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ASSESSING MANAGEMENT OPTIONS TO REDUCE THE ANIMAL WELFARE IMPACTS ON BROILER FARMS IN HIGHLY PATHOGENIC AVIAN INFLUENZA EPIDEMICS

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1 Foreword

In responding to an emergency animal disease (EAD) outbreak, it is generally acknowledged that the welfare of animals is an important consideration. In recent overseas responses aimed at disease eradication, it has been necessary to devote significant resources to the management of welfare issues. In Australia, it is recognised that such commitment of resources is necessary and appropriate, given the need to act responsibly and ethically in an animal disease emergency.

This collaborative study between officers of the Australian Government Department of Agriculture, Fisheries and Forestry and the chicken meat industry, which was facilitated by Animal Health Australia (AHA), has important findings for animal welfare management during a response to an incursion of highly pathogenic avian influenza (HPAI) in Australia. AHA members had previously agreed to the principles for animal welfare management during an EAD response.

The purpose of this study was to develop guidance for Chief Veterinary Officers relating to animal welfare compensation, and to further investigate the implementation of disease control principles and their effect on animal welfare and its management. The work was greatly assisted by the information and advice provided by the Australian Chicken Meat Federation and key industry personnel.

This study explores the extent to which chicken meat properties are at risk of encountering welfare problems in response to an HPAI incursion in Australia and assesses the effects and impacts of implementing different welfare management strategies on farms. It also considers potential effects on the overall disease control response, because limited resources may need to be diverted from control activities to manage animal welfare problems.

The aim of animal welfare management during an EAD response is to ensure:

1. destruction of the minimum number of non-infected animals
2. maintenance of acceptable animal welfare standards for all livestock species, without compromising disease control and eradication efforts
3. effective management of animals within restricted areas and elsewhere, based on sound risk assessment, to avoid later welfare problems
4. best use of available resources (finances, personnel, infrastructure, feed and water)
5. movement and other disease control measures are applied to minimise the likelihood of slaughter being necessary due to animal welfare issues.

The study has helped test the proposed principles for animal welfare management in an EAD response; such a response will be managed according to the terms of the Emergency Animal Disease Response Agreement (EADRA). Under EADRA arrangements, this will enable the alleviation of animal welfare issues that might occur as a consequence of restrictions imposed for disease control. The author, Dr Sam Hamilton and respective industry contributors are to be commended for the quality and usefulness of this study which represents a valuable addition to Australia's EAD preparedness arrangements.

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CHIEF EXECUTIVE OFFICER

2 Executive summary

Australia's agreed guidelines for the management of highly pathogenic avian influenza (HPAI) epidemics allow for the movement of broilers (meat chickens) to slaughter from Restricted Areas (RAs) after negative surveillance assessments have been conducted on the flock (referred to here as process slaughter). All meat from broilers in RAs must be cooked to inactivate the virus. However, there are several uncertainties about how this policy could be implemented during an outbreak. For instance:

- occupational health and safety concerns may affect the availability of labour
- access to abattoirs within Control Areas (CAs) may limit the ability to slaughter broilers in processing plants
- the ability to upscale abattoir throughput to accommodate accelerated processing may be limited
- the logistics of conducting the required surveillance in poultry flocks prior to slaughter have not been determined for HPAI epidemics
- there are limited plants available for commercially cooking poultry meat and these may not be in CAs. The flexibility permissible in AUSVETPLAN permit conditions requires clarification.
- the volume of heat treated meat may exceed a company's markets and this may be exacerbated by a general reduction in demand for chicken meat during a HPAI outbreak.

Absolute movement restrictions will have adverse impacts on the welfare of broilers, because if they are delayed from being moved to slaughter they can be at risk of developing animal welfare problems from overcrowding. Industry has advised that broiler farms that are delayed from sending birds to slaughter for three or more days would be at risk of welfare problems, regardless of whether they were kept in sheds or free-range conditions. The extent of such potential animal welfare problems are not well characterised for outbreaks of emergency poultry diseases, but areas with high densities of broiler farms (e.g. the Sydney region and the Mornington Peninsula), are likely to be more vulnerable than other parts of Australia simply because there are more broiler farms expected to be within RAs in these areas.

This paper describes the development and analysis of epidemiological and economic models to evaluate strategies to manage potential adverse animal welfare outcomes for broilers on farms. This study simulated outbreaks of HPAI in the Mornington Peninsula and Sydney regions. The implications of six disease control strategies were considered:

- Baseline control strategy (BCS), involving the quarantine and the culling of infected premises (IPs), imposition of three km RA and 10 km CA zones around IPs and dangerous contact premises (DCPs), movement restrictions, tracing, and passive and active surveillance
- Expanded zones control strategy (EZCS), involving similar assumptions to the BCS but with larger disease control zones
- Pre-emptive culling of DCPs, within a three km RA (BCS+PEC), involving similar assumptions to the BCS but with additional culling of DCPs
- Pre-emptive culling of DCPs, within a 10 km RA (EZCS +PEC), involving similar assumptions to the EZCS but with additional culling of DCPs

- Pre-emptive culling of all farms within a three km RA (BCS+3km cull), involving similar assumptions to the BCS but with additional culling of all poultry farms within 3kms of IPs and DCPs
- Pre-emptive culling of all farms within three km of IPs with a 10 km RA (EZCS+3km cull), involving similar assumptions to the EZCS but with additional culling of all poultry farms within three km of IPs and DCPs.

Five alternative animal welfare strategies were examined for each disease control strategy:
- WS1 'do nothing' to investigate the potential scale of the problem
- WS2: complete culling of broiler farms that develop potential welfare problems (i.e. those overdue for pickup for three or more days)
- WS3: Process slaughter of broilers due for their next pickup after surveillance, assuming that farms would be completely depopulated when they are due to send their next batch of birds to slaughter
- WS4: Culling of all broilers in RAs that are under 28 days old and process slaughter of older broilers after surveillance, assuming that farms would be completely depopulated when they are due to send their next batch of birds to slaughter
- WS5: Pre-emptive culling of all broiler farms in the RA, prioritised for those due to send birds to slaughter soonest, as a proxy for those with those approaching highest stocking densities.

Outputs from the epidemiological model included the number of infected farms, epidemic duration, number of farms and birds with welfare problems, number of farms and birds culled for animal welfare purposes and the number of farms and birds process slaughtered. In this study, the median of these distributions is taken as the 'likely case' and the upper bound of the 95% probability interval is taken as the 'worst-case scenario'

Variable costs of implementing each welfare strategy were compared using a partial budgeting approach in a spreadsheet model. These costs incorporated:
- The cost of culling broilers on farms with welfare problems (including disposal)
- Compensation for destroyed broilers on farms culled for welfare purposes
- The cost of testing of broilers in RAs before movement to slaughter.

Welfare issues in poultry are thought to occur most likely in housed (including free-range) broiler farms due to overcrowding as a result of movement restrictions preventing turn off. Notwithstanding the need for an enterprise Approved Animal Welfare Plan, the consensus view of industry experts was that very little can be done by farm management to significantly avert overcrowding and associated welfare issues other than to remove stock. If broiler farms are delayed to move birds to slaughter for three or more days, industry advised that overcrowding may put birds at risk of animal welfare problems.

To further explain this generalisation it is recognised that whilst it is possible to slow down the growth of the birds to a small extent, the overall impact is not significant in these rapidly growing animals. The possible tactics for retarding growth are either not practical in the circumstances or in themselves are likely to result in adverse welfare outcomes. For example:

- diet dilution is impractical (existing feed in silos prevents the formulation and delivery of different specification diets to affected farms)

- rationing of feed to flocks used to ad lib feed will result in welfare problems

- appetite suppression (e.g. through water restriction, or dietary modification) would also probably result in adverse welfare outcomes.

Although free-range broilers are likely to be housed indoors during outbreaks, it is recognised that their indoor stocking densities will be lower than intensively-reared broilers. It is possible that free-range farms may take longer than three days to develop welfare problems. As a proportion of farms in the Mornington Peninsula area are kept under free range conditions, this study may have overestimated the number of farms with developing welfare problems. However, given the large differences in the effectiveness and costs of each welfare strategy, this is unlikely to change conclusions about the relative effectiveness of each welfare strategy studied here.

The two strategies considered in this study to alleviate overcrowding were culling (involving humane killing and disposal on farm with compensation) and process slaughter (movement under permit for slaughter at an abattoir to enter the food supply without compensation). Industry advised that birds over 28 days were most appropriate for slaughter and commercial utilisation. The studies demonstrated that the welfare management component of a disease response can be significant.

Results indicate that although the median number of infected farms was similar between regions, the Mornington Peninsula is more vulnerable to larger outbreaks of HPAI than Sydney, in the worst-case scenario.

Disease control strategies with larger disease control zones (e.g. the EZCS) led to a marginal reduction in the number of infected farms under the worst case scenario. However, these led to large increases in the number of farms and birds with animal welfare problems in the likely and worst cases and cannot be recommended unless there is suspicion or evidence of extensive spread.

Although the animal welfare strategies studied did not affect epidemiological outputs in the likely case, their effectiveness in managing potential broiler welfare problems in the RA varied greatly. Welfare strategies that allowed for the process slaughter of broiler farms (i.e. WS3) were able to reduce the median number of broiler farms and birds with welfare problems to zero and were the cheapest in terms of the costs considered here, by around $867,000 and $7.9 million in the median case and worst-case for the BCS, respectively, when compared with the next cheapest strategy (WS4). When smaller disease control zones were implemented, these strategies required 430,000 extra birds to be process slaughtered from nine farms in the Mornington Peninsula in the median case. This may be achievable, although one must consider that this throughput would have to be achieved in the first eight days after diagnosis of the index case. However, under the worst case scenario 5.9 million additional birds would have to be slaughtered in the first 60 days after diagnosis. This period is quite long when compared with the production cycle of broiler farms.

This is because (a) flocks in the original RA are processed out sooner, (b) the model assumes that, while broiler farms in RAs will not be restocked after depopulation, broiler farms in CAs and other non-infected areas are allowed to routinely restock during outbreaks, and (c) because RAs can expand into these previous CAs and non-infected areas when new IPs and DCPs are detected, restocked farms can become affected by movement restrictions in an escalating scenario.

It may be unrealistic to manage potential broiler welfare problems where large disease control zones are implemented. Process slaughter strategies would require the early processing of an additional two million more birds in the likely scenario, again within the first eight days after diagnosis. When the worst-case scenario is considered, 8.9 million extra birds would require processing in 49 days. On face value, however, these demands may be unrealistic.

The likely number of farms with potential welfare problems was also reduced to zero when the process slaughter strategy was supplemented by the culling of broiler farms less than 28 days old (WS4). This strategy reduced the number of additional birds requiring processing by 40 to 50% for both the BCS and EZCS.

However, sensitivity analysis studies showed that the process slaughter strategies are unlikely to be successful if their implementation is delayed until 14 days after the diagnosis of HPAI. If these process slaughter strategies cannot be implemented early in an outbreak, the culling of all broiler farms in RA zones appears to be the next most viable option (WS5). Although it reduced the likely number of welfare farms to zero for the BCS it resulted in substantial welfare-associated costs in the order of $1.8 million in the likely scenario and $22.7 million in the worst-case scenario.

