Project title: Adaptive management in an ongoing pandemic

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Background

Mathematical modelling has played a vital role in the response to the COVID-19 pandemic, especially in the UK. However, a significant difficulty that is ubiquitous across models and contexts is the existence, and subsequent handling, of uncertainty. Uncertainty is present in many areas, for example: the transmissibility and lifecycle of the disease; the existence of asymptomatic infections and their role in transmission; the effect that interventions will have on spread; adherence of the general public to guidelines and intervention policies; the sensitivity of tests and efficacy of vaccines. These sources of uncertainty make it difficult to precisely predict the outcome of interventions and thus choose the 'optimal' course of action.

Adaptive management (AM) is a decision-making framework that aims to address the issue of making an optimal decision when faced with large amounts of uncertainty. It is well established in ecological fields such as resource management, but is relatively new in the context of epidemiology. The idea behind AM is an iterative process of control implementation, monitoring and adaptation (Figure 1). As such, a key component of AM is the link between monitoring and the resolution of uncertainty over time, and how that changes the optimal control intervention. The other components of the framework encompass the general tenets of structured decision making: having a quantifiable objective, set of possible actions and models of system behaviour that allow the prediction of control outcomes, and thus optimisation of control, in a rigorous, structured manner.

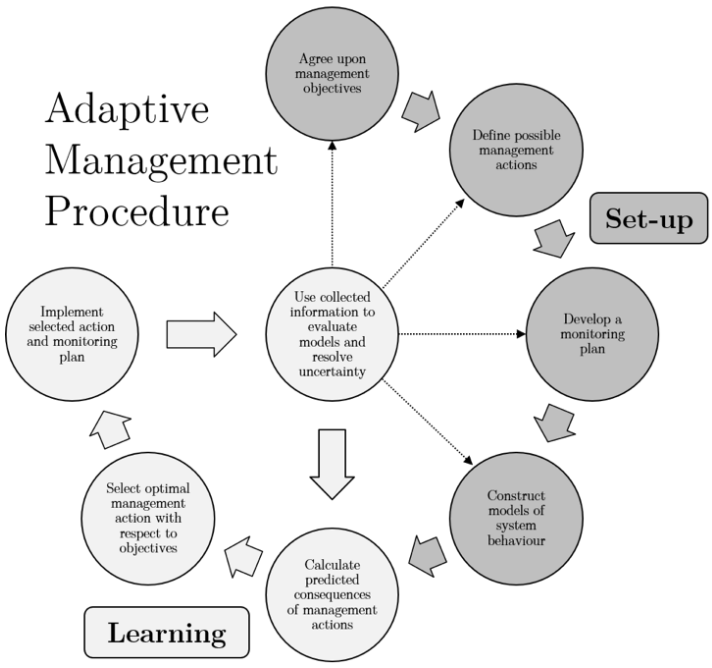

Figure 1: Adaptive management (AM) addresses the difficulties of epidemic control through a structured, iterative framework. The set-up phase (dark grey circles) provides a quantitative representation of management objectives, possible actions, planned monitoring and system behaviour, decided upon a priori with input from stakeholders. In the learning and implementation phase, the set-up components are used to forecast the possible effects of control. As the epidemic progresses, predictions from competing models of system behaviour are compared to incoming information, reducing uncertainty in the effect of control. The recommendations are adapted as necessary and the process repeats.

Project aim

The general aim of this project is to apply AM in the context of the ongoing pandemic. In doing so, we can analyse the role of uncertainty resolution and demonstrate the utility of an iterative, adaptive approach to control policy in reducing the impact of the pandemic on the UK. Depending on the state of the pandemic at the time the project commences, this work could focus on real-time control questions (such as the distribution of vaccines and balancing the necessity for nonpharmaceutical interventions) or retrospective analyses of how decisions could have been improved (for example the implementation and subsequent relaxation of lockdowns). The components of the AM framework will be formulated as necessary to answer such questions. For any scenario, we envisage the following areas of analysis:

i. Using the Expected Value of Perfect Information (EVPI), and other related measures, within an adaptive framework to assess the importance of different uncertainties and the benefit that resolving them may afford.

ii. Modelling the mechanisms underlying real-time information gain and uncertainty resolution, to analyse the feedback-loop between optimal control and uncertainty resolution.

iii. Construct and compare both 'passive' and 'active' AM approaches to managing the pandemic in the UK. Passive AM represents a reactive approach to control adaptation in light of new information. Active AM differs in that it anticipates the effect that new information might have and follows a pre-determined plan of action, dependent on which forecasted path unfolds.

References and further reading

Adaptive management in general

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