The role of cattle markets in disease transmission

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1 Background

Mathematical models of infectious diseases are being increasingly used to inform policy decisions. The advantages of such models are that multiple control options can be rapidly tested and compared, without the risks and costs associated with field experiments. However, for such models to be practically useful tools generally requires detailed data, both in terms of populations and epidemiology.

In early 2001, an outbreak of foot-and-mouth (FMD) disease occurred in the United Kingdom for the first time in over thirty years (1). Mathematical modellers were consulted at an early stage during the outbreak and provided policy advice to help control the epidemic (2-3). The ability of such models to make accurate predictions was facilitated by the availability of highly resolved demographic and infection data. In the UK, an annual livestock census records the location and species composition of all livestock farms in the UK whilst individual cattle movements are recorded via the Cattle Tracing System (CTS). This allows mathematical modellers to construct networks to simulate the risk of disease spread between farms via livestock movements (4).

Almost 3/4 of these livestock movements go through cattle markets and therefore markets may play a key role in the early stages of disease outbreaks. However the risk associated with markets has never been quantified and little is known about the potential for amplification of transmission on markets.

2 The project

In recent work (in preparation) we have analysed the potential for disease transmission through the livestock movement network and have considered two extreme cases regarding the role of markets:

1. A movement through a market is treated in the same way as a direct movement between farms (and therefore markets play no role in disease transmission).

2. Complete mixing occurs at a market. If a market becomes infected then *all* movements off that market can infect the destination farms with equal probability.

These extremes lead to drastically different epidemic sizes.

In this project we consider including a bio-security parameter, α that will dictate how transmission of markets is determined, and transition through the two extremes. A low value of α would correspond to the situation where all herds on a market were kept in isolation before being transported to their destination, thereby minimising the risk of disease spread within a market. As α increases this corresponds to an increase in mixing between different herds, resulting in an increased risk of transmission. This project will therefore investigate the effect of bio-security in markets upon the risk of epidemics occurring, as well as the epidemic size, duration and geographic extent of these outbreaks. Data are available from the CTS and these data will be incorporated into the model and diseases with different parameters can be explored.

3 Outcomes

This 3 month project complements other research at Warwick, both in Complexity and Mathematics and Life Sciences. During the 3 months, the student will gain a thorough understanding of network epidemic models whilst tackling a novel question, providing the student with an excellent foundation in epidemiological modelling.

Only the level of coding taught during the Complexity MSc is a prerequisite for this project. The model will be built in Matlab and depending on progress

may be recoded in C or similar to allow for more intensive simulations to be carried out.

4 References

1. Anderson I (2002). Foot and Mouth Disease 2001: Lessons to be Learned Enquiry. The Stationary Office, London.

2. Keeling MJ, Woolhouse MEJ, Shaw DJ, Matthews L, Chase-Topping ME et al. (2001). Dynamics of the 2001 UK foot and mouth epidemic: stochastic dispersal in a heterogeneous landscape. Science 294: 813-817.

3. Ferguson NM, Donnelly CA, Anderson RM (2001a). Transmission intensity and impact of control policies on the foot and mouth epidemic in Great Britain. Nature 413: 542-548.

4. Robinson and Christley (2007) Exploring the role of auction markets in cattle movements within Great Britain, Preventive Veterinary Medicine 81: 2137