Predicting critical care needs during a pandemic
How simulation software redefined capacity planning at its most critical moment

NHS Lanarkshire is the third largest Health Board in Scotland, serving a population of 655,000 across rural and urban communities in Lanarkshire. Their 12,000 strong team of staff work in communities, health centres, clinics and offices in the region and at their three district general hospitals.

When COVID-19 emerged it posed huge questions for healthcare organizations globally; how much capacity would be needed to care for those who became infected, would there be enough ventilators and other equipment to care for patients appropriately and so much more.

At NHS Lanarkshire, advice from both UK and Scottish governments had suggested that the major NHS Trusts (in England & Wales) and Health Boards (in Scotland) prepare for the worst case scenario of a five-fold increase in demand for critical care in the Spring 2020 peak of the COVID-19 pandemic. This left NHS Lanarkshire with the challenge of trying to predict, at very short notice, the critical care resources they would actually require over the coming weeks and months and work out how they could best deal with the ongoing situation.

Simulation to predict critical care needs

Given the time-sensitive nature of making decisions and preparing for the potential demand, NHS Lanarkshire teamed up with data scientists from the University of Strathclyde Business School and simulation modelling experts Simul8 to create a data model that could predict critical care needs at the start of the COVID-19 pandemic.

By creating a digital simulation that accurately replicated the expected flow of COVID-19 patients through the critical care department through sophisticated modelling software from Simul8, NHS Lanarkshire was able to use the latest available data to reshape centrally-produced forecasts and make informed and accurate decisions based on local circumstances. Contrary to earlier government advice, the model highlighted that the Health Board had already made sufficient additions to its capacity to be able to manage the projected surge in critical care needs brought on by the pandemic.

This meant avoiding the costly adaptations to resourcing needs that would have otherwise been wasteful, as well as providing front line staff and capacity planners with peace of mind.

“Once the executive team at Lanarkshire had set their key question – which was what will be your critical care need? And do we currently have the resource and the capability to meet that? – the fact that we were able to give them the answer within two weeks, and roughly seven to ten days before the COVID-19 peak started, was vital in helping them manage this pandemic.” This according to Dr Nicola Irvine, consultant physician, doctoral researcher and one of the team leads in this successful collaboration.

Creating the simulation

Simul8 digital simulation software was used to create the model for this advanced new planning approach. “As its name suggests”, said Chandrava Sinha from the Department of Management Science at the University of Strathclyde, who worked with Nicola Irvine and Gillian Anderson in building the simulation model, “a digital model is an approximate representation of any real-life system. They are basically mathematical or statistical models created using a computer which tries to best mimic and present a real life scenario or a proposed scenario, and to then answer various ‘what if’ questions to help decision-makers make a very well informed decision.”

A crucial element of the modelling process for NHS Lanarkshire was the use of data that the team were able to build into the simulation. To cut through any conflicting evidence and to make the model as accurate to local needs as possible the team drew on a range of data sets. This included very localised community data, such as population profiling, as well as national trends that were being received from central government. It also included wider international data from countries such as Italy and Spain where the pandemic wave was a few weeks ahead. This approach allowed Simul8 to create a model that was as accurate as possible to local needs.

Chandrava added: “This data all fed into the model and then gave us the maximum utilisation of beds across all different categories on a week-by-week basis for the whole first wave of the pandemic.”

Collaborating for success

Dr Irvine emphasises the need for a “triumvirate of executive expertise, clinical expertise and modelling expertise” in building and implementing a successful model such as this one.

The clinician understands the behaviours of the organisation at floor level; the modeller is able to interpret that nuanced dynamic environment and to simplify and abstract data into a model that can be usefully predictive; and an executive team will have the overview needed to set the most pertinent question, and then the authority to act on the predictions of the model.

“Validation is also a key part of any modelling process”, continued Dr Irvine. “You want to make sure that you've captured the process that you are modelling, the environment, the disease, the activity etc. Crucial to this was the daily information that we were receiving from the hospital’s management team. We were able to constantly update our simulation using data from the local hospitals and authorities, as well as from wider resources such as the intensive care audit and information from the European Centre for Disease Control.”

Identifying the wider impact

In modelling for COVID-related planning, the research team realised that it was not just critical care that would be affected by the pandemic, but other areas of healthcare services would see knock on effects too.

“We were aware that other patients with emergency medical problems were presenting in smaller volumes”, said Dr Irvine, “but the turnaround time for testing the number of people who were presenting with suspected COVID – two days – was causing bottlenecks in the emergency department. This had potential to disrupt emergency care and other areas of urgent care, such in acute medical units.”

Further insights were also generated via the model in predicting that even while cases in the community were reducing, there were also some potential issues about infection being transmitted within the hospital that would need mitigating as well.

Dr Irvine added: “Simul8 modelling meant that we could say ‘here is the likely impact from COVID-19, but your other inpatient resources are predicted to be impacted too and you need to have a plan in place for this’.”

Wider adoption of simulation

The University of Strathclyde research team is led by Professor Robert Van Der Meer and includes Dr Nicola Irvine, Gillian Anderson, Chandrava Sinha and Holly McCabe as healthcare modelling specialists. The success of the Simul8 model in assisting NHS Lanarkshire at the beginning of the pandemic means that Holly and Gillian are now developing the model to

support the development of an Early Warning System for the next stage in the COVID-19 pandemic.

Professor Van Der Meer said: "The Strathclyde model really demonstrates the value of simulation for critical decision making. The approach provides evidence for those factors that are unknown and does so by generating an extremely localised picture of the situation. It is from here that you can make confident decisions where the risk has been mitigated significantly.

“We are grateful for the fantastic working relationship that our team has developed with NHS Lanarkshire, which really has been pivotal in the success of this initial project. Together we are now looking ahead at further applications of our simulation tool to support the Health Board. This includes the next possible peak and how to manage resources under the added pressures during the winter months.”

As for wider applications, Dr Irvine is now a strong advocate for the use of digital simulation not just in critical care but throughout health services. “To be honest, I struggle to think of any applications in healthcare where simulation modelling wouldn't be useful”, she said.

“As a clinician, these models allow you to create a virtual, experimental laboratory where you can see the patient, staffing and efficiency outcomes when testing different systems. To deliver this as a real-life trial would be cumbersome and it would take a long time, which would receive a lot of opposition. To instead be able to deliver the trial in a virtual environment and get a very clear picture of the outcomes without the associated risk or costs makes it a lot easier to achieve buy-in, and this makes digital simulation truly invaluable.”