

Role of Movement and Dispersal on Disease Dynamics and Evolution with Applications to Influenza and Other Diseases

A new A/H1N1 influenza (flu) strain was identified in Mexico City on April 2009. Within weeks 590 confirmed cases with 26 deaths had been reported in Mexico; 140 cases in Canada; 403 in 38 states across the USA; and about 1500 cases in twenty-five nations in Europe, Canada, New Zealand, and Asia. The preliminary reports suggested that the 2009 A/H1N1 outbreak bore similarities to 1918 H1N1 flu outbreak and the WHO pandemic alert classification quickly rose from level 3 to 5. Recent past pandemics have exhibited dynamics where the initial outbreak was followed by a second wave the first driven by what appeared to be a mild virulent strain in the spring followed by a more explosive outbreak in the fall. Advances in vaccines, antiviral drugs, and improved health practices and services since these past epidemics can help slow the spread of this potentially deadly disease. Advances in disease surveillance, particularly those following the SARS epidemic and the tragic events of 9/11, are being used to track influenza morbidity and mortality while our ability to conduct timely influenza tests has expanded to the point that we can now quickly identify specific strains. The explosion in mathematical modeling, along with real-time data collection and analysis, gives us new tools to evaluate a vast number of intervention possibilities as the epidemic unfolds.

These frequent invasions and global epidemic outbreaks motivate our study of the role of dispersal in disease dynamics. Modeling dispersal in general, must be tied in to specific scientific questions of interest but unfortunately such an approach often does not lead to simple dynamical systems (broadly understood to include stochastic processes). In fact, the incorporation of relevant biological or sociological processes often leads to potentially high dimensional nonlinear dynamical systems. Here, we introduce simplified versions of these models in order to highlight their role in applications. Several approaches will be illustrated in the context of real or potential outbreaks including the Mexican “flu” outbreaks.

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