Clostridium difficile: A System Dynamics Analysis for the NAO

Summary: Over the summer of 2008 a model was constructed showing the development of *Clostridium difficile* (*C. difficile*) outbreaks in a standard sized hospital and exploring various policies for limiting that spread. The model represents patients in different stages of contamination and involves mechanisms relating to the cleaning of beds, toilets as well as staff hand cleaning.

Model Content

The model shows the spores moving via three transmission vectors:

- From staff carriers to susceptible patients, then from infectious patients to *C. difficile* free staff.
- From contaminated beds to susceptible patients, then from infectious patients to clean beds.
- From contaminated toilets to susceptible patients, then from infectious patients to cleaned toilets.

Model Contributions

1) The model served to capture, synthesise and record information from a wide range of sources, including literature, cases of outbreaks and expert interviews.
2) By representing the underlying mechanisms and parameters relating to *C. difficile*, the model provides a formal theory of epidemic outbreaks.
3) The model allows users to explore and understand the complex consequences of the interaction of a number of transmission vectors, behavioural responses and policy interventions aimed at combating outbreaks.

Insights

Outbreak Mechanisms: Outbreaks are sustained by a combination of new susceptible patient admissions and the tight binding of the three transmission mechanisms.

*Provision of Isolation Facilitie*s: Detecting and isolating patients with *C. difficile* is critical to combating an outbreak. The following are observed:

i) The size of the isolation facility is important, as is the delay before isolation.
ii) The response to changes in isolation capacity and isolation delay are seen to be non-linear.
iii) There is a trade-offs between that capacity and the delay before isolation takes place: lower isolation capacity can be compensated for by lower delay.

Improved Cleaning: the model allows improvements to bed, toilet and hand cleaning to occur as a behavioural response to the appearance of an outbreak. The following are observed:

iv) The response to these changes are seen to be non-linear.
v) Those individual responses are found to have little effect, as the feedback loops created by the other transmission vectors 'take up the slack'. Only combinations of all three are effective.

Length of Stay: Has a comparatively insignificant effect on outbreak dynamics.

Occupancy Level: Has a comparatively insignificant effect on outbreak dynamics.

Reduction in antibiotics use: A reduction in prescription in the general population can be a significant factor in combating outbreaks.

Dr. David C. Lane
London School of Economics
18th February 2009