HOUSE OF LORDS

SELECT COMMITTEE ON SCIENCE AND TECHNOLOGY

COVID-19 Rapid Summary: Modelling the Pandemic

Many members of the public are puzzled and anxious about aspects of the COVID-19 pandemic. These short summaries of our regular meetings are a record of evidence heard from scientists with internationally recognised expertise about what is known and unknown about the developing science, and which we hope will be helpful to the public.

Background

The Committee heard evidence across two sessions on 2 June about the epidemiological models used to inform the UK's response to the pandemic, both in previous stages and looking forward. This note summarises key points made by the witnesses. The full transcripts and a recording of the sessions are available at the following links:

- Transcript of evidence session 3
- Transcript of evidence session 4
- Parliament Live TV

The inquiry will continue on Tuesday 9 June, when the Committee will question experts about how behavioural science can be used to inform responses to pandemics, before moving on to talk about the science and role of testing.

Models of the pandemic

A wide variety of models have fed into the UK's response to the pandemic. Different modelling groups, based at different institutions, have each produced several models. Representatives from several of these groups make up the Scientific Pandemic Influenza Group on Modelling (SPI-M), a sub-group of the Scientific Advisory Group for Emergencies (SAGE), which is advising the Government on the pandemic. Advice to the Government therefore combines the outputs from many different types of models and modelling approaches.

The most well-known models are those that seek to project the likely spread of the disease in the population. *Statistical models* use real-world data and can be very accurate; but in these circumstances they are accurate only for projecting a few weeks ahead. *Mathematical models* are used to forecast possible scenarios over a period of months. By viewing many possible scenarios together, it can be possible to make a judgement about what might considered the most likely outcome, as well and best and worst-case scenarios.

The main type of mathematical model of disease spread is the S-I-R model, which categorises individuals as susceptible to infection (S), infected (I) and recovered (R). The main models that have been used in this pandemic are based on existing models of influenza pandemics, modified for application to COVID-19. We heard that applying the models to COVID-19 involved changing the model parameters (but not necessarily changing the models themselves) to account for different processes in this pandemic compared to influenza pandemics.

Using models in policy making

We heard that similar models have been used to model this pandemic around the world, with similar basic assumptions and datasets, and that they have produced largely similar sets of outcomes. We heard that the main reason responses to the pandemic have varied in difference places is due to how the model outputs have been interpreted, in combination with wider considerations, such as economic factors and judgements about how issues outside of the modelling will transpire (e.g. the availability of a vaccine). For example, some witnesses explained that Sweden made the decision to not implement a full lockdown based on a judgement that countries will find it very hard to stop a second wave and that by front-loading the health impacts they can lift restrictions earlier.

Modelling groups within SPI-M are commissioned by SAGE to answer specific questions that have been asked by the Government. For example, modellers may be asked to model the impact of a six-week lockdown on transmission rates. Throughout the pandemic, SAGE and its subgroups, including SPI-M, have been producing consensus statements to provide answers for these questions. We heard that there is generally good understanding of models by those who make policy decisions, but we did hear concerns that sometimes the questions posed by decision makers are not the right questions, or seek too narrow an answer. For example, modellers were sometimes asked to provide single numbers rather than a range, or a single scenario curve instead of a range of possible outcomes. We also heard concerns that some types of analysis have not been as prominent in advice given to Government, and that the consensus statements cannot include all of the views or nuances.

Uncertainty in models

Uncertainty in epidemiological models can be the result of several factors, including incomplete data, poor quality data, and poor understanding of the mechanisms of the virus and its transmission. To take into account some of these uncertainties, models can be run with a range of different values for key input parameters (such as R0), resulting in a range of possible outcomes. The range of outcomes may narrow as more data becomes available. We heard that there is sometimes too much focus on the mean values, rather than considering the range as a whole.

Witnesses told us that no-one knew exactly how people's behaviour and interactions would change in response to various measures, and so conservative assumptions were made about, for example, levels of adherence to interventions such as social distancing. Adherence has been higher than expected, and this data was fed back into models to improve their projections. We heard that modelling did not seek to estimate the impact of "fatigue" on adherence to measures based on how soon they were implemented or how long they were left in place.

