

An overview and comparison of surveillance methods to demonstrate freedom from classical swine fever

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Abstract

Classical swine fever (CSF) is a porcine disease of economic significance, and one of six diseases for which the World Organisation for Animal Health (OIE) grants official recognition for freedom from disease. Currently most published literature only concerns surveillance to detect CSF if known to be present in a region, rather than surveillance to demonstrate its absence. We reviewed current CSF surveillance methods in four countries that are free of CSF (Australia, the USA, Denmark, and the UK), to compare these with Australia's surveillance methods for demonstrating CSF freedom. Information on each country's pig industry and markets, and surveillance programs for CSF was collected from government published reports, websites, and journal articles. All four countries had surveillance programs appropriate to their circumstances for demonstrating freedom from CSF, with important differences in the populations targeted and the number of samples collected. The USA's surveillance program was notable for its detailed targeting of high-risk populations, and Denmark's program for its routine surveillance in healthy, low-risk populations. Key actions proposed to enhance Australia's CSF surveillance based on this information included providing more CSF-specific material to generate increased awareness amongst veterinarians and producers, considering the incorporation of CSF-specific testing into current surveillance protocols, and increasing serosurveillance in high-risk populations.

Introduction

Classical swine fever (CSF) is a highly contagious viral disease of pigs caused by the agent CSF virus, a member of the genus *Pestivirus* in the family *Flaviviridae* (1). Infection with CSF virus may result in acute disease with high mortality within 1-4 weeks, or a chronic disease form that can last for weeks to months (1,2). As with other pestiviruses, *in utero* infections can cause different outcomes depending on the stage of gestation at the time of infection: piglets may be aborted, stillborn, persistently infected, or normal and non-viraemic (2). CSF virus may be transmitted oronasally, transplacentally, and orally through the feeding of contaminated animal tissues (swill feeding) (2). The incubation period ranges from 2-15 days for acute infections, up to three months for chronic infections, or several months for persistently infected piglets (3). Because of the variety and non-specific nature of clinical signs and post-mortem lesions, diagnostic testing is required for a definitive diagnosis of CSF

(1). There is no evidence that CSF poses a risk of infection in any species outside of the *Suidae* family. However, it is a disease of economic importance – the presence of CSF virus within a country has major implications for international trade (1) and may seriously impact production (4). It has been estimated that if CSF were to become endemic in Australia, the loss of gross annual income would be 9% across the national pig industry, and up to 37% in certain regional industries (4).

Australia received official recognition of CSF freedom from the OIE in May 2015 (5) but some opportunities for improvement were identified in the assessment of the official dossier (6). These included improving awareness of CSF, and reviewing surveillance methods, including diagnostic testing algorithms (6).

The objective of this study was to compare Australia's surveillance methods to demonstrate freedom from CSF with the approaches used in other similar countries, to identify opportunities for improvement. This review also aimed to establish whether there is an international consensus on the most effective methods to demonstrate freedom from CSF – although all countries included have official OIE CSF-free status, it was not known to what extent the approach to surveillance may differ according to characteristics such as industry, geography, and international trade markets.

Materials and methods

The countries selected for consideration in this study in addition to Australia were the USA, the UK, and Denmark, on the basis of the following inclusion criteria:

- Free of CSF for >10 years, and official freedom recognised by the OIE;
- Information on animal disease surveillance policies freely available from government departments and industry bodies; and
- CSF is considered a disease of importance.

The selected countries also had key differences from Australia in terms of geographical context, international trade patterns, presence of porcine diseases, and risks for pig production, which allowed assessment of whether such factors influence CSF surveillance policy.

The key terms used in searching for information included: CSF, classical swine fever, hog cholera, European swine fever, surveillance, and monitoring. The databases used to search for information were Discovery, PubMed, Web of Science, and Google Scholar. However, most information was sourced from reports published by pig industry bodies and the relevant government departments responsible for animal disease health and surveillance – the Australian Government Department of Agriculture and Water Resources (DAWR), the US Department of Agriculture (USDA), the UK’s Department for Environment, Food and Rural Affairs (DEFRA), and the Danish Veterinary and Food Administration (DVFA). Direct contact was also made with the DAWR, USDA, DEFRA and DVFA to obtain and verify information. Agricultural census data was used to establish an idea of industry size and structure. Information on diagnostic tests used for surveillance was acquired from government reports, or directly from the relevant National Reference Laboratories. In all cases, an effort was made to use information from within the last three years to ensure relevant and timely comparisons.

Results and discussion

Passive surveillance measures

In all four countries, CSF is a notifiable disease, with notification required upon suspicion of CSF (5,7-10). All countries had a CSF-specific contingency plan and some form of exotic disease awareness program, but CSF-specific educational materials were only identified for the USA (7-11). In addition to deliberate campaigns to generate awareness, relatively recent outbreaks of CSF in the UK (in 2000), and in countries directly bordering the USA and Denmark (Germany in 2008 and Mexico in 2009) may have increased consciousness of CSF as a differential diagnosis in these countries (12). However, the effectiveness of awareness strategies can be more objectively assessed by the annual number of notifications, presented in Table 1. This information shows that the number of suspected CSF cases notified in Denmark, the UK, and the USA are comparable to those in Australia.

Table 1. Number of disease investigations for CSF notifications per year by country, based on latest data available. All investigations were negative.

