Modelling the spread of a pandemic

TakeAIM Winner 2018:
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Pandemic flu is one of the world's most dangerous risks: very likely and potentially devastating. Controlling a pandemic depends on understanding and being able to predict how one might spread. For an infectious disease like flu that is transmitted directly from person to person, we might expect that, in general, infection is more likely to spread between cities close together than those far apart. However, the way we choose to measure distance between two cities can profoundly affect the predicted disease dynamics.

The simplest view of distance is "as-the-crow-flies" – the direct distance measured in a straight line between two cities. This has been used with success in mathematical models to explain past disease spread, including the 2009 swine flu pandemic, and predict future behaviour. But humans don't tend to travel in straight lines. Instead, our routes are more likely determined by where roads are, especially in the US where over 90% of trips under 500km are driven, so measuring distance along roads may make more sense.

We replace direct distance with road distance to produce improved mathematical models for pandemic spread. Our research using 2009 swine flu pandemic data from the US shows that road distances are better able to explain the pandemic spread than direct distances. Furthermore, our new model predicts that infection reaches mountainous areas later and populous urban centres, like New York City and Los Angeles, earlier. These differences could be crucial in the event of a pandemic in deciding when and where to implement control strategies.

The Smith Institute, enabled by the generous sponsorship of our leading corporate partners, ran the TakeAIM competition in 2018 to make visible the crucial role that mathematics will increasingly play in all aspects of our lives. The competition was open to undergraduate and postgraduate students working in the mathematical sciences. First prize was £1,250 of Apple vouchers, with nine runners-up each receiving £100 of Amazon vouchers.