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Comparison of alternatives to passive surveillance to detect foot and mouth disease incursions in Victoria, Australia

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ABSTRACT

This study aimed to evaluate strategies to enhance the early detection of foot and mouth disease incursions in Australia. Two strategies were considered. First, improving the performance of the current passive surveillance system. Second, supplementing the current passive system with active surveillance strategies based on testing animals at saleyards or through bulk milk testing of dairy herds. Simulation modelling estimated the impact of producer education and awareness by either increasing the daily probability that a farmer will report the presence of diseased animals or by reducing the proportion of the herd showing clinical signs required to trigger a disease report. Both increasing the probability of reporting and reducing the proportion of animals showing clinical signs resulted in incremental decreases in the time to detection, the size and the duration of the outbreak. A gold standard system in which all producers reported the presence of disease once 10% of the herd showed clinical signs reduced the median time to detection of the outbreak from 20 to 15 days, the duration of the subsequent outbreak from 53 to 42 days and the number of infected farms from 46 to 32. Bulk milk testing reduced the median time to detection by two days and the number of infected farms by six but had no impact on the duration of the outbreak. Screening of animals at saleyards provided no improvement over the current passive surveillance system alone while having significant resource issues. It is concluded that the most effective way to achieve early detection of incursions of foot and mouth disease into Victoria, Australia is to invest in improving producer reporting.

1. Introduction

Foot and mouth disease (FMD) is one of the most infectious diseases of domestic livestock (OIE, 2012). FMD is endemic in two-thirds of the world (Grubman and Baxt, 2004; Kompas et al., 2015) where it causes annual losses of US$6.5–21 billion (Knight-Jones and Rushton, 2013). Increasing international movements and trade present an on-going threat to FMD-free countries. In the past 15 years, there have been a number of outbreaks of FMD in previously free countries despite the application of stringent quarantine measures. These outbreaks resulted in estimated financial losses of more than US$1.5 billion (Knight-Jones and Rushton, 2013) and substantial disruption to the international livestock trade (Blayney et al., 2006)

In the face of the continuing threat of FMD introduction, early detection of an incursion is of particular importance because the longer the time to detection and the larger the size of the outbreak at detection, the more difficult is the task of disease eradication (Carpenter et al., 2011; Matthews, 2011). A common form of surveillance used to detect disease incursions is passive surveillance; the observation and reporting of clinical signs of disease in animals by animal health professionals, para-professionals, animal owners, producers, processors and others across the livestock industries (Hoinville, 2011). Key observation points for livestock include the farm, the market/saleyard and the abattoir. Passive surveillance tends to detect diseases associated with unusual or obvious clinical signs. While it has its limitations in terms of providing representative information on populations, in timeliness of detection and in having poor sensitivity, it can be a very effective method of identifying new and emerging diseases (Langstaff, 2008). Previous qualitative studies have also shown that the time between first clinical appearance of disease and the actual reporting of that

Abbreviations: CVO, Chief Veterinary Officer; FMD, foot and mouth disease; GSAT, general surveillance assessment tool; IP, infected premises; PCR, polymerase chain reaction.

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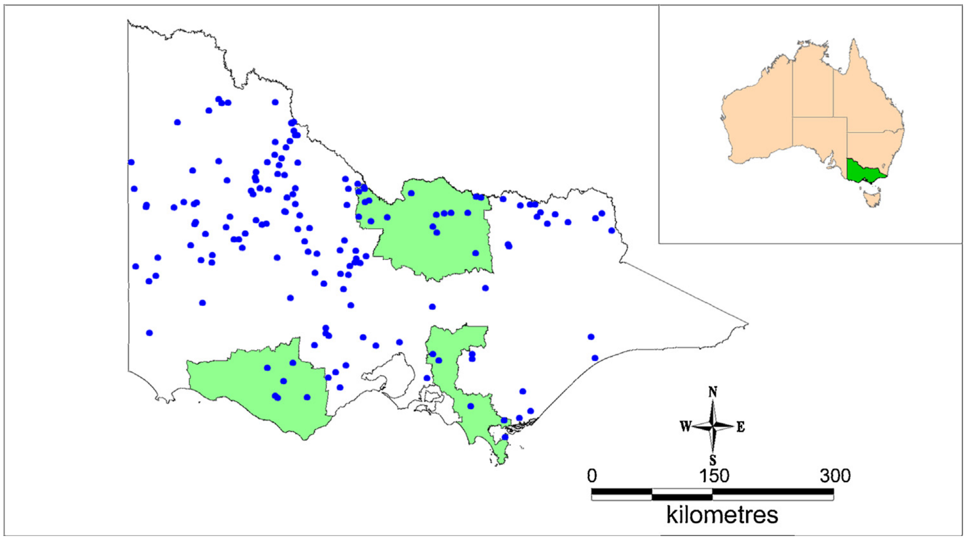

