

Infectious Disease Dynamics

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Report from the organisers:

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State of the art

January 1, 2013, marked the 20th anniversary of the start of the 6-month *Epidemic Models* programme, held in the Institute's first year. This program was very influential in shaping the research field of infectious disease dynamics from its mostly mathematical initial development in the early and mid-twentieth century, and notably in the nineteen-seventies and eighties, to its current breadth and depth. In the following 20 years, Infectious Disease Dynamics has matured into a rich and highly multi-disciplinary research field, aimed at understanding the dynamics, control and intervention effects of human and animal infections, both fundamentally and as applied to relevant public health concerns. Not only has the number and diversity of researchers in this field grown tremendously, but also the tools used, data available, and questions studied, have changed and matured. For example, there is now much better understanding of the way in which various characteristics of individuals, populations and infectious agents -- such as genetic composition, age, social interaction, life history, location -- influence, and are influenced by, the dynamics of infectious diseases. Data, mathematical and statistical methods and computational tools, have evolved accordingly. For example, genetic, immunological, social, contact, spatial, ecological and movement data are increasingly collected because analysis of models has shown the importance of the corresponding factors. These evolutions have brought an increased understanding of key processes and mechanisms, and stronger ties to veterinary and human public health decision making.

Goals and topics

At the time of the original Newton Institute meeting, many of the participants had a mathematical background, and many met regularly at other gatherings of mathematical biologists, or in their respective mathematical fields. In the last 20 years this position has changed substantially. In fact, most of the people now contributing to the field have a non-mathematical background, even many of those contributing new theoretical advances (or at least instigating such advances). Many researchers from diverse areas have been drawn to the field, for various reasons related to publication success, societal relevance and funding possibilities. This has resulted in a dichotomy where interaction and collaboration are concerned: the people most interested in the biological insight and public health 'versus' those interested primarily in the mathematical understanding and methodology. This is detrimental for real progress.

Our short programme had four main goals:

- to take stock of progress in the last twenty years, following the original Newton meeting; to assess where we are today and provide a synthesis;
- to set the agenda for future research: to determine the main challenges, both in understanding & public health needs and in methodology;

- to resolve the dichotomy that has grown; to foster collaboration and a new generation of young talented researchers with the aim of starting to address some of the challenges identified above, through a programme of concrete research activities;
- to take a systematic look at the use of models to inform public health decisions, and to analyse where and why models fail in their predictions (learning from past performance).

Programme structure

The programme opened with a one-week workshop (19-23 August 2013). This workshop was by invitation only and the participants were 100 researchers from very diverse backgrounds and at different career stages. We attracted a large proportion of the foremost researchers in their respective corners of the infectious disease dynamics field. Many had not attended the same meeting in recent years, or interacted directly, or even at all. At the workshop, we invited 46 of the participants each to give a presentation of 30 minutes, the topic of which was prescribed by the organisers. For the first 1.5 days, the speakers were asked to address 20 years of progress in their topic. For this we paired up a prominent researcher from the original Newton programme in 1993 and a promising researcher from a “post-Newton” generation. The next three days were devoted to looking forward. We asked similar pairs of researchers, and the occasional singleton, to address what they saw as the current and future challenges and directions in the particular topic we had selected for them.

The main part of the programme involved about 30 researchers in residence. For this, the organisers had made a selection where we balanced area of expertise, state of career, gender and country. Of course, quality of work in their area and willingness to interact with others were prime overall criteria.

The programme was a mix of (in)formal lectures at the end of almost every day, and discussion meetings at the end of the morning of almost every day. The discussion meetings addressed topics that had emerged from the workshop as especially in need of more interaction for progress. In addition, there was a short hands-on course on phylodynamic methods, and a lively pair of lectures and public debate on the topic of badgers and bovine tuberculosis. There, two experts presented the state of knowledge, culminating in an article in the Sunday Times.

Outcomes and achievements

At the workshop, the sessions on the first 1.5 days were devoted to broad topics: stochastic, deterministic and statistical methods, linking models to data, evolution, veterinary epidemiology, social networks, public health, and ecology. Sessions in the vision for the future addressed: design of experiments and statistical inference, stochastic methods, deterministic methods, social and spatial contact structure, evolution of virulence and resistance, phylodynamics, multi-host and multi-agent systems, immune-epidemiology, decision-making in public health, priorities for HIV, for malaria and for neglected tropical diseases. The workshop ended with a long lecture by Sir Roy Anderson (Imperial College) who provided his vision on the use of models for public health and the future needs for, and potential contributions of, the field to public health policy.

All lectures of the workshop combined provide a unique documentation of the state of the art and future direction of the field. They were all recorded and are available for viewing on the Institute web site (give link?).

Publications

The discussion sessions led to the idea for a special issue of the journal *Epidemics*. This issue will be guest-edited by five of the participants, and contain approximately 20 short contributions in a fixed format, giving an overview of the main challenges in 20 different areas of the field. The contributions will have authors from among the long-term and visiting participants, as well as from the workshop participants and beyond. In all cases, the authors have not collaborated in these combinations before. The idea is that the present generation of young scientists is provided with a well-argued set of excellent challenges to address. The issue will appear in 2014.

The discussion sessions also gave rise to ideas for a summary of the nature and methods of our field, as well as its state of the art and future directions, aimed at public health policy makers and a more general scientific audience. This review paper is in preparation and will be submitted to a major highly visible general science journal before the end of 2013.