3 List of Abbreviations

BCS	Baseline control strategy
BCS+3km cull	Baseline control strategy with pre-emptive culling of all populated farms within three km of IPs and DCPs
BCS+PEC	Baseline control strategy with pre-emptive culling of dangerous contact premises
CA	Control Area
DCP	Dangerous Contact Premises
EADRA	Emergency Animal Disease Response Agreement
EZCS	Expanded zones control strategy
EZCS+3km cull	Expanded zones control strategy with pre-emptive culling of all populated farms within three km of IPs and DCPs
EZCS+PEC	Expanded zones control strategy with pre-emptive culling of dangerous contact premises
EZCS+WS3+delay	A strategy designed for sensitivity analysis to investigate the impacts of a 14 day delay on the implementation of process slaughtering on WS3.
EZCS+WS4+delay	A strategy designed for sensitivity analysis to investigate the impacts of a 14 day delay on the implementation of process slaughtering on WS43.
HPAI	highly pathogenic avian influenza
IP	Infected Premises
NAIVE	National Avian Influenza Vaccination Expert Advisory Group
RA	Restricted Area
Ro	Basic reproduction ratio
SP	Suspected Premises
WS1	Welfare Strategy 1, 'do nothing'
WS2	Welfare Strategy 2, complete culling of broiler farms that develop potential welfare problems (i.e. those overdue for pickup for three or more days)

WS3	Welfare Strategy 3, process slaughter of broilers due for their next pickup after surveillance, assuming that farms would be completely depopulated when they are due to send their next batch of birds to slaughter.
WS4	Welfare Strategy 4, pre-emptive culling of all broilers in RAs that are under 28 days and process slaughter of older broilers after surveillance, assuming that farms would be completely depopulated when due for their next pickup.
WS5	Welfare Strategy 5, pre-emptive culling of all broiler farms in the RA, prioritised for those due to send birds to slaughter soonest, as a proxy for those with those approaching highest bird densities.

Introduction

Movement restrictions of live poultry are a component of the disease control strategy for highly pathogenic avian influenza (HPAI) listed in AUSVETPLAN.[1] Although movements of poultry would be prohibited unless under exceptional circumstances from Infected Premises (IPs), Dangerous Contact Premises (DCPs) and Suspected Premises (SPs), there are provisions under AUSVETPLAN for broilers (meat chickens) in Restricted Areas (RAs) to move to slaughter under permit (referred to here as 'process slaughter'). This is provided that they come from inspected flocks that are determined free of infection after clinical inspection and diagnostic testing, and that the birds are subject to immediate slaughter in the Control Area (CA) at approved abattoirs. Poultry products must then be subject to heat treatment at approved premises.

However, there are concerns about how this policy could be implemented during an emergency animal disease outbreak. Real and perceived occupational health and safety concerns may affect the availability of labour. Access to abattoirs within CAs may limit the ability to slaughter broilers in processing plants. The ability to upscale abattoir throughput to accommodate accelerated processing may be limited. The logistics of conducting the required surveillance in poultry flocks prior to slaughter have not been determined for HPAI epidemics. There are limited plants available for commercially cooking poultry meat (V. Kite, pers. comm., 2011). It is unclear whether AUSVETPLAN implies that cooking must occur on approved premises within CAs, or whether fresh meat could be moved under permit for cooking at plants outside CAs. The former position is assumed and it is possible that cooking plants may not be incorporated within CAs. Finally, the demand for heat treated meat may exceed a company's markets and this may be exacerbated by a general reduction in demand for chicken meat during a HPAI outbreak.

Movement restrictions will adversely affect the welfare of broilers. If broilers are delayed from being moved to slaughter they are at risk of developing animal welfare problems from overcrowding. The extent of potential animal welfare problems are not well understood for outbreaks of emergency poultry diseases, but it is reasonable to assume that areas with high densities of broiler farms (e.g. the Sydney region and the Mornington Peninsula), are more vulnerable than other parts of Australia. This is simply because more broiler farms would be expected to be included in RAs in these areas.

Modelling can be useful to gain insight into the potential impacts of outbreaks of emergency animal diseases. Since 2005, the Department of Agriculture Fisheries and Forestry (DAFF) has developed a simulation model, called AISPREAD, to investigate the potential transmission and control of HPAI in Australia, which has been used in a recent study commissioned by the National Avian Influenza Vaccination Expert Advisory Group (NAIVE) to investigate the use of emergency vaccination. The model captures realistic control strategies (including zone-based movement restrictions) and the production cycles of broiler farms. For this study, it has been extensively modified to investigate the number of broiler farms adversely affected by movement restrictions during outbreaks and to investigate the cost and effectiveness of potential strategies to reduce

[1] Animal Health Australia (2011). Disease strategy: Avian influenza (Version 3.4). Australian Veterinary Emergency Plan (AUSVETPLAN), Edition 3, Primary Industries Ministerial Council, Canberra, ACT. www.animalhealthaustralia.com.au/wp-content/uploads/2011/04/AI3_4-06FINAL16Feb11.pdf

these outcomes. A glossary is provided on page 31 to assist in interpretation of technical terms used in this report.

4 Scope of this project

The scope of the project is to inform signatories to the Emergency Animal Disease Response Agreement (EADRA) cost sharing deed of the potential costs of compensating owners for the culling of broilers for welfare reasons resulting from disease control policy implementation. Although this study focuses on broilers, it is recognised that disease control policies may also have adverse impacts on other poultry enterprises, including specialist pullet producers, hatcheries, layers, meat turkeys and meat ducks. The animal welfare impacts of disease control policies and strategies to manage potential animal welfare problems secondary to movement restrictions on enterprises other than broiler farms are outside the scope of this study. The study did not consider the immediate welfare issues in a standstill, the failure of water, feed and power supplies, bankruptcy, potential difficulties in accessing labour due to real or perceived Occupational Health and Safety concerns during an outbreak, or any other 'black swan' events.

This technical report has been prepared by the Department of Agriculture, Fisheries and Forestry for Animal Health Australia to inform discussions about EADRA. It does not necessarily represent the Australian Government position on potential amendments to EADRA.

5 Objectives

The objectives of this study are to use epidemiological and economic models to:

1. Assess the scale of potential animal welfare problems due to movement restrictions imposed during epidemics of HPAI in the Sydney region and the Mornington Peninsula, in terms of the number of birds and farms affected.
2. Investigate potential for strategies involving pre-emptive culling of broilers and the process slaughter of broilers from RAs to reduce the number of birds and farms with welfare problems and to quantify the potential costs associated with each animal welfare strategy, including compensation for broilers culled for welfare purposes.
3. Make recommendations to Animal Health Australia on ways to minimise the welfare impact and welfare related costs for broilers during HPAI epidemics (including AUSVETPLAN strategy and movement restrictions).

6 Methods

6.1 Description of the epidemiological model

6.1.1 Model assumptions

AISPREAD is stochastic spatial simulation model that represents potential spread of HPAI between farms in the commercial chicken meat, chicken layer, duck and turkey industries in Australia. Because farms are represented individually in the model, it can reproduce production cycles on different types of poultry farms. This is of particular importance to this study because it tracks the age and number of birds on single-aged farms, which will allow the investigation of age-based interventions on broiler farms to address current or anticipated animal welfare concerns.

AISPREAD simulates the transmission of HPAI between farms by ‘local spread’, movements of poultry, and indirect contact (fomite) spread. In modelling spread of infection, it takes into account functional and structural arrangements associated with the operation of the Australian poultry industries (e.g. integrated production and supply arrangements within and between regions, and contact networks associated with service providers). Indirect transmission of HPAI is simulated through 10 different pathways representing transmission via contact networks of service providers (Table 1). The model can incorporate a range of surveillance and control options, including zone-based movement restrictions, to manage an outbreak of HPAI (described in Table 2).

Table 1 List of indirect transmission pathways in AISPREAD.

Feed deliveries	Routine sanitation
Dead bird collection	Used cardboard egg trays
Litter and/or manure collection	Routine vaccination
Day-old chick delivery	Slaughter crews
Litter delivery	Broiler/turkey pickup crews

Table 2 Potential disease control strategies included in AISPREAD.

Passive surveillance	This represents the reporting of suspicious clinical signs to authorities. When farms report infection they become Suspected Premises (SPs), are placed under quarantine and are scheduled for a visit by a surveillance team as part of the emergency response.
Active surveillance by dead bird collection	Active surveillance can occur by the sampling of dead birds from farms within the Restricted Area (RA) and Control Area (CA). This commences four days after the index farm is identified to account for the time required to mobilise personnel and equipment. Dead bird surveillance, where dead birds are collected from selected farms, is set to occur on 50% and 10% of the premises within the RA and CA every seven days.
Active surveillance by surveillance teams	SPs and Dangerous Contact Premises (DCPs) are scheduled for visits by surveillance teams. The number of surveillance teams available can be limited to account for scarce resources.
Diagnostic testing	The sensitivity of surveillance visits and dead bird collection on unvaccinated farms is assumed to be 95% and 93%, respectively. Positive farms become Infected Premises (IPs).
Tracing	Forwards and backwards tracing is performed on all newly identified IPs. This is done by recording all transmission events on infectious farms in a list. Tracing is conducted by searching this list to identify movements of live birds and service providers that were involved in the spread of infection to or from the IP within the 21 days prior to diagnosis. *A priori*, the sensitivity of tracing is assumed to be 95%.
Zoning	RA and CA zones are set dynamically each day in the model as buffer zones or pre-defined areas around IPs and DCPs. Users can vary the radius of RA and CA zones.
Quarantine and movement restrictions	Quarantine and movement restrictions in the model are implemented by turning off specific transmission pathways in the RA and CA, and on SPs, DCPs and IPs, based on AUSVETPLAN guidelines. Of most importance to this study is that under baseline assumptions, SPs, IPs and DCPs are

Table 2 Potential disease control strategies included in AISPREAD.	
	prevented from restocking or moving birds off the farm. Farms in the RA are also prevented from restocking.
Culling, disinfection and decontamination of farms	IPs are scheduled for culling after they are diagnosed. The number of farms on which culling can occur per day can be varied to account for limited resources.
Pre-emptive culling	Pre-emptive culling of DCPs and/or farms within disease control zones can be incorporated in the model. This has implications for the resources allocated to cull farms.
Process slaughter of broilers	Broiler chickens can be permitted to move to slaughter after a surveillance team has visited the farm within 48 hours and results of swabs tested for Influenza A by RT-PCR are negative (Kathy Gibson, pers comm., 2011).[a]
Emergency vaccination	Emergency ring or buffer vaccination of longer lived flocks can be incorporated into the model.
[a] This is consistent with proposed changes to the AUSVETPLAN disease control strategy manual for avian influenza.	

A full description of AISPREAD's design, together with baseline parameters, source code and details of verification and validation studies can be downloaded from the internet.[2]

Several modifications were made to AISPREAD's baseline parameters for this study, based on those used in previous work commissioned by the NAIVE Group and after consultation with the Australian Chicken Meat Federation. These include:

- Increasing the time that fomites remain contaminated from 5 to 6 days.
- Increasing the baseline local spread function to be consistent with the secondary transmission of infection recorded for overseas epidemics of HPAI[3]
- Allowing for local spread to occur until farms are fully depopulated
- Increasing the number of culling teams that are available to 10, and assuming that each team could cull up to 30,000 birds in a day
- Limiting the number of surveillance visits to a maximum of 10 farms per day[4]. Surveillance visits apply only to the investigation of SPs and DCPs. Broiler farms are separately scheduled for surveillance visits under process slaughter strategies.

