Introductory guide: Covid-19 modelling

21 April 2020 Written by the National Demand and Capacity Team

NHS England and NHS Improvement

Introduction

This document is intended for users who want to familiarise themselves with some of the techniques that are being used to model demand for healthcare services during the COVID-19 pandemic.

This guide and further introductory information published by the Demand and Capacity Team including a case study are available here:

https://future.nhs.uk/system/login?nextURL=%2Fconnect%2Eti%2FDemand%5FCapacity%2Fview%3FobjectID%3D19539312

Modelling COVID-19: Where do I start?

Some questions to help start your thinking

- What am I counting?
  - What are the key resources you need to model for, and how do they relate to infection caseloads?
  - E.g. Beds (critical and non-critical) required, community contacts, equipment
- How quickly do I need this information?
  - There will be a trade-off between speed of development, and the detail/accuracy available
  - For Covid-19 modelling, the timeframe for peak of infection curve: To be useful, models should be providing results in the next 1 – 2 weeks
- What resources do I have?
  - What analytics platform and skillsets are available?
  - How much time is available to learn new techniques or develop new skills?
- Is there anything that I can use to expedite model development?
  - Open source analytics resources
  - Commercial analytics resources
  - Partner organisations (e.g. STPs, CCGs, research groups)

Who needs to be involved?

Modelling is a team effort: you will get better results by combining knowledge from different fields.

At a minimum, we recommend that you have:

- Someone involved in operational management and delivery (eg. service manager)
- An informatics specialist who knows your local data systems
- Input from clinical leads

Without this mix of operational and information knowledge, any attempts at modelling will be much more difficult to carry out.

We have found that including a third person who is not involved in service delivery who can act as an impartial ‘critical friend’ can also be very helpful.

What factors do I need to take into account when modelling?

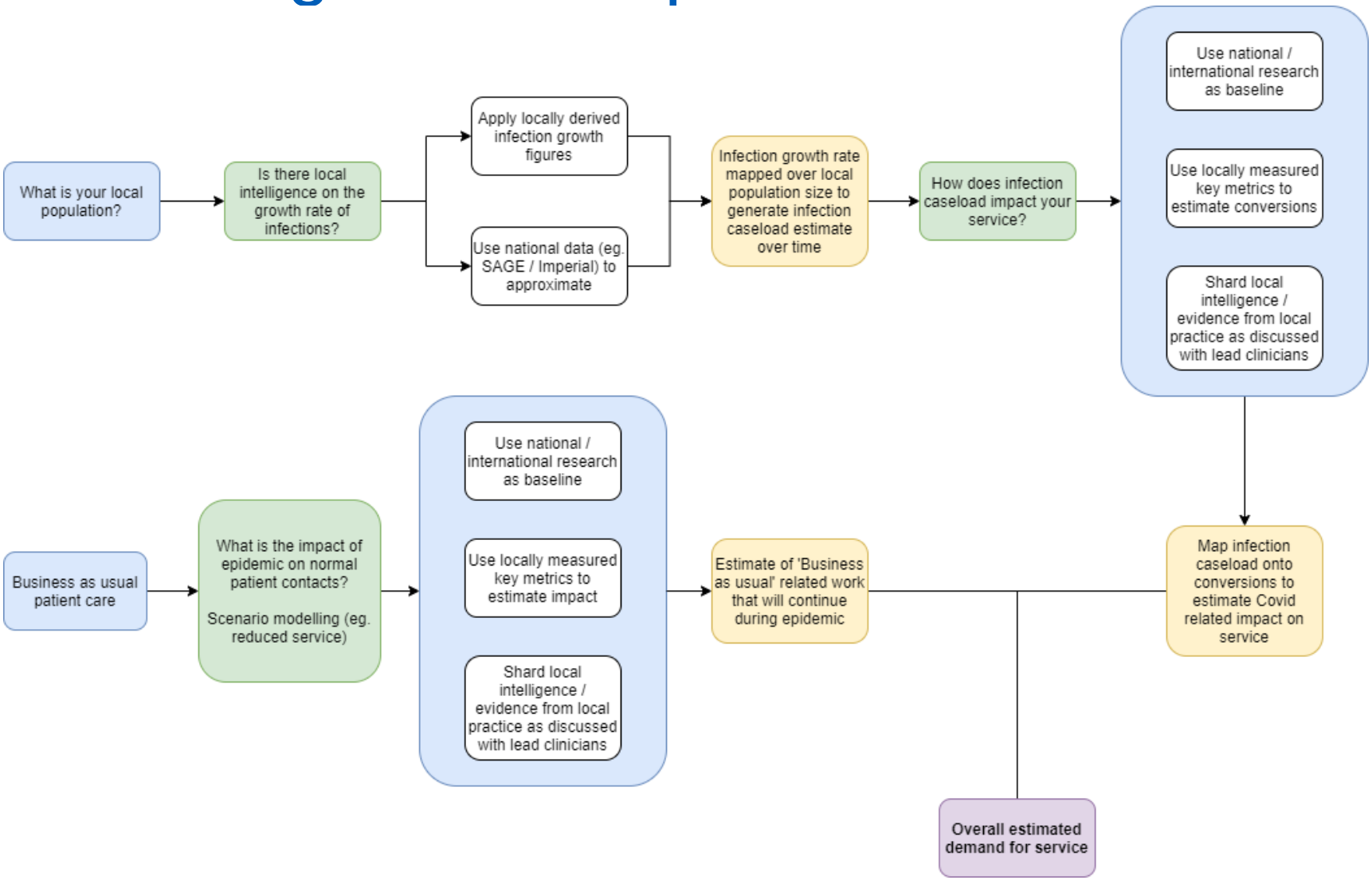
There will be many factors that will affect demand and capacity for your service – a key task for modelling will be how you account for these in a structured and systematic way.