Modelling at different scales

We heard that the objective of modelling earlier in the pandemic was to illustrate the likely impacts (particularly death rate) of the virus spreading in the absence of lockdown. This modelling was done at a population level, using the same assumptions about transmission rates across all areas and all settings, and assuming the impacts of measures would be uniform across the population.

As a result of country-wide interventions, transmission in the wider community has been much reduced. However, the epidemic is continuing in settings such as care homes with high transmission rates and high death rates. We heard concerns from some experts that the modelling scenarios were not aimed at the right targets; that is, they were aimed at the whole population when the burden of this disease is highly concentrated amongst those aged 70 and over those living in care homes. Some witnesses questioned the approach of focussing on a single number for R when communicating with the public. They explained that R is a useful value for forecasting the overall impact of the virus, but that policies should be based on different rates in different areas and settings (and on a wider range of factors).

There are geographical variations in transmission rates and death rates, but clearer data will be needed if localised policies such as lockdowns are to be used. We were cautioned that there are limits to the scale at which models can make useful projections.

Approaches to future stages of the pandemic

Some measures, such as shielding, were targeted at groups who are more vulnerable to the virus, but we heard that the impact of shielding was not included in the modelling. Data about the death rates in the elderly was incomplete because initially it was not collated from care homes. Now this data is available, and some models can be targeted on that part of the pandemic.

In future stages of the pandemic, there will be much more data available, for example from tracking and tracing. Modellers can use this data to calibrate the mathematical models to make more useful longer-term scenarios. We heard that it is important that researchers have time to analyse the impacts of previous relaxations before giving advice on potential further relaxations.

Testing is increasingly being used as part of the UK’s response to the pandemic, and will be part of the track and trace system. Modelling suggests that it has the potential to reduce the transmission rate by 0.2 (based on contact tracing in other countries), but the effectiveness depends upon the proportion of people who show symptoms, how well (and how quickly) they can identify contacts, and how many of those contacts then isolate.

As the pandemic progresses, we heard that the focus of efforts to inform planning will shift from modelling to data. Basic epidemiology will be used to study local areas and different settings, including increased surveillance and testing of cases. This will provide the data that is needed to make short-term statistical forecasts and to aid planning. It was noted that the public is familiar with the strong focus on modelling to inform planning thus far, and that this change to surveillance-based approaches will be significant.

Glossary

Coronaviruses
Coronaviruses are a type of virus that can cause respiratory and intestinal illnesses in humans and animals. There are seven known types of coronavirus that affect humans. Four are common and contribute to a third of common-cold infections globally. Three (SARS-CoV-1, MERS-CoV and SARS-CoV-2) are known to cause more severe illness and sometimes death.

COVID-19
COVID-19 is the illness causes by the SARS-CoV-2 virus, in the same way as the SARS-CoV-1 virus causes SARS (severe acute respiratory syndrome) and the MERS-CoV virus causes MERS (Middle East respiratory syndrome). COVID-19 illness tends to be milder than SARS or MERS, but the virus is more infectious.

Reproduction number
The reproduction number of a virus is the average number of people an infected person will go on to infect.

The *basic* reproduction number, R0 ("R nought"), is the average number of people infected by each single infected person at the start of a pandemic, before any interventions have taken place. If R0 is greater than one then an infection will spread exponentially. Early R0 figures in Wuhan were between 2 and 3, i.e. each infection led to two or three further infections. In the UK this would lead to 80% of the population being infected. Current estimates places R0 at between 2.5 and 3.1, which is higher than SARS or MERS.

The *effective* reproduction number, R, is used to describe the reproduction number through the course of the pandemic, in response to various interventions. The aim of many interventions is to reduce R below one, so that the spread of the virus cannot be sustained.

SARS-CoV-2
SARS-CoV-2 is a new type of coronavirus that was first identified in December 2019 in Wuhan, China.

S-I-R model
An S-I-R model splits the population into three states: susceptible to infection (S), infected (I) and recovered (R). The model simulates how people move between the different states, and how different interventions may change the number of infected people or the timing of the peak. More advanced versions of these models can include other states, such as "exposed but not yet infectious" (E).