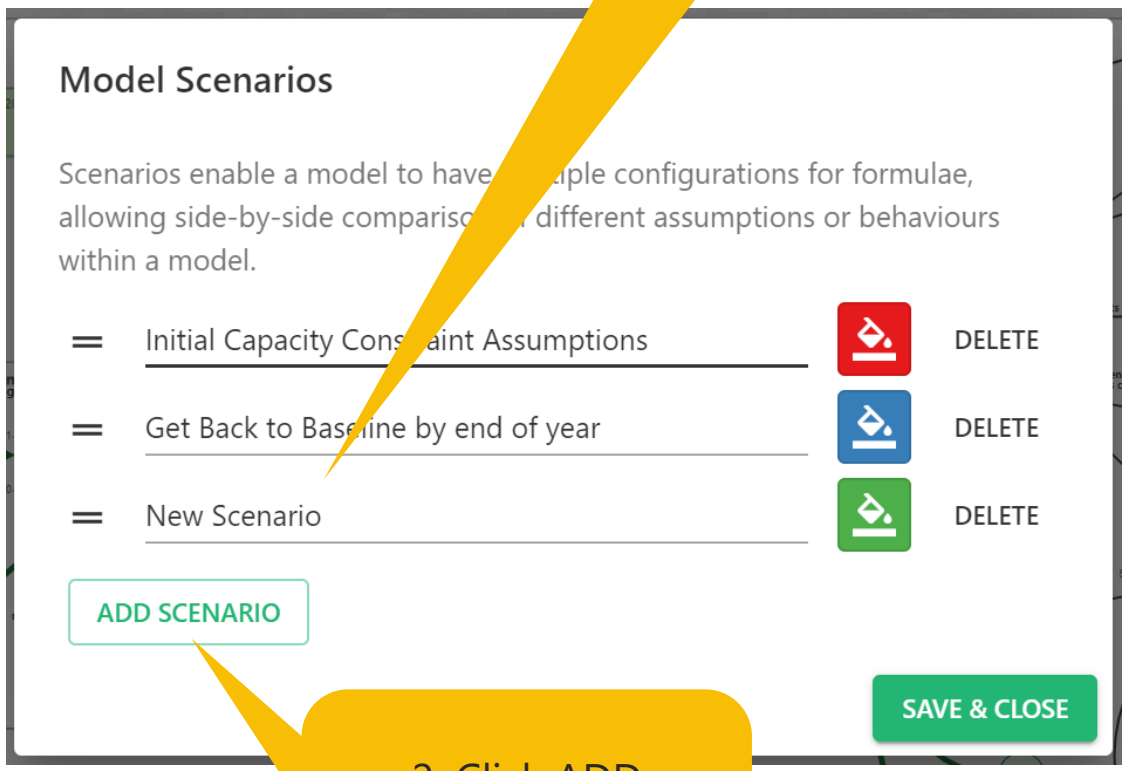
An additional scenario has been created to show the resources thar would be required to bring the waiting list back to pre-Covid level by the end of the year . This is called “Get Back to Baseline by end of year” and can be changed within the scenario or by creating a new scenario using the same variables. The assumptions are:

- The only changes are to the number of beds, theatres, consultants and diagnostics available. These changes are based on a single specialty at a single trust and may need to be amended in local models to show the same reduction in the waiting list. These are:
    - Beds. Numbers – 70% increase
    - Theatres. Numbers – 80% increase
    - Staffing. Absence rate - 70% increase
    - Diagnostics. Numbers – 85% increase
- All other variables remain the same as the “Initial Capacity Constraint Assumptions” scenario

Creating a New Scenario



1. Click MANAGE SCENARIOS to access the scenarios dialog box



2. Click ADD SCENARIO to create a new scenario

3. Rename the scenario to something helpful

Creating a New Scenario Video

A video of a new scenario being created can be found at:

https://www.youtube.com/watch?v=EzyUOJzxeqk&feature=youtu.be

Uses for the Model

We appreciate that there are many different questions that people might have about the impact of Covid on waiting lists for planned care. No single model is capable of addressing all questions well and the chances that our model will coincide with the questions that you or your local teams might have are relatively slim. Here are some ways in which you might use our work to support your own.

1. **As a point of reference**: When you're working on a piece of analysis its often useful to see how someone else has approached a similar problem. You might want to compare approaches and consider the strengths and limitations of the two approaches, the assumptions made, the simplifications applied, the model functionality etc.

2. **As a source of assumptions**: One of the key challenges when modelling the outcome of some future scenario is to parameterise your model with assumptions about the timing and scale of certain impacts. Given that no-one can know these with any certainty, assumptions that others have made can be a useful reference point.

Uses for the Model

3. **As a source of data (or data wrangling code) :** To construct our models we have assembled large quantities of data. This data wrangling process is time consuming. You might want to use these datasets as inputs into your own model(s), or adapt the data wrangling scripts (r and tsql) to produce your own bespoke data tables.

4. **To run specific scenarios supported by the model**: Our model allows certain parameters to be adjusted to create new scenarios. You may wish to run locally relevant scenarios within our models.

5. **As a starting point to develop a more complex model:** It may be that with some additional variables or functionality, our model might be able to address some new questions that are relevant in your area. Feel free to use our model as a starting point and add complexity and functionality as required. The sheetless software is relatively intuitive. And you may wish to consider joining the action learning set (ALS) on system dynamics starting in September 2020. If you are interested in joining the ALS please contact Mike Woodall at m.woodall@nhs.net for more details.

Available Support

Available Support

There is support available to help local teams use and adapt the model

- Videos of how to use elements of the model have are included in the document:
  - Copying in the model dataset on page 24
  - Altering variables on page 32
  - Creating a new scenario on page 38
- Surgeries with booked time slots
  - 9-12 on Tuesday 4th August
  - 1-5 on Wednesday 5th August
  - To book a 15 or 30 minute time slot please e-mail m.woodall@nhs.net with your preferred date, time and duration

Useful Links

Useful Links

General Links

- https://en.wikipedia.org/wiki/System_dynamics
- http://systemdynamics.org.uk/
- https://strategydynamics.com/
- https://www.thewholesystem.co.uk/

Other Example Models

- http://systemdynamics.org.uk/the-local-covid-course-and-model/
- https://www.kpho.org.uk/joint-strategic-needs-assessment/jsna-population-cohort-model
- http://systemdynamics.org.uk/wp-content/uploads/2013-Day1-CfWI-Paper.pdf

Software Options

- https://sheetless.io/
- https://insightmaker.com/
- https://www.iseesystems.com/store/products/stella-architect.aspx

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