Fig. 1. Map of Victoria (the study area) showing major dairying areas (shaded areas) and the location of smaller pig farms (•).

disease by farmers is often too long, resulting in extensive spread of the disease (Elbers et al., 1999; Elbers et al., 2010). Reporting of disease by producers is limited by a number of factors including inability to recognise the disease (Hopp et al., 2007), the potential deleterious impact of reporting disease on the individual farm through quarantine, stamping out, etc. (Elbers et al., 2010) and a lack of trust in government (Palmer et al., 2009; Elbers et al., 2010). Any actions that could overcome these barriers to reporting could well be effective in enhancing the efficacy of passive surveillance for detecting disease incursions.

The performance and reliability of the passive surveillance 'system' in Australia has been of concern for a number of years, largely owing to reductions in government expenditure on agriculture and a reduction in the veterinary services in rural areas (Nairn et al., 1996; Frawley, 2003; Matthews, 2011). Similar concerns have been expressed in other countries including the United States (Bates et al., 2003) and The Netherlands (Klinkenberg et al., 2005).

A recent review of Australia's preparedness for FMD (Matthews, 2011) found that there is a strong possibility that an incursion of FMD may not be readily detected due to a range of factors. Modelling studies in Australia (Martin et al., 2015; East et al., 2016) have indicated that expected times to detection would be 20–33 days with an upper 90th confidence interval of 22–47 days, depending on region. The predicted delay to detection is similar to those observed in recent outbreaks in other countries (Anderson, 2002; Bouma et al., 2003; Yoon et al., 2013). It is therefore of interest to examine whether potential exists to improve time to detection through introducing active surveillance, using new methods of surveillance or enhancing the existing passive surveillance system.

Saleyards and markets have been recognised as important amplifying points for FMD because of their potential facilitate rapid spread of infection over wide areas (Mansley et al., 2003; Animal Health Australia 2014a). Active surveillance using real-time detection systems to identify FMD at saleyards was proposed by Bates et al. (2003) as a way to prevent dissemination of disease through transport of infected animals away from the saleyard. Hernández-Jover et al. (2011) estimated the sensitivity of the current surveillance system in place at Australian pig saleyards and abattoirs for detecting FMD as no more than 0.35 indicating that potential for improvement to saleyard surveillance exists.

New methods of surveillance may arise through development of new technologies and one example of this is the development of bulk milk testing for FMD (Reid et al., 2006; Thurmond and Perez, 2006). Foot and mouth disease virus is detectable in the milk of infected cows for 1–3 days before clinical signs of infection appear (Blackwell et al., 1982; Reid et al., 2006). This observation provides potential to detect dairy cows infected with FMD prior to the appearance of clinical signs; an earlier time point than possible through passive surveillance. The tests developed allow for the detection of FMD virus in samples diluted up to 1 in 10^4 (Reid et al., 2006) and this would allow testing of bulk milk samples after arrival at a milk processing facility. Given these developments in PCR diagnostic technology for detecting FMD virus in milk samples, the feasibility of testing milk samples for FMD is of particular interest because sampling schemes to collect bulk milk are already in place for a number of quality assurance programs.

This paper aims to examine the potential for improving early detection of FMD in Victoria, Australia through:

1. Enhancing the performance of the current passive surveillance system through education campaigns that increase producer awareness of disease and the capacity to recognise diseased animals
2. Active surveillance programs at saleyards
3. Active surveillance using bulk milk testing

To do so, we used a spatially dynamic epidemiological model for FMD in Australia (Garner and Beckett, 2005) to assess the impact of these programs on the time to detection before an FMD outbreak is reported and the size and duration of the outbreak at the time of reporting. Issues influencing the effectiveness of these strategies are also discussed.

2. Materials and methods

2.1. Study area

The study area for this project is the state of Victoria (Fig. 1) where the temperate, climate and higher rainfall allow more intensive farming than much of the rest of Australia. Victoria is Australia's largest food and fibre exporting state and is the centre of Australia's dairy production. It has 9.2% of the national beef cattle population, 63.6% of the dairy cattle population, 24.8% of the pig population and 21.3% of the sheep population (ABARES, 2014). The study area contains 42,279 farms with FMD susceptible species categorised into one of eight different types (see below) for the purposes of