Broiler farms are assumed to send three batches of birds to slaughter during their production cycle. Those that are prevented from moving birds to slaughter for three or more days after planned peak density are assumed to become at risk of welfare problems in this study for practical purposes. It is acknowledged that birds are kept in natural ventilation, fan assisted ventilation, controlled environment or free-range conditions and that the individual characteristics of each enterprise will affect how long it may take before welfare problems emerge and the actions possible under the Approved Animal Welfare Plan. This is because they affect the planned peak

[2] Hamilton S (2011) Simulating the transmission and control of highly pathogenic avian influenza in the Australian poultry industries. PhD thesis. University of Sydney. https://skydrive.live.com/redir.aspx?cid=7cba973c1831dd97&resid=7CBA973C1831DD97!107&parid=root.

[3] The local spread pathway was calibrated so that the basic reproduction ratio (R_0) or the average number of secondarily infected farms per infected farm would be 3.3 for farms in the Sydney region.

[4] Baldock. C (1992) *Study of resources required to manage selected exotic animal disease scenarios*, Report for the Exotic Animal Disease Preparedness Consultative Council (Exandis).

density and also the capacity of the facility (for example the ventilation system) to cope with the extra bird mass post peak density. Furthermore, during outbreaks, free-range birds are likely to be housed continuously indoors. Relevant assumptions about the timing of activities on broiler farms, culling and process slaughter are presented in Appendix 1.

6.1.2 Population data sources

Demographic data on the characteristics, location and contact networks of chicken meat, chicken layer, duck and turkey farms were obtained from a series of industry surveys conducted in 2005 and 2007. A list of farm types included in the model is presented in Table 3.

Table 3 Different farm types included in AISPREAD.

Industry	Type of farm
Chicken meat	Broiler
	Parent breeder
	Rearer and parent breeder
	Rearer parent breeder
	Grandparent breeder
	Rearer and grandparent breeder
	Rearer grandparent
	Great-grandparent breeder
Chicken egg	Layer
	Pullet and layer
	Pullet
	Breeder
Duck	Grower
	Parent breeder
	Elite breeder
Turkey	Grower
	Parent breeder
	Elite breeder

6.1.3 Introduction scenarios

6.1.3.1 Sydney

For this introduction scenario, it was assumed that HPAI would be introduced into a multi-aged chicken layer or combined pullet and layer farm near Rossmore in the Sydney region and HPAI would not be detected on the initially infected farm until 14 days after it was introduced.

6.1.3.2 Mornington peninsula

A second scenario was developed to investigate an incursion into a multi-aged combined pullet and layer farm near Pearcedale in the Mornington Peninsula. As for the Sydney introduction scenario, it was assumed that HPAI would not be detected on the initially infected farm for 14 days.

6.1.4 Disease control strategies

The animal welfare impacts of six disease control strategies were studied (Table 4). For the basic control strategy (BCS), that the RA and CA zones were set to 3 and 10 km around IPs and DCPs, and movement restrictions would prevent the transport of all birds within RAs to slaughter. Under the expanded zones control strategy (EZCS), the radius of RA was 10 km around IPs and DCPs, and the CA is the entire Sydney or Mornington peninsula region (depending on the outbreak scenario). In this case, if IPs occur outside the initial CA region, additional CA boundaries are drawn within 20 km of IPs. Two strategies also investigated the addition of pre-emptive culling of DCPs to the BCS and EZCS strategies (BCS+PEC and EZCS+PEC, respectively). Two final strategies involved adding the pre-emptive culling of all populated farms within three km of IPs to the BCS and EZCS strategies (BCS+3km cull and EZCS+3km cull). Ring culling has been implemented in the model instead of contiguous culling of adjoining properties because farms are represented as points, not property boundaries, thus complicating the identification of adjoining properties.

Although vaccination can be included in AISPREAD, it was not considered in this study because it had negligible impact on disease eradication outcomes in studies commissioned for the NAIVE group. Also, it is questionable whether administration of inactivated vaccines would be useful for broilers, which are intended to live for only a few weeks after full vaccine-derived immunity is achieved. Vaccination technologies exist which would permit the vaccination of day-old broiler chicks (e.g. fowlpox-vectored H5 vaccines), but these are not registered in Australia. Furthermore, studies indicate that these H7 fowlpox-vectored vaccines may have questionable efficacy against Australian H7 strains.[5] In this study, it is assumed that restocking of farms in RA zones is prohibited.

Table 4 Description of disease control strategies.

Name	Description	Explanation
BCS	Baseline control strategy	Quarantine and the culling of infected premises (IPs), imposition of three km Restricted Area (RA) and 10 km Control Area (CA) zones around IPs and DCPs, movement restrictions, tracing, and passive and active surveillance.
EZCS	Expanded zones control strategy	As for the BCS, but with 10 km RA and CA zones initially involving the entire Sydney or Mornington peninsula region. Where outbreaks occur outside these regions, CA boundaries are assumed to be 20 km.
BCS+PEC	Pre-emptive culling of DCPs, with a three km RA	As for the BCS, but with pre-emptive culling of DCPs.
EZCS+PEC	Pre-emptive culling of DCPs, with a 10 km RA	As for the EZCS, but with pre-emptive culling of DCPs.
BCS+3km cull	Pre-emptive culling of all farms within a three km RA	As for the BCS, but with pre-emptive culling of all populated farms within the RA, i.e. in a three km buffer zone around infected premises (IPs).
EZCS+3km cull	Pre-emptive culling of all farms within three km of IPs with a 10	As for the EZCS, but with pre-emptive culling of all populated farms within a three km buffer zone around IPs and

[5] Bublot, M, Pritchard, N, Swayne, D, Selleck, P, Karaca, K, Suarez, D, Audonnet, J & Mickle, T (2006) Development and use of fowlpox vectored vaccines for avian influenza, *Annals of the New York Academy of Sciences*, 1081 193–201.

Table 4 Description of disease control strategies.		
Name	Description	Explanation
	km RA	DCPs.

6.1.5 Animal welfare strategies

Five potential animal welfare strategies (WS1 to 5) were developed to manage potential animal welfare problems on broiler farms. These are described in Table 5.

Table 5 Description of welfare strategies.		
Name	Description	Explanation
WS1	Welfare Strategy 1 'Do nothing'	Base case to investigate the potential scale of the problem.
WS2	Welfare Strategy 2 Cull on demand	Complete culling of broiler farms that develop welfare problems (i.e. if overdue to send birds to slaughter for three or more days).
WS3	Welfare Strategy 3 Planned process slaughter	Process slaughter of broilers when the next pickup is due, after negative surveillance. This assumes that farms would be completely depopulated when due for their next pickup.
WS4	Welfare Strategy 4 Pre-emptive culling and process slaughter	Pre-emptive culling of all broilers in RAs that are under 28 days old and process slaughter of older broilers after surveillance, assuming that farms would be completely depopulated when due for their next pickup.
WS5	Welfare Strategy 5 Pre-emptive culling in RAs	Pre-emptive culling of all broiler farms in the RA prioritised for those due to send birds to slaughter soonest, as a proxy for those with those approaching highest bird densities.

The implications of all five animal welfare strategies were assessed for the BCS, EZCS, BCS+PEC, EZCS+PEC and EZCS+3km cull disease control strategies for both study areas. Because disease control strategy BCS+3km involves the pre-emptive culling of all farms (including broiler farms) in the RA, only Welfare Strategy 1 was examined.

6.1.6 Model outputs

One hundred epidemics were simulated for each introduction scenario up until HPAI was reported on the initially infected farm on day 14. These 100 epidemics were used, in turn, to investigate each combination of disease control and animal welfare strategies. This matched design increases the comparative power of the study, because it allows the effects of control strategies to be examined between epidemics with the same starting conditions. Simulations were run until infection was eradicated and there were no further farms due for culling.

For each combination of disease control strategy and Welfare Strategy, the following outputs were used for analysis:

- The number of infected farms
- The duration of epidemics
- The number of broiler farms and birds that develop animal welfare problems
- The number of broiler farms and birds from RAs slaughtered in processing plants
- The number of broiler farms and birds in RAs culled for animal welfare purposes.

Because distributions were heavily skewed, outputs were summarized as the median and 95% probability intervals (PI), rather than averages and standard deviations. Here, the median value of these distributions is considered a 'likely' scenario, and the upper bound of the 95% PI (the 97.5% percentile or the 97.5% most extreme value) is described as the 'worst-case' scenario.

For example, the distribution of the number of infected farms in HPAI outbreaks in the Mornington Peninsula for BCS+WS1 is presented in Figure 1. The distribution is positively skewed, meaning it has a long 'tail' on the right hand side of the graph. The average number of infected farms (23 infected farms) may be misleading because it is influenced by a few very large outbreaks, and the median value (3 infected arms) provides a better measure of central tendency of the distribution. Similarly, the 97.5% percentile (117 infected farms) provides a better indication of the extremities of the distribution than the maximum value (154 infected farms), which may be less realistic. Please see Appendix 3 for further information about using means and medians to describe the central tendency of highly skewed distributions.

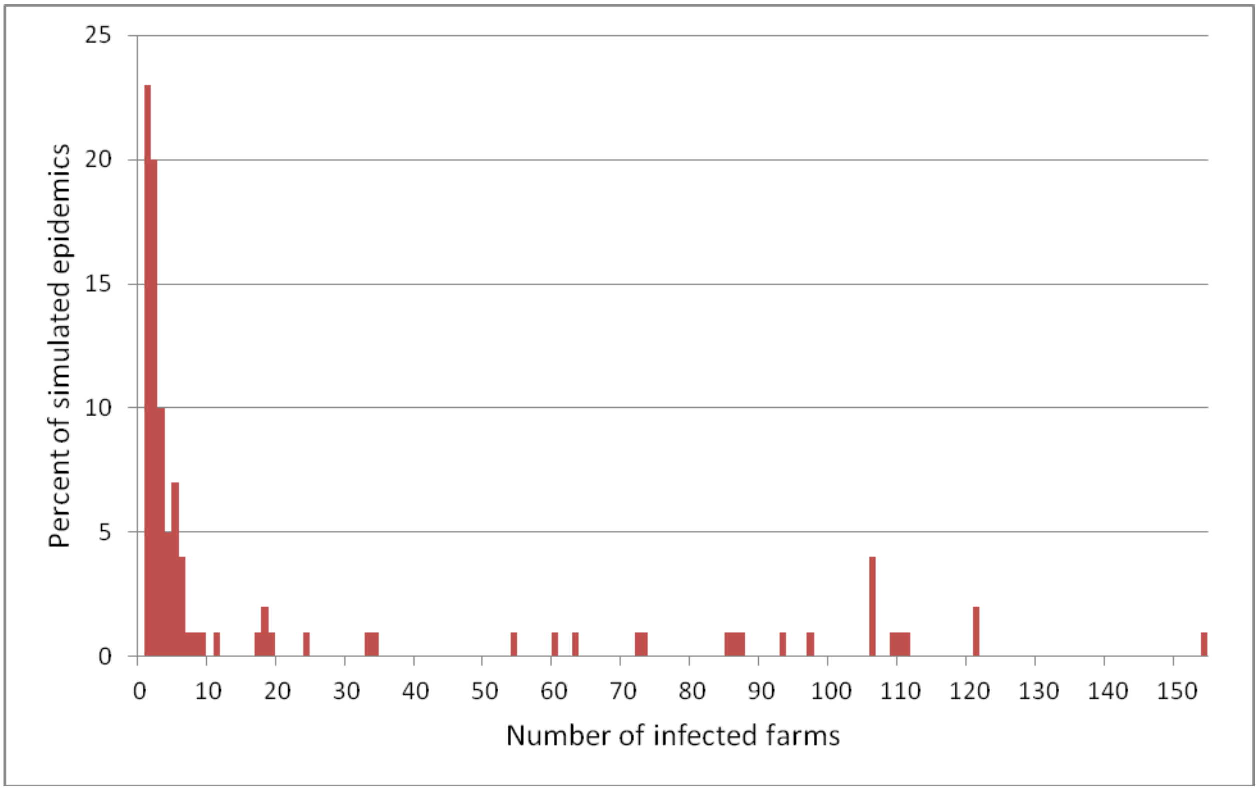

Figure 1 Probability distribution of the number of infected farms for simulated HPAI outbreaks in the Mornington Peninsula where the BCS+WS1 strategy was implemented. In this highly skewed data distribution, most simulated outbreaks infected three or fewer farms, but the largest outbreak infected 154 farms.

