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Editorial: Using models to fight disease: HIV and Ebola

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Animals and plants evolved sex to fend off parasitic infections. Now look where it has got us (1).

The natural and social history of our species has, in large part, been the story of our struggle against disease and understanding the nature of this struggle has been one of the great scientific triumphs of the last century. The natural history of infectious disease takes many and varied forms. The Black Death in Europe killed up to 200 million people over a period of 400 years from 1346 to 1671 (2). The influenza epidemic, at the end of the First World War, killed an estimated 50 million people, about half of them in three months between October and December of 1918 (3). Now we are faced with two major threats from viral diseases: Over the last 30 years HIV has spread across the world and continues to plague us. Over the last 3 months the hemorrhagic fever caused by the Ebola virus has spread across West Africa killing thousands of people. If we are to contain HIV in the long-run and Ebola, hopefully, in a much shorter time, this will depend on our ability to understand the nature of the threat and the strategies of the disease causing organisms.

In this issue of the Quarterly we discuss several important issues related to HIV and Ebola. Alex Welte asks: "When is the best time to start HIV-positive people on anti-retroviral therapy (ART)?" Carel Pretorius discusses what impact early treatment for HIV might have on the AIDS related epidemic of tuberculosis (TB). Rein Houben explores this further, showing ways in which mathematical modelling can support and improve TB control in high HIV prevalence settings. Lucio Tolentino and Wim Delva examine some important but difficult issues around the use and need for agent based models in understanding the spread and control of HIV. Wolfgang Preiser brings us right up to date with the immediate and daunting challenge of dealing with Ebola.

Models of HIV and TB have provided important insights into the likely course of the HIV-pandemic and the potential impact of early treatment (4) as well as the impact of HIV and the control of HIV on TB in Africa (5). Now the United Nations Joint Programme on HIV and AIDS (UNAIDS) is promoting a policy of immediate treatment for all those infected with HIV (6). While the earlier studies have all shown that ending AIDS is technically feasible, doing this will depend on good science, the development of sound strategies, but above all on political will and commitment.

Alex Welte makes the case for immediate treatment for all those who are infected with HIV. While acknowledging that much more needs to be understood about the potential problems if treatment adherence is poor, if drug resistance develops, about toxicity and other long-term side effects of ART, and about the impact on the health system, the evidence is clear that immediate treatment gives infected people their best prognosis, will bring the epidemic to an end most rapidly, and will reduce the burden on the health services. What we need now is to develop new, imaginative and creative ways to deliver ART to all the 30 million people in need, ensure that the supply chain is strong, that stigma and discrimination can be dealt with, that high levels of compliance can be achieved and that the virus can be fully suppressed in infected people.

Even before the epidemic of HIV took hold, TB was one of the major killers of people in Africa. Carel Pretorius shows that ART for people infected with HIV will not in itself achieve long-term TB control goals. The problem is that ART reduces the likelihood of people developing TB, but only by about 60% so that the eventual elimination of TB will depend on greatly strengthening TB case detection and treatment for all those at risk including those who are not infected with HIV.

Even in our modern scientific culture it remains difficult for mathematicians to communicate effectively with epidemiologists, epidemiologists with clinicians and clinicians with those who make policy. But communicate we must, and Houben uses recent work on modelling TB in high-HIV settings to argue for better co-ordination between the modelling community and key stakeholders, including advocates, health policymakers, donors, and national or regional finance officials. Only an active dialogue among these key players will ensure that new results are effectively communicated and new policy-relevant questions are swiftly addressed.

Mathematical models can be of many kinds. They can be very simple models based on our intuitive understanding of disease transmission, they can be very simple relationships based on dimensional analysis and arguments, they can be compartmental models in which infections flow from one compartment to another, they can be cohort models in which one follows a cohort of individuals as they progress through stages of disease, or they can be agent-based models in which one creates a

population of people, each with individual risk factors and characteristics, to see how the disease spreads. The art of good modelling then is to balance the quality of the data, against the level of detail in the model while keeping the questions to be answered clearly in mind. Tolentino and Delva outline the power but also the challenges associated with developing agent-based models of the HIV epidemic.

On August 8, 33 weeks into the longest, largest, and most widespread Ebola outbreak on record, the World Health Organization (WHO) declared the epidemic to be a Public Health Emergency of International Concern (7). Preiser discusses the scale and nature of the epidemic which most experts expect to get worse before it gets better. The sadly belated response to Ebola, which the world community may have seriously underestimated, reminds us of the importance of strengthening the field response to such outbreaks, of the need for much better surveillance, patient care, contact tracing and infection control. Where all of these are in place, as is happily the case in South Africa, a substantial epidemic is unlikely to take hold. But this reminds us that we neglect good public health systems at our peril.

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