We recommend you process map these variables before you begin modelling – this will help you:

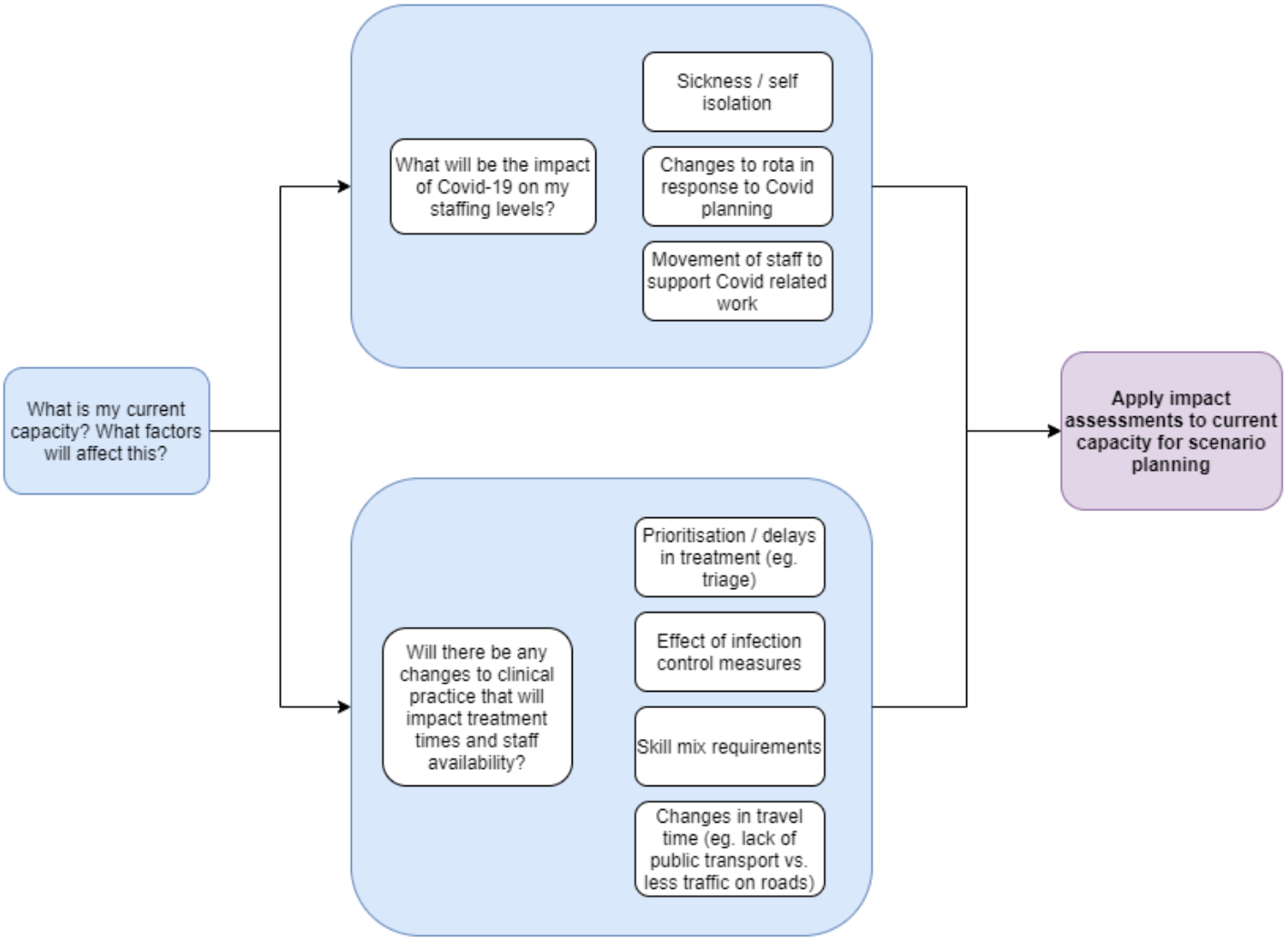
- Structure how you model your service
- Highlight what inputs you need to quantify before you begin
- Document your thought processes