6.1.7 Sensitivity analysis

It is likely that process slaughter strategies may not be able to be implemented from day one of a control program. For this reason, a sensitivity analysis was conducted in the Mornington Peninsula introduction scenario for Welfare Strategies 3 and 4 under the EZCS control. For these studies, process slaughter commenced 14 days after HPAI was initially detected (EZCS+WS3+delay and EZCS+WS4+delay). This pessimistic estimate has been made to investigate the impacts of large delays in implementing process slaughter strategies.

6.2 Description of the economic model

A simple spreadsheet economic model was developed to assess the differential costs of different welfare strategies through a partial budgeting approach. Animal welfare costs included:

- The cost of culling and disposal of broilers on farms for welfare purposes
- Compensation for destroyed broilers on farms culled for welfare purposes
- The cost of testing of broilers in RAs before movement to slaughter

A full description of parameter estimates and the rationale for these estimates are presented in Appendix 2.

7 Results

7.1 Epidemiological outputs

There were limited differences in the median number of infected farms (ranging between 3 to 4 farms) and epidemic duration (ranging between 19 to 24 days) across all introduction scenarios, disease control strategies and welfare strategies (Table 6).

No consistent trends could be drawn about the duration of the worst-case scenario outbreaks when disease control and welfare strategies were compared between the Mornington Peninsula and Sydney. However, worst-case scenario outbreaks in the Mornington Peninsula tended to infect more farms than in outbreaks in Sydney. For example, under BCS+WS1, there were 48 (70%) more farms infected in this area compared with the equivalent strategy in the Sydney region.

In the Mornington Peninsula, disease control strategies based on the EZCS (involving larger disease control zones) led to 7 to 20% fewer infected farms and were eradicated 5 to 32% more rapidly in the worst-case scenario. This difference was more profound in the Sydney region, where EZCS-based strategies led to a 48 to 74% reduction in the number of infected farms and were eradicated 3 to 48% more rapidly. However, supplementary disease control strategies, involving pre-emptive culling of DCPs and culling of all farms within a three km radius, did not show consistent or substantial benefits in terms of the number of infected farms or epidemic duration.

For simplicity, the impacts of alternative animal welfare strategies for outbreaks in the Mornington Peninsula are described in this report, because they led to larger outbreaks and consistently led to higher numbers of broiler farms at risk of welfare problems. Results of both the BCS and EZCS disease control strategies are presented because the size of disease control zones had an impact on epidemiological and animal welfare parameters. As supplementary disease control strategies had limited or no substantial benefits on the epidemiological outputs they were not considered further. For completeness, full epidemiological and animal welfare results are presented in Appendix 4 (Tables A3 and A4).

Table 6 Epidemiological outputs for all combinations of disease control and welfare strategies for outbreaks in Mornington Peninsula and Sydney.				
	Mornington Peninsula		Sydney	
Scenario	Infected farms	Epidemic duration (days)	Infected farms	Epidemic duration (days)
	Median (95% PI)			
BCS+WS1	3 (1 to 116)	22 (16 to 88)	3 (1 to 68)	20 (15 to 88)
BCS+WS2	3 (1 to 125)	22 (16 to 78)	3 (1 to 45)	20 (15 to 72)
BCS+WS3	3 (1 to 127)	22 (16 to 74)	3 (1 to 56)	20 (15 to 67)
BCS+WS4	3 (1 to 133)	20 (16 to 69)	3 (1 to 89)	20 (15 to 87)
BCS+WS5	3 (1 to 129)	20 (16 to 68)	3 (1 to 42)	20 (15 to 73)
BCS+PEC+WS1	4 (1 to 123)	23 (16 to 91)	3 (1 to 67)	23 (14 to 76)
BCS+PEC+WS2	4 (1 to 125)	23 (16 to 86)	3 (1 to 60)	21 (14 to 76)
BCS+PEC+WS3	4 (1 to 130)	25 (16 to 83)	3 (1 to 93)	20 (14 to 77)
BCS+PEC+WS4	4 (1 to 133)	20 (16 to 82)	3 (1 to 100)	20 (14 to 75)
BCS+PEC+WS5	3 (1 to 129)	21 (16 to 77)	3 (1 to 71)	20 (14 to 57)
BCS+3km_cull+WS1	3 (1 to 127)	20 (16 to 76)	3 (1 to 53)	19 (14 to 58)
EZCS+WS1	3 (1 to 108)	21 (16 to 66)	3 (1 to 23)	20 (15 to 78)
EZCS+WS2	3 (1 to 110)	22 (16 to 55)	3 (1 to 19)	20 (15 to 45)
EZCS+WS3	3 (1 to 112)	22 (16 to 63)	3 (1 to 21)	20 (15 to 55)
EZCS+WS4	3 (1 to 114)	20 (16 to 54)	3 (1 to 23)	20 (15 to 47)
EZCS+WS5	3 (1 to 120)	21 (16 to 62)	3 (1 to 15)	20 (15 to 38)
EZCS+PEC+WS1	3 (1 to 114)	24 (16 to 62)	3 (1 to 35)	21 (14 to 65)
EZCS+PEC+WS2	3 (1 to 114)	23 (16 to 63)	3 (1 to 30)	20 (14 to 52)
EZCS+PEC+WS3	4 (1 to 112)	22 (16 to 64)	3 (1 to 37)	19 (14 to 57)
EZCS+PEC+WS4	3 (1 to 107)	22 (16 to 62)	3 (1 to 42)	20 (14 to 51)
EZCS+PEC+WS5	4 (1 to 107)	23 (16 to 73)	3 (1 to 20)	21 (14 to 48)
EZCS+3km_cull+WS1	3 (1 to 112)	20 (16 to 68)	3 (1 to 24)	19 (15 to 56)
EZCS+3km_cull+WS2	3 (1 to 105)	20 (16 to 63)	3 (1 to 28)	19 (15 to 59)
EZCS+3km_cull+WS3	3 (1 to 115)	20 (16 to 72)	3 (1 to 23)	19 (15 to 58)
EZCS+3km_cull+WS4	3 (1 to 113)	20 (16 to 59)	3 (1 to 16)	19 (15 to 39)
EZCS+3km_cull+WS5	3 (1 to 116)	21 (16 to 70)	3 (1 to 24)	20 (15 to 52)

7.2 Animal welfare outputs

7.2.1 The potential scale of the problem

The EZCS had greater animal welfare impacts compared with the BCS when no strategies were put in place to manage the welfare of broilers on farms in RAs (i.e. under WS1). Under the EZCS, 36 farms and 2.2 million broilers had animal welfare problems in the median case, compared with 10 farms and 466,000 broilers under the BCS (Figures 2 and 3, respectively). In the worst-case scenario, both disease control strategies had more profound animal welfare impacts, with 98 and 146 farms and 7.8 and 11.6 million birds affected under the BCS and EZCS, respectively.

7.2.2 Comparison of welfare strategies

Welfare strategies involving the process slaughter of broilers in RAs (WS3 and 4) consistently reduced the median number of broiler farms and broilers with potential welfare problems to zero (Figures 2 and 3, respectively). However, under the worst-case scenario, these strategies led to 36 to 37 farms and 2.4 to 2.9 million birds at risk of potential welfare problems under the BCS and EZCS, respectively. This is because farms designated as IPs can also develop welfare problems due to movement restrictions associated with quarantine, which is a particular problem for larger outbreaks where culling resources are more likely limited the destruction of infected farms. In the median case, this strategy involved the process slaughter of nine farms and 430,000 birds under the BCS and 32 farms and 2.2 million broilers under the EZCS (Figures 4 and 5, respectively).

When total costs were considered, WS3 was consistently the least expensive, with welfare costs in the order of $23,000 and $86,000 in the median case (Figure 6) and $176,000 and $267,000 in the worst-case for the BCS and EZCS, respectively. Because no birds were culled for welfare purposes, there were no associated welfare compensation costs.

When this strategy was adapted to include culling of younger broiler farms, median welfare-associated costs were increased to $0.9 million for the BCS and $3.6 million under the EZCS (Figure 6). Under the worst-case scenario, costs were increased by $7.9 million and $10.7 million for both strategies. These increases in cost were mostly due to welfare compensation costs of $0.5 million for culled birds under the BCS, where a median of six farms and 355,000 broilers were culled for welfare purposes (Figures 7 and 8, respectively). Costs were substantially increased under the EZCS because of the cost of welfare culling and compensation for broiler farms less than 28 days of age. For instance, there was a median of 1.5 million broilers culled on 18 farms, costing an additional $2.1 million. However, the culling of younger flocks reduced the median number of birds and farms process slaughtered from RAs to five farms and 221,000 birds under the BCS and 19 farms and 1.0 million birds under the EZCS (Figures 4 and 5, respectively).

Welfare Strategy 5, involving the culling of all broiler farms in the RA, was also successful in reducing the median number of broiler farms and broilers with potential welfare problems to zero under the BCS (Figures 2 and 3). It was less successful under the EZCS, and reduced these outputs to three farms and 98,000 birds. However, in the worst-case scenario it led to a very limited reduction of the number of farms and birds with potential welfare problems for both the BCS and EZCS, which resulted in a median of 13 and 46 farms being culled for welfare purposes, respectively. Median welfare costs were $1.8 million for the BCS (made up of welfare compensation costs of $1.1 million) and $8.3 million for the EZCS (of which $6.3 million was welfare compensation costs) (Figure 6). Under the worst-case scenario, these costs increased to $22.7 million and $30.6 million for both of these disease control strategies.

When farms were culled after they were three or more days overdue for slaughter (WS2), the number of farms and broilers at risk of welfare problems were very high and were comparable to the ‘do nothing’ approach (WS1) (Figures 2 and 3). The median numbers of farms and birds culled for welfare purposes was 10 farms and 440,000 birds (for the BCS) and 33 farms and 2.2 million birds (for the EZCS). Median and worst-case scenario costs were comparable to those for the WS5.