Australia (13)	One in 2014, three in 2013, four in 2012
Denmark (7,14,15)	Seven in 2015, Ten in 2014, five in 2013
UK (16)	Five in 2015, six in 2014, zero in 2012
USA (17)	14 in financial year ending 2010

Active surveillance measures

Denmark is unique among the four countries because it routinely tests for CSF in apparently healthy pig populations. The DVFA conducts random serological sampling of a maximum of 2% of sows at slaughter to screen for CSF, and also collects tissue samples for CSF testing from selected swine carcasses submitted for autopsy (7). No evidence was found to suggest that any of the other three countries

mandate CSF-specific testing in apparently healthy, low-risk populations in the absence of suspicion of CSF. All four countries conduct serological risk-based surveillance, although their varying approaches to defining risk result in significantly different numbers of samples collected (Table 2). Both Australia and the USA conduct CSF testing in populations at higher risk of CSF incursion. In Australia, this occurs as part of the Northern Australia Quarantine Strategy (NAQS), which conducts annual surveys of feral pigs for a range of diseases, including CSF (5). The USA’s active surveillance program targets 27 ‘high-risk’ states. In these states the USDA screens for CSF in eligible tissue samples from all sick pigs sent to local veterinary diagnostic laboratories, and pig carcasses condemned at slaughter due to erysipelas or septicaemia. The USDA also maintains additional serological surveillance requirements in slaughter establishments in Florida, Texas, and Puerto Rico, and sites of swill feeding (10). Both DEFRA and the DVFA collect serological samples for CSF testing from all boars at semen collection centres, and certain pigs intended for export outside of the EU, as part of export certification requirements (7,9). Although Denmark collects the greatest number of samples (Table 2), largely due to its randomised sampling, the USA has the most targeted risk-based surveillance program. However, given the USA permits certain high-risk activities (swill feeding and importation of live pigs), the emphasis on risk-based surveillance may therefore be to compensate for this increased risk (10).

Table 2. Number of samples routinely collected for CSF testing as part of active surveillance per year by country.

Australia (13)	Serological samples from feral pigs: 293 in 2013, 529 in 2012, 485 in 2011
Denmark (7)	Serological samples from 2% of sows at slaughter and for export requirements: 28,399 in 2015, 30,844 in 2014, 41,726 in 2013; plus tissue samples from 250 carcasses in 2015
UK (16)	Serological samples for export requirements: 2,882 in 2015, 2,979 in 2014, 4,636 in 2012, 4,248 in 2011
USA (17)	Serological samples: 14,666 in financial year ending 2010, comprising samples from sick pigs: 3,431, condemned carcasses: 2,753, feral swine: 2,560, high-risk herds: 5,922.

Diagnostic tests used for surveillance

All countries had a similar laboratory testing protocol for CSF exclusions, performing virus isolation and a real-time reverse transcriptase polymerase chain reaction (rRT-PCR) [based on published test protocols (18,19)]. The serological protocols were similar or the same for both exclusions and routine surveillance in all countries: including screening with an antibody enzyme-linked immunosorbent assay (ELISA) and use of a confirmatory test with the ability to differentiate CSF from other pestiviruses (the neutralising peroxidase linked assay in Australia, Denmark and the UK, and the immunoperoxidase assay in the USA) (10). Thus any differences in sensitivity and specificity of CSF surveillance systems between countries are more likely to emanate from the

overall structure of the system, rather than from differences in the tests used. For example, Denmark and Australia have similar serological testing protocols, but these are applied to different populations – while Australia screens samples from feral pigs, Denmark screens samples from healthy pigs, as well as AI centres and export abattoirs, resulting in a larger number of samples collected, thus increasing their system's sensitivity.

Key actions for Australia

1. Improved awareness of CSF. Although Australia appears to have adequate numbers of notifications by international standards, Australia could improve awareness of CSF through producing material specific to CSF for distribution amongst producers and veterinarians, and presenting it in a range of media. Awareness-raising articles have been included in industry and veterinary publications (20), and presentations have been made to Australian pig veterinarians (Hamilton, pers. comm. 2016).
2. Incorporating CSF-specific testing into current surveillance. Australia could implement routine sampling similar to the USDA's program, testing for CSF in pigs showing specific clinical signs, or in carcasses condemned due to erysipelas or septicaemia. This would be particularly useful in cases where secondary infections may mask the symptoms of CSF. A national surveillance case definition for CSF is under development to improve submission of samples from lower-likelihood cases (Hamilton, pers. comm. 2016). Australia could also implement surveillance in apparently healthy pig populations as is done in Denmark – for example, random sampling for CSF in pigs sent to slaughter. This surveillance method would facilitate detection of low virulence strains (as these tend to elicit less obvious clinical signs) but may be cost prohibitive.
3. Risk-based surveillance in domestic pig populations. Although swill feeding is illegal in Australia, the greatest risk of CSF incursion may be from feeding CSF contaminated material to domestic or feral pigs. If this is considered to be an unacceptable risk, surveillance could be targeted towards pigs in peri-urban areas where there may be a higher likelihood of illegal swill feeding (Queensland, New South Wales, and Victoria), and sites where feral pigs are prevalent (New South Wales, Queensland, and the Northern Territory). Further research would be required to ascertain the risk profile of particular herds in such areas.

However, the benefits of increasing CSF surveillance will differ in each country according to the size of their pig export market and the risk of CSF incursion. For example, Denmark and the USA have significant pig export industries while Australia exports only 11% of its pork production (7,10,21). It is likely that the more extensive surveillance requirements of Denmark (in healthy populations) and the USA (in risk-based populations) are present to support their wider international market access. Additionally, as Australia does not share land borders with other countries, and manages the risk of an incursion by only allowing pork products to be imported from

CSF free countries, it may have a lower risk of CSF incursion. Thus, although Australia's CSF surveillance system results in fewer samples tested annually than those of the USA, UK, and Denmark, this appears to be appropriate given the reduced domestic pig population and risk of CSF incursion. While Australia could increase the number of samples it routinely collects for CSF surveillance, it probably does not need to be of the same scale as in the USA and Denmark.

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