The following pages are example process maps for both demand and capacity modelling that you can build on for your own service.

Process mapping your demand modelling: an example



Process mapping your capacity modelling: an example



Where do I get data from?

Your model will require inputs regarding local populations, infection growth rates and conversions to service delivery requirements. These resources are a good starting point, which you may refine as you get more information locally.

Population data for your area

- ONS – be aware that you may need this segmented by age group & gender

https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/adhocs/11516ukpopulationsummarybyageandgeographymid2018

Infection rate (may vary over time)

- Scientific Advisory Group for Emergencies (SAGE)

https://www.gov.uk/government/groups/scientific-advisory-group-for-emergencies-sage-coronavirus-covid-19-response

- Imperial College: MRC Centre for Global Infectious Disease Analysis

http://www.imperial.ac.uk/mrc-global-infectious-disease-analysis/covid-19/covid-19-resources/

Service-relevant parameters (e.g. hospitalisation rate, ITU conversion rate)

- SAGE
- Imperial College
- Local data, as it develops – this is where understanding your key metrics, and monitoring them will be helpful.

What modelling techniques can I use?

The following section outlines 3 types of models that we have seen being developed for modelling the impact of Covid-19.

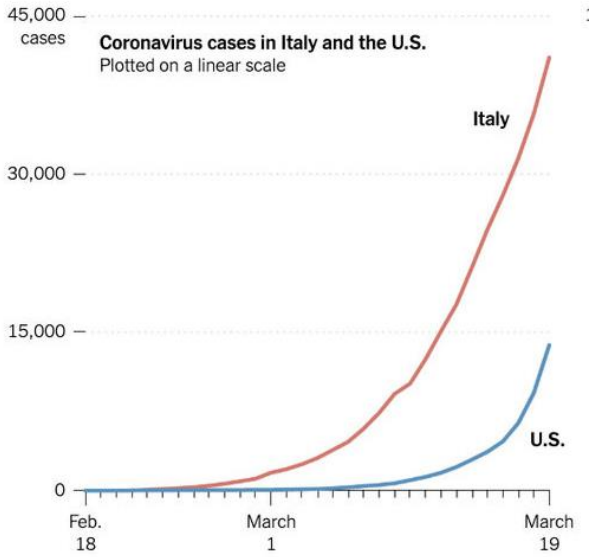
If you have limited experience in modelling, we recommend using the most simple option (the exponential growth model), as, in the current circumstances, learning more advanced techniques are likely to take too much time.