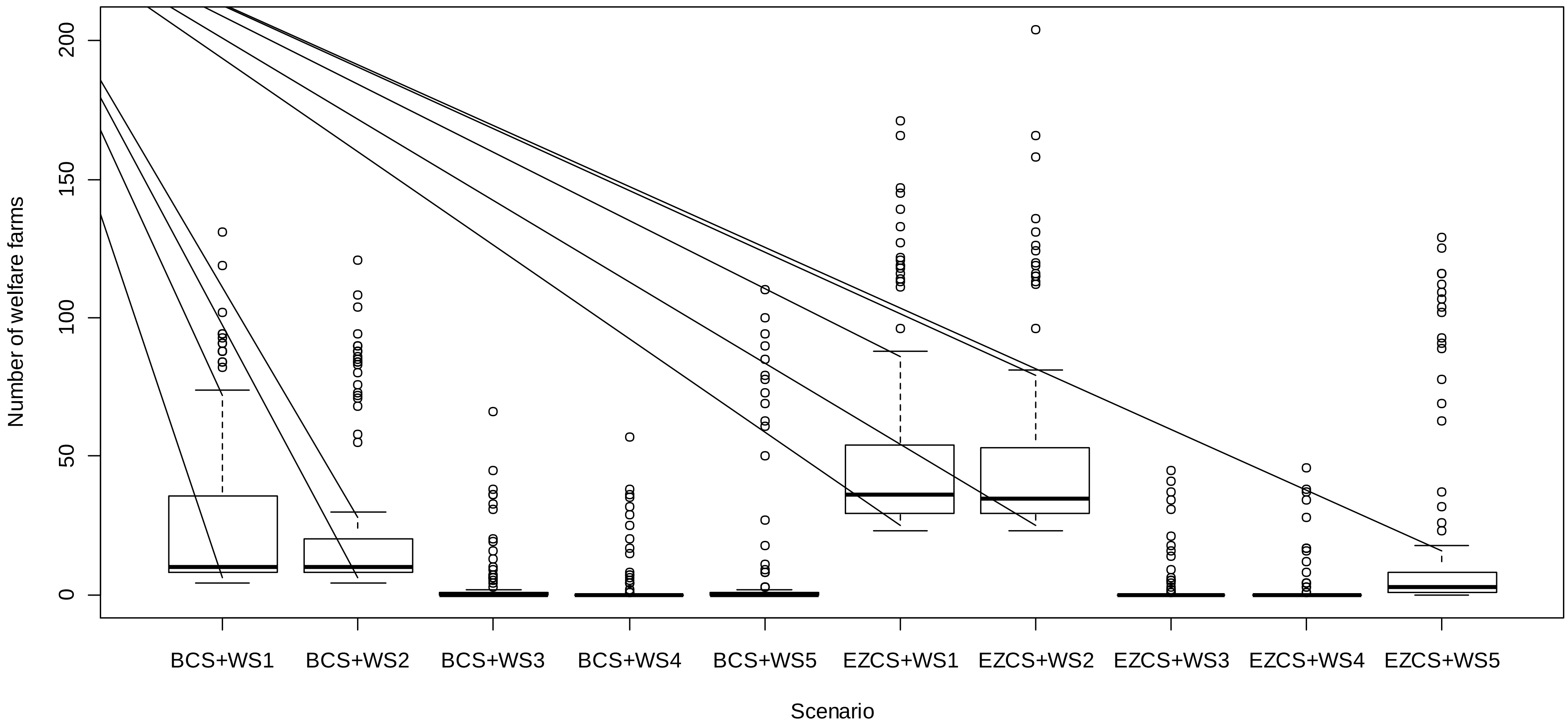

Figure 2 Number of broiler farms with welfare problems under Welfare Strategies 1 to 5 (WS1 to 5) for the baseline control strategy (BCS) and expanded zones control strategy (EZCS). Assistance in interpreting box-and-whisker plots can be found in Appendix 3.

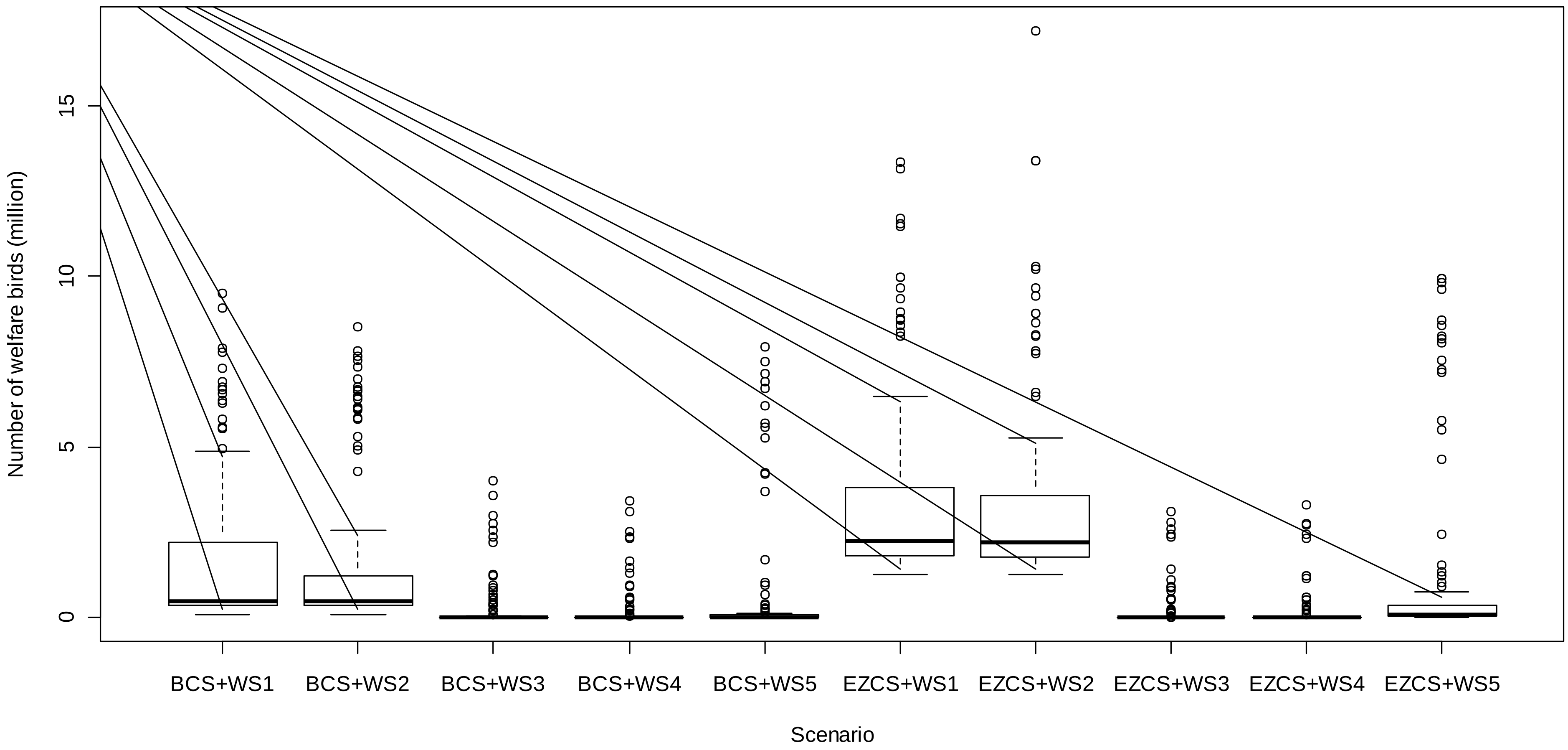

Figure 3 Millions of birds with welfare problems under Welfare Strategies 1 to 5 (WS1 to 5) for the baseline control strategy (BCS) and expanded zones control strategy (EZCS).

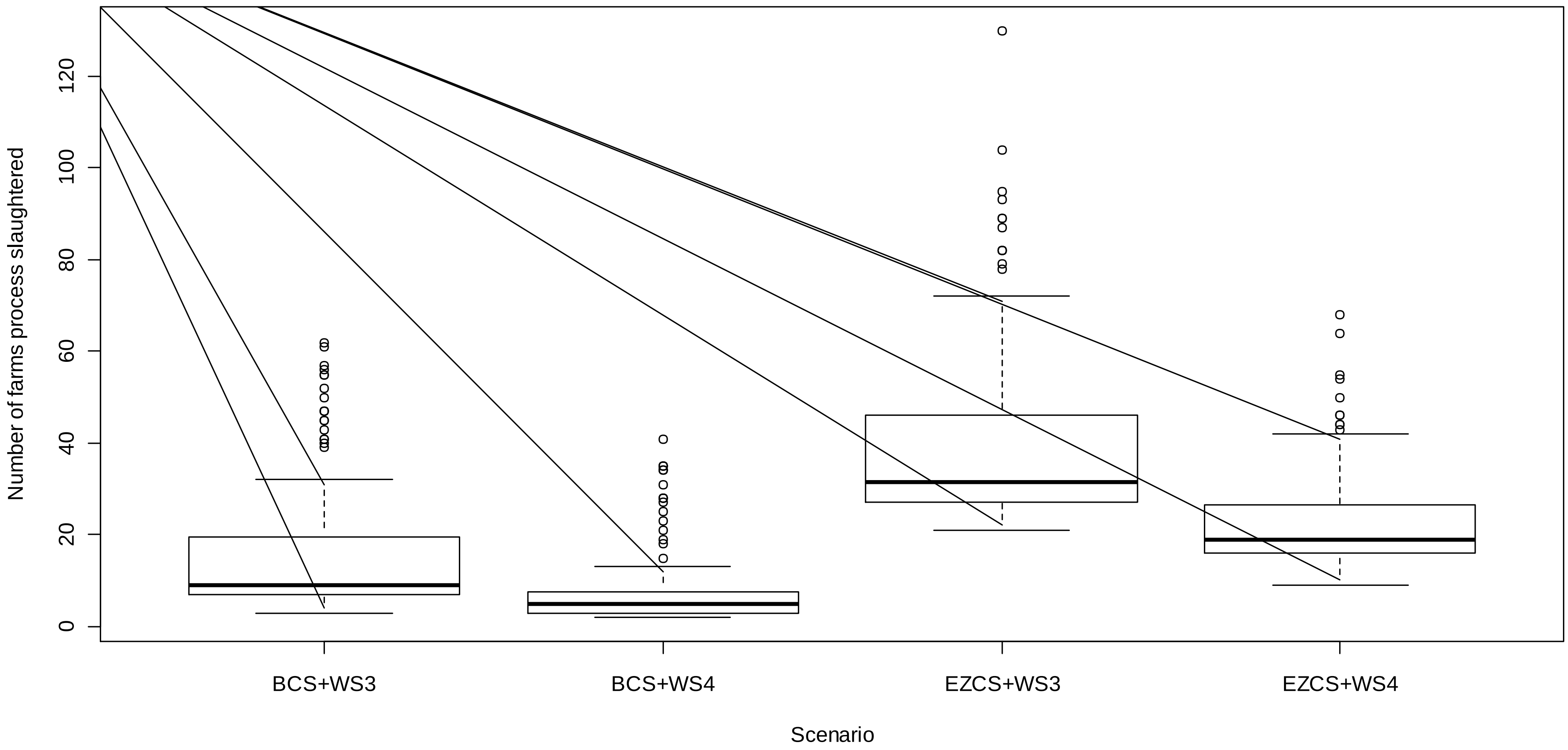

Figure 4 Number of broiler farms process slaughtered under Welfare Strategies 3 and 4 (WS3 and 4) for the baseline control strategy (BCS) and expanded zones control strategy (EZCS).

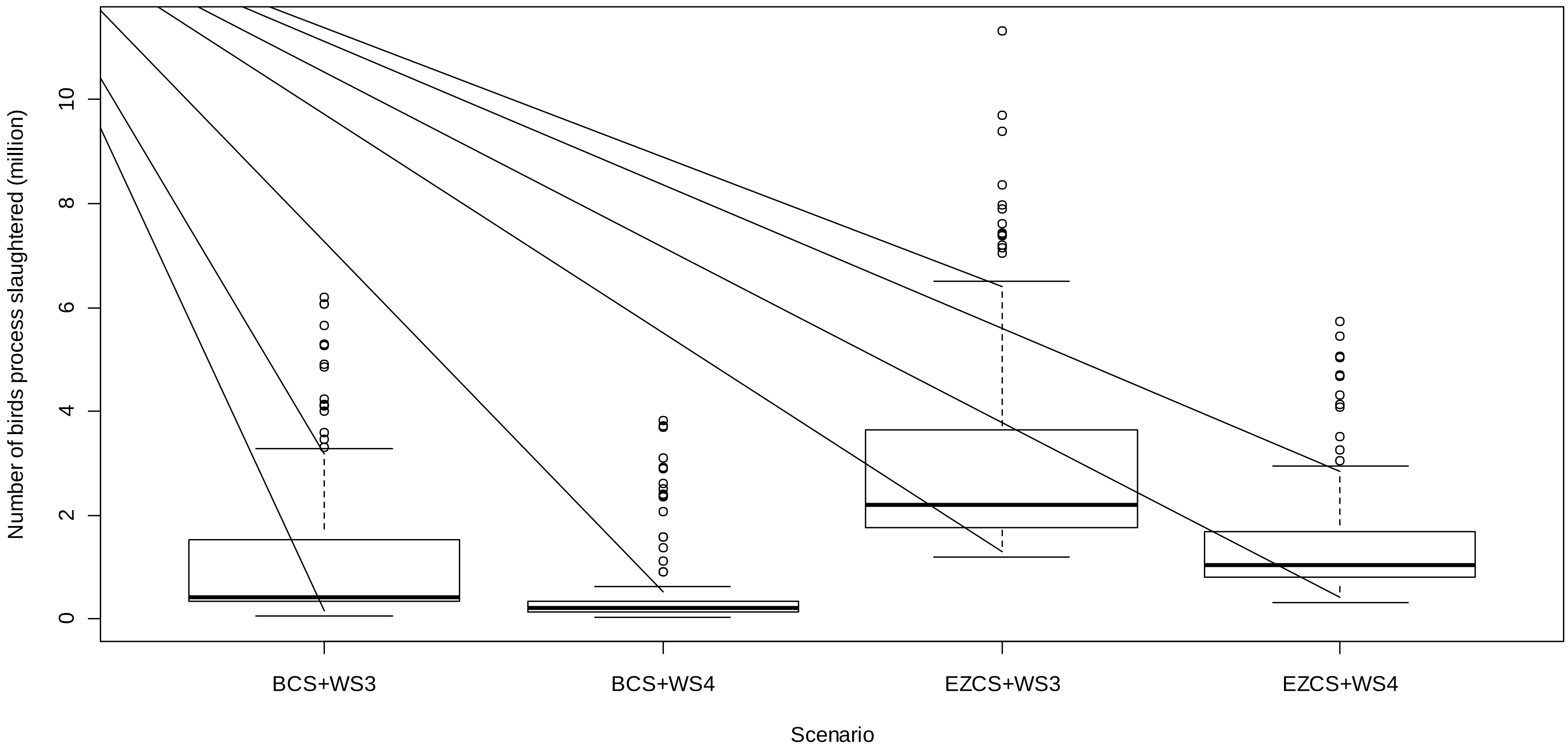

Figure 5 Millions of broiler birds process slaughtered under Welfare Strategies 3 and 4 (WS3 and 4) for the baseline control strategy (BCS) and expanded zones control strategy (EZCS).

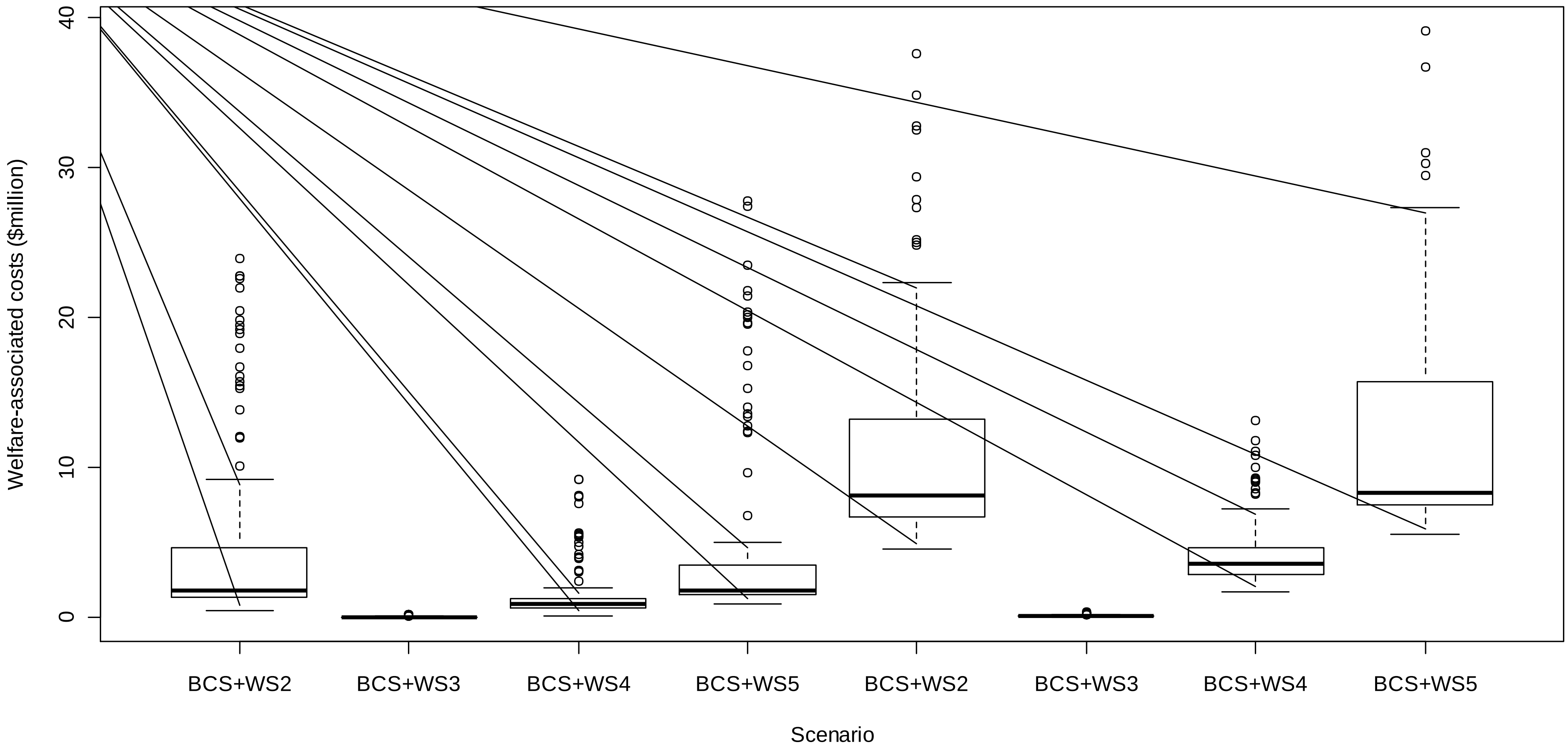

Figure 6 Welfare-associated costs associated with Welfare Strategies 2 to 5 (WS2 to 5) under the baseline control strategy (BCS) and expanded zones control strategy (EZCS).

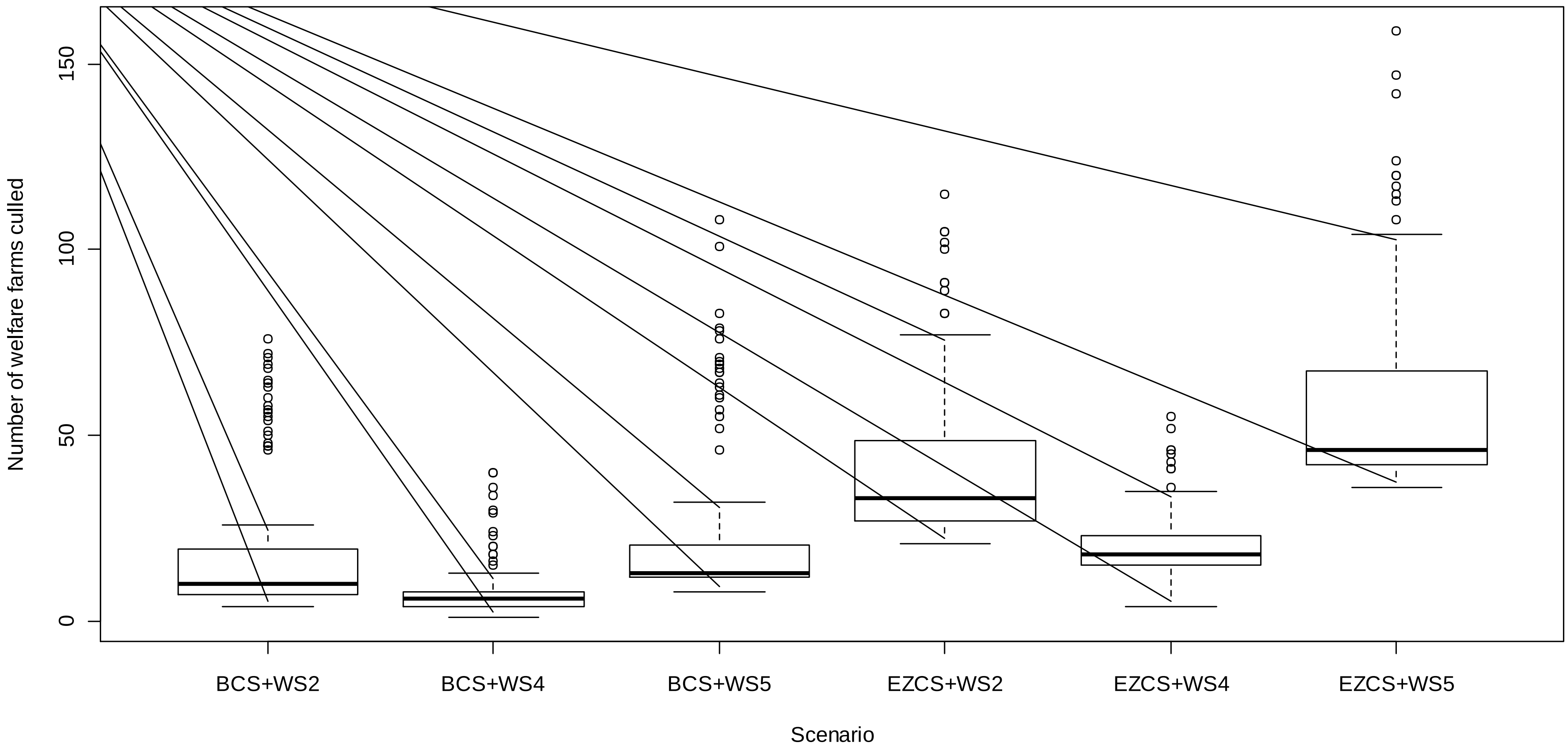

Figure 7 Number of farms culled for welfare reasons under Welfare Strategies 2, 4 and 5 (WS2, 4 and 5) for the baseline control strategy (BCS) and expanded zones control strategy (EZCS).