Some general tips on using models:

- Do be aware of the assumptions that underpin the model methodology, and how this would apply to your service.
- Update your model frequently, using the most up-to-date information. This is of particular importance at the moment, as parameter values may change quickly.
- Keep sense checking your information against how your service is running in real life, and use this to refine your data collection and modelling decisions.

1. Exponential growth models

This approximates caseloads during the growth phase of an epidemic.



Calculations typically looks something like this:

Every x days, the caseload will increase by y%

Pros

- Easy to apply – you can quickly create a model in Excel

Cons

- Assumes growth is infinite – will eventually overestimate
- Not useful when you are near the peak of the infection

A tool that you can access online

- Web app, London School of Hygiene and Tropical Medicine: https://cmmid-lshtm.shinyapps.io/hospital_bed_occupancy_projections/

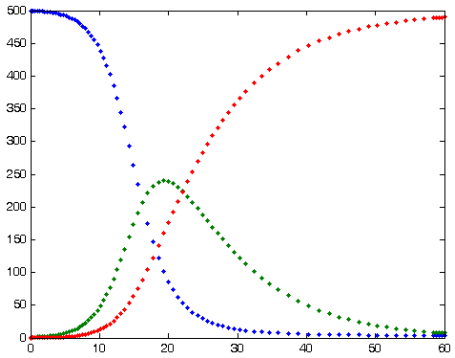
2. Epidemiological models (SIR/ SEIR)

Models causal chain of events: Non-immune individuals > Infected > Recovered (immune)

Pros

- Will predict the whole lifecycle of the epidemic

  (predicted infection caseload is in green):



Cons

- Requires understanding of more advanced statistics – if you aren't used to applying these techniques, then it will be very challenging to learn 'on the job'
- Specialist knowledge required to identify external factors (eg. social distancing) and estimate their impact on infection growth

A tool that you can access online

- SEIR web app (open source), developed by Gabriel Goh (research scientist at OpenAI)
  http://gabgoh.github.io/COVID/index.html

3. Queuing theory

Combines demand distribution with factors like length of stay (LOS) to estimate bed usage.

Pros

- Gives practical outputs that directly relate to service management (eg. beds required over time).

Cons

- Specialist knowledge required to correctly apply calculations, much like the SIR/SEIR models
- You will need to have the demand curves, as well as LOS information before you start (and update as you go)

A tool that you can access online

- Bristol, North Somerset and South Gloucestershire CCG, open source model in R: https://github.com/nhs-bnssg-analytics/covid19-reqd-beds-projection

Where do I find more advanced information about modelling?

The NHS England and NHS Improvement Analytics Team have set a space on FutureNHS which you can access here: https://future.nhs.uk/DataanalyticsCOVID-1919

They have also developed a methodology which they have published here:

https://future.nhs.uk/DataAnalyticsCovid19/view?objectId=67441989#

More general resources on analytics (eg. tutorials and courses) can be found here:

https://future.nhs.uk/DataAnalyticsCovid19/view?objectID=19711504

How do I apply the results of my model?

How you use the results of your modelling will depend on how you answered the questions at the start of this document.

For example, if you have good quality intelligence on your local infection rates and are experienced in applying advanced modelling techniques, then you may use your modelling results to plan your staff rota and contingency planning in detail.

Alternatively, if you have limited data and your team have not had much experience in applying modelling to your service, then the process mapping element may be more helpful in highlighting factors you need to consider when making operational decisions.

The process of modelling your service will give you some educated ‘guesses’ as to what may happen. You can use this information to risk manage your service across a range of scenarios, and keep you and your patients safer.

How do I get in touch with the Demand & Capacity team?

Please e-mail us to:

- Share your work
- Ask questions on modelling

E-mail england.demandandcapacityproject@nhs.net

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