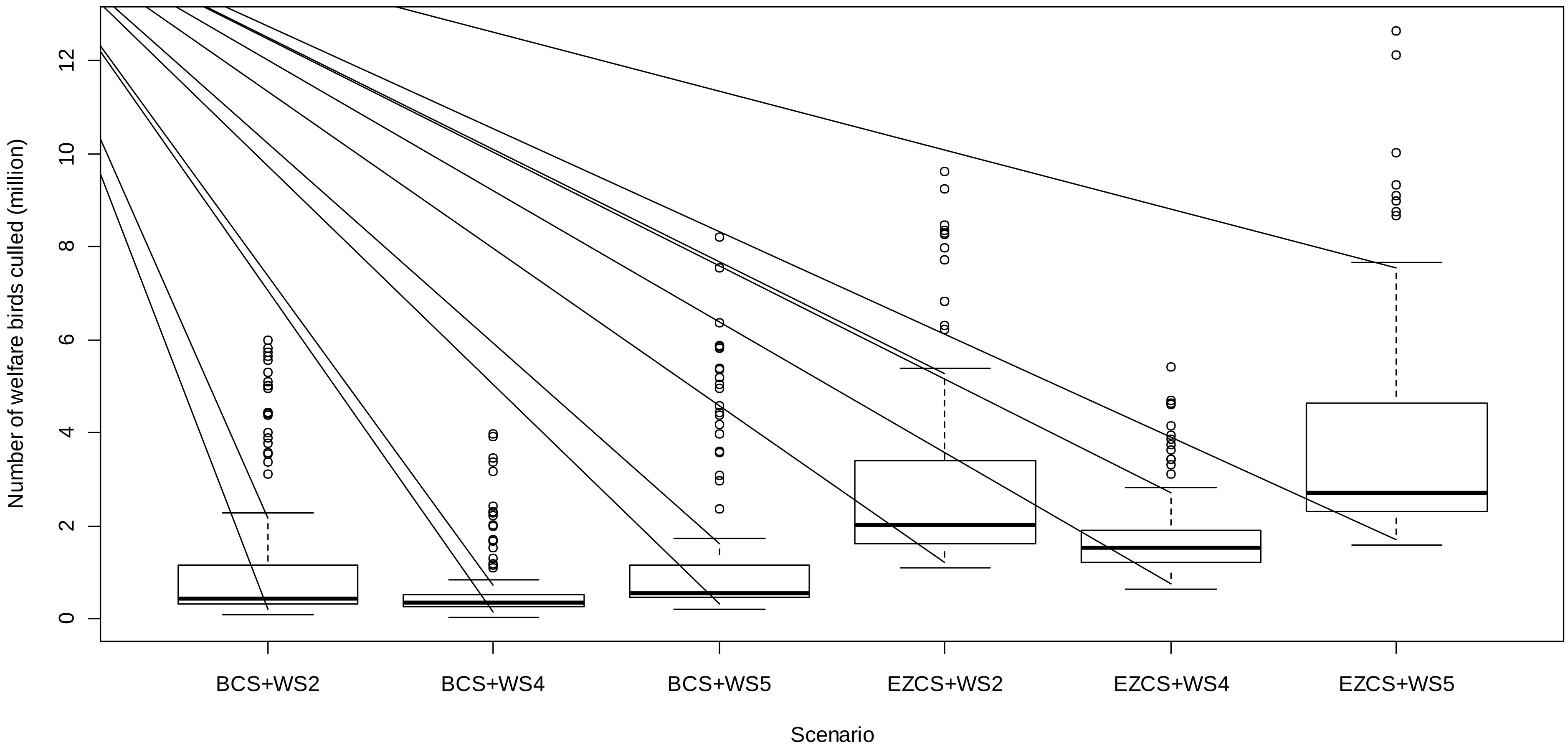

Figure 8 Millions of broilers culled for welfare reasons under Welfare Strategies 2, 4 and 5 (WS2, 4 and 5) for the baseline control strategy (BCS) and expanded zones control strategy (EZCS).

7.3 Sensitivity analysis

Table 6 illustrates the implications of delayed implementation of process slaughter strategies. Although median numbers of infected farms and epidemic duration were comparable for both the EZCS+WS3 and EZCS+WS4 strategies when process slaughter was delayed, the worst-case scenarios led to 19 to 23 (17 to 20%) more infected farms and outbreaks that were 3 to 9 days (5 to 17%) longer. The median number of welfare farms for WS3 and WS4 was increased by 17 and 14 farms in the median case and by 19 to 24 farms in the worst-case scenario, respectively.

The delay in implementing process slaughter led to a minor decrease in the welfare-associated costs of around $25,000 for WS3, because of the reduction in the number of broiler farms tested before processing. Median welfare associated costs were comparable for WS4 when process slaughter was delayed.

Table 6 Number of infected farms, epidemic duration, welfare farms and birds, farms and birds culled for welfare reasons and farms and birds process slaughtered for the sensitivity analysis scenarios for outbreaks in the Mornington Peninsula. [a]

	Infected farms	Epidemic duration (days)	Welfare farms	Welfare birds (1000)	Farms culled for welfare	Birds culled for welfare	Process slaughtered farms	Process slaughtered birds (1000)	Welfare-associated costs ($1000)
	Median (95% probability interval)								
EZCS+WS3 [a]	3 (1 to 112)	22 (16 to 63)	0 (0 to 36)	0 (0 to 2517)	n/a	n/a	32 (21 to 94)	2190 (1295 to 8902)	86 (85 to 267)
EZCS+WS3+ delay [b]	3 (1 to 131)	23 (16 to 66)	17 (9 to 60)	1297 (668 to 5003)	n/a	n/a	22 (9 to 95)	1912 (727 to 8615)	61 (31 to 252)
EZCS+WS4 [a]	3 (1 to 114)	20 (16 to 54)	0 (0 to 36)	0 (0 to 2578)	18 (7 to 46)	1540 (790 to 4619)	19 (10 to 55)	1037 (553 to 5046)	3628 (1958 to 10,980)
EZCS+WS4+ delay [b]	3 (1 to 137)	21 (16 to 63)	14 (8 to 55)	1048 (493 to 4948)	19 (6 to 49)	1535 (768 to 5171)	8 (2 to 44)	640 (174 to 4225)	3632 (1842 to 12,716)

[a] Assuming process slaughter can start at day one of a response
[b] Assuming process slaughter can start at day 14 of a response

8 Discussion

These results suggest that even though the likely number of infected farms was similar between regions, the Mornington Peninsula is more vulnerable to larger outbreaks of HPAI than Sydney in the worst-case scenario (taken as the upper bound of the 95% probability interval). This is consistent with previous modelling studies conducted by DAFF which concluded that this was due to higher farm densities, the larger proportion of broiler and layer farms, and the extensive service provider networks in the region.[2, 6] Resources for culling IPs appear to be adequate to manage the likely outbreaks, where the spread of infection was limited, but may be limiting when larger disease control zones are implemented. It is noted that a foam-based depopulation machine has been purchased by Victoria and has been used successfully to cull ducks in a recent outbreak of LPAI (M. Ramsay, pers. comm. February 2012). However, this is not believed to substantially increase the total culling capacity, which was assumed to be 300,000 birds per day in this study.

Although disease control strategies which involve implementing large disease control zones (e.g. the EZCS) led to small reductions in the number of infected farms in the worst-case scenario, they resulted in higher numbers of broiler farms at risk of welfare problems. Clearly, this is because more farms are likely to fall in larger RA zones.

The animal welfare strategies studied here did not adversely affect the spread of disease or the duration of epidemics in the median case. However, there were large differences in the number of farms and birds with welfare problems under each disease control and Welfare Strategy. Welfare strategies that allowed for the process slaughter of broiler farms (i.e. WS3) were able to reduce the number of broiler farms and birds with welfare problems to zero and were the cheapest in terms of the costs considered here, by around $867,000 and $3.5 million in the median case for the BCS and EZCS, respectively, when compared with WS4. When the worst-case scenario was considered, it was $7.9 million and $10.7 million cheaper than WS4 under the BCS and EZCS.

This is because this strategy did not allow birds to be culled for welfare purposes and so there were no associated welfare compensation costs. When smaller disease control zones were implemented, in the median case, these strategies would require 430,000 birds to be process slaughtered from nine farms in the Mornington Peninsula. This may be achievable, although one must consider that this throughput would have to be achieved in the first eight days after diagnosis, as it was assumed that HPAI would be detected on the initially infected farm 14 days after introduction and in the likely case, HPAI was eradicated on day 22. However, under the worst case scenario 5.9 million additional birds would have to be slaughtered in the first 60 days after diagnosis. This period is quite long when compared with the production cycle of broiler farms.

The explanation for this is that because (a) flocks in the original RA are processed out sooner, (b) the model assumes that, while broiler farms in RAs will not be restocked after depopulation, broiler farms in CAs and other non-infected areas are allowed to routinely restock during outbreaks, and (c) because RAs can expand into these previous CAs and unaffected areas when new IPs and DCPs are detected, restocked farms can become affected by movement restrictions in an escalating scenario.

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[6] NAIVE (2011) Report on simulation modelling to evaluate the effectiveness of emergency vaccination to control and eradicate HPAI in the commercial Australian poultry industries. 18 March 2011.

Given the limited benefits of larger disease control zones on the size and the duration of outbreaks, it would seem advisable to implement smaller disease control zones, particularly in cases where limited spread is believed to have occurred. However, if larger disease control zones are implemented, process slaughter strategies would require the early processing of an additional two million birds in the likely scenario, again within the first eight days after diagnosis. When the worst-case scenario is considered, 8.9 million extra birds would require processing in 49 days. On face value, however, these demands appear unrealistic.

As mentioned previously, welfare strategies that involved the culling of younger broiler farms (less than 28 days old) in the RA together with the process slaughter of older birds increased the likely welfare costs for the BCS and EZCS. It reduced the number of farms and birds to be slaughtered in the RA by around 40 to 50% in the likely and worst-case scenarios compared with WS3. This would require 221,000 extra birds being slaughtered (compared with routine throughput) in six days in the median case and 3.4 million birds in 55 days in the worst-case scenario under the BCS. Under the EZCS, this strategy required the processing of an additional one million birds in six days and five million birds in 40 days, for the median and worst-case scenarios. It appears that this strategy may be beneficial if throughput of processing plants in the CA is considered a limiting factor in implementing WS3 in smaller disease control zones, but may not sufficiently reduce the increased demand on processing plants if larger disease control zones are implemented.

When process slaughter strategies were delayed by 14 days in the sensitivity analysis study, there was a substantial increase in the number of farms with welfare problems. Although not as unfavourable as the 'do nothing' approach (WS1) or culling farms after they develop welfare problems (WS2), in these cases it would lead to an increase of 14 and 17 welfare farms under the EZCS for the median case. If required, further modelling studies may consider allowing for the culling of broiler farms early in an outbreak until process slaughter strategies can be implemented. These may further reduce associated animal welfare impacts.

Another alternative welfare strategy to consider is the culling of all broiler farms in RAs, prioritised for those due to send birds to slaughter sooner (WS5). This strategy effectively reduced the number of welfare farms to zero and three in the median case for the BCS and EZCS. This was less successful when the worst-case scenario was considered, where there were around 100 'welfare farms' under both disease control strategies. Such a strategy was substantially more expensive than WS3, and may lead to increased animal welfare costs of $1.7 million in the median case and $22.5 million in the worst-case scenario for the BCS. Costs were substantially higher for the EZCS: $8.2 million in the median case and $30.4 million in the worst-case, again highlighting the disadvantages of imposing larger disease control zones.

Although free-range broilers are likely to be housed indoors during outbreaks, it is recognised that their planned indoor stocking densities may be lower than conventionally-housed broilers. It is possible that free-range farms may take longer than three days to develop welfare problems. As a proportion of farms in the Mornington Peninsula area are kept under free range conditions, this study may have overestimated the number of farms with developing welfare problems. However, given the large differences in the effectiveness and costs of each welfare strategy, this is unlikely to change conclusions about the relative effectiveness of each welfare strategy studied here. Industry advises that there are comparatively fewer free-range farms in the Sydney region.

Although this study does not incorporate the value of the social amenity of avoiding animal welfare cases, modelling suggests that culling of farms after they develop welfare problems is the least favourable option. This is because it led to comparable numbers of welfare farms and birds as the 'do nothing' approach, and total welfare-associated costs were similar to culling all farms in the RA.

It is acknowledged that implementing a process slaughter strategy during a HPAI outbreak may be unrealistic. Several factors may affect the ability to implement such a strategy, including (but not limited to):

- real and perceived human health risks for catching crews and processing plant workers exposed to potentially infected birds (even though they must be inspected and flocks must be PCR negative)
- uncertainties about the ability to cook the large volume of chicken meat from farms in RAs and the ability to transport uncooked product large distances
- the reduced salvage value of cooked product (which may lead to consequential losses to industry)
- the risks of HPAI transmission through movement of product and secondarily, whether product may be transported long distances (potentially interstate) to cooking plants.

9 Conclusions

Unless there is evidence or suspicion of extensive spread of HPAI at the time of diagnosis, these results suggest that implementing a basic stamping-out strategy with three km RA and 10 km CA buffer zones would minimise the risk of adverse animal welfare outcomes on broiler farms due to movement restrictions. Conversely, implementing larger disease control zones may have severe impacts on broiler welfare unless process slaughter strategies can be implemented from the start of an outbreak.

This study suggests that the process slaughter of broilers is the most effective option to minimise animal welfare problems. It was also $876,000 cheaper in the likely case and $7.9 million in the worst-case scenario, when compared with the next cheapest strategy. It reduced the number of birds and farms with welfare problems to zero in the median case. However, the practicality of implementing such a strategy from day one of an outbreak response is questionable. Therefore, it is recommended that further investigations concentrate on scoping the ability to implement such process slaughter strategies in high-poultry density regions during HPAI outbreaks.

If further enquiry demonstrates that process slaughter is unrealistic, modeling results suggest that the culling of all broiler farms in RA zones is the next best option. Although it reduced the likely number of welfare farms to zero, at least when smaller disease control zones were considered, it resulted in substantial welfare-associated costs in the order of $1.8 million in the median case and $22.7 million in the worst-case scenario.

Glossary

The following glossary is provided for the reader's convenience. Definitions have been derived from several references.[1, 7, 8]

Active surveillance	Surveillance in which the primary users of the data actively initiate and design the data collection.
Control Area	A declared area in which the conditions applying are of lesser intensity than those in a restricted area (the limits of a control area and the conditions applying to it can be varied during an outbreak according to need).
Culling	The killing of animals for disposal. Carcasses from culled animals are not used for human consumption.
Dangerous Contact Animal	An animal showing no clinical signs of disease but which, by reason of its probable exposure to disease (revealed by tracing and epidemiological investigation), will be subjected to disease control measures (which may require slaughter of some or all such animals).
Dangerous Contact Premises	Premises that contain dangerous contact animals or other serious contacts.
Fomite	An inanimate object which may transmit disease causing agents. For example, vehicles, equipment or people.
Indirect contact spread	The transmission of infection by fomites. This does not include aerosol transmission or transmission by direct contact between animals.
Infected Premises	A defined area (which may be all or part of a property) in which an emergency disease exists, is believed to exist, or in which the infective agent of that emergency disease exists or is believed to exist. An infected premises is subject to quarantine served by notice and to eradication or control procedures.
Local spread	The transmission of infection between neighbouring farms. The mechanisms underlying the local spread of infection are not well described, but might include airborne transmission of virus or transmission by unidentified direct or indirect contacts.
Median	The middle value of a probability distribution. The numerical value separating the higher half of a sample, a population, or a probability distribution, from the lower half. Median is a better description of central tendency in a skewed distribution than the mean or average value.
Movement control	Restrictions placed on the movement of animals, people and other things to prevent the spread of infection
Multi-aged farms	Poultry farms which have multiple ages of birds on site.

[7] Blood and Studdert (1990) Balliere's Comprehensive Veterinary Dictionary, Balliere Tindall, London, UK.
[8] Cameron, A (in press) Risk-based disease surveillance, a manual for veterinarians, Food and Agriculture Organisation of the United Nations, Rome, Italy.

Passive surveillance	An activity in which the primary purpose for the collection of data is not surveillance, including the reporting of suspected clinical signs of disease to authorities.
Probability interval	The interval of a probability distribution between which a defined proportion of values fall.
Process slaughter	The transportation of animals, under movement controls, to a processing plant and their slaughter for human consumption.
Quarantine	Legal restrictions imposed on a place or a tract of land by the serving of a notice limiting access or egress of specified animals, persons or things.
Restricted Area	A relatively small declared area (compared to a control area) around an infected premises that is subject to intense surveillance and movement controls.
Single-aged farms	Poultry farms which have a cohort of similar aged birds on site.
Slaughter	The killing of animals for the preparation of meat for human consumption.
Surveillance	A systematic program of investigation designed to establish the presence, extent of, or absence of a disease, or of infection or contamination with the causative organism. It includes the examination of animals for clinical signs, antibodies or the causative organism.
Suspected Animal	An animal that may have been exposed to an emergency disease such that its quarantine and intensive surveillance, but not pre-emptive slaughter, is warranted. *or* An animal not known to have been exposed to a disease agent but showing clinical signs requiring differential diagnosis.
Suspected Premises	Temporary classification of premises containing suspect animals. After rapid resolution of the status of the suspect animal(s) contained on it, a suspect premises is reclassified either as an infected premises (and appropriate disease control measures taken) or as free from disease.
Tracing	The process of locating animals, persons or other items that may be implicated in the spread of disease to or from a premises, so that appropriate action can be taken.
Zoning	The process of defining Restricted Area and Control Area zones.

10 Appendix 1. Assumptions about the operation of broiler farms.

10.1.1 Operation of broiler farms

Integrated broiler farms in Australia are typically 'single-age, meaning that all birds are at similar stages of production. These farms are usually managed using a partial depletion system, where flocks are 'thinned' by moving ('harvesting') a proportion of birds to slaughter at different times during the production cycle. While actual numbers of harvests undertaken on commercial broiler farms varies by company and region and can range from a single harvest to five harvests, in the model, it is assumed that this occurs three times throughout the production cycle of a broiler farm and one third of birds are removed at each pickup. If not affected by disease control zones or quarantine restrictions, it is assumed that farms are empty between 5 and 28 days (with a most likely value of 14 days) before they are restocked.

The timing of these activities is set for each farm at the start of a new production cycle by sampling from probability distributions. This allows for the model to capture variability between production practices on different farms. Parameters for probability distributions governing these activities are presented in Table A1. Based on advice from the Australian Chicken Meat Federation, it is assumed that if a thinning visit or final depopulation is delayed for over three days then potential welfare problems occur due to overcrowding.

Table A1 Production parameters for broiler farms

Parameter description	Minimum	Most likely	Maximum
Age at first thinning (days)	31	33	35
Age at second thinning (days)	40	42	44
Age at final depopulation (days)	48	52	56
Time between batches (days)	5	14	28

10.1.2 Culling

Culling for disease control or animal welfare purposes can occur on a maximum of 10 farms per day and a maximum of 30,000 birds could be culled on a farm per day. Culling would continue for farms over 30,000 birds for several days. Because resources are assumed to be limited, the culling of IPs and DCPs is prioritised over welfare premises in disease control zones. For Welfare Strategy 5, where all broiler farms are culled in the RA zone, the time until the next thinning is due on the farm is also used to prioritise culling, because farms with flocks that are closer to 'thinning' will develop welfare problems sooner than others.

It is noted that the Victorian Department of Primary Industries has purchased foam depopulation equipment, which will increase the capacity for depopulation and reduce costs in the future. Estimates of the culling capacity may be amended as required, for future studies. It is also recognised that the disposal of large numbers of poultry may cause a problem during an outbreak.

10.1.3 Process slaughter of broilers

Where process slaughter strategies are permitted, it is assumed that broiler farms in the RA are able to move birds to slaughter provided a surveillance team has inspected the flock in the past 48 hours and samples taken are PCR negative. This reflects a policy change which is proposed for the revised edition of AUSVETPLAN, as the current edition requires inspection and negative serological surveillance within 24 hours of slaughter (Kathy Gibson, pers comm., 2011). It is assumed that the sensitivity of surveillance team visits is 95%, as would be the case if these teams would sample birds to ensure there would be at least 95% confidence in detecting infection at a conservative design prevalence. Under these strategies, all birds would be moved to slaughter when the next thinning visit is due (i.e. farms will be completely depopulated in a single pickup after 28 days). Full depopulation is assumed because the risk of transmission of infection by pickup crews under partial depletion is likely to be unacceptable.

11 Appendix 2. Description and rationale for economic parameter estimates.

Table A2 presents parameter estimates of the variable costs of animal welfare strategies. The compensation value of broilers was estimated as a function of their age, as illustrated in Figure A1.

Table A2 Variable costs of disease control and animal welfare strategies for partial budgeting.

Input	Description	Value	Reference
Culling and disposal of broilers culled for welfare purposes	Cost assumed by NAIVE Group ($30,000), less the cost of disinfection ($6200). [a]	$23,800 per shed (assumed to be 30,000 birds)	NAIVE Group, 2011; NSW Hansard, 2000; ABS 2011
Compensation for broilers culled for welfare purposes		See Figure A1.	
Costs of additional testing for broilers under test-and-move strategies	Assuming 50 PCR tests per farm. [b]	$2600 per farm	Cannon & Roe 1982; NSW DPI 2011

[a] cost per shed at Mangrove Mountain was $4240, $6200 in 2011 dollars
[b] 149 samples would be required to detect a 2% prevalence with 95% confidence, with samples combined into pools of 3. Each PCR test assumed to cost $51.65.

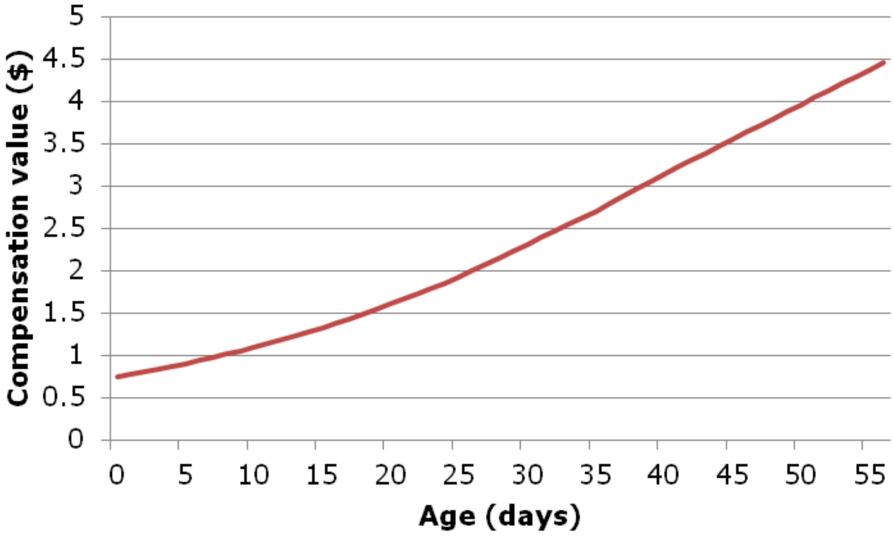

Figure A1 Value of broiler chickens by age. (Source: V. Kite pers. Comm. December 2011).

11.1 References

ABS (2011) Consumer Price Index Inflation Calculator. www.abs.gov.au/websitedbs/d3310114.nsf/home/consumer+price+index+inflation+calculator

NSW DPI (2011) Vet Lab Manual Laboratory Charges http://www.dpi.nsw.gov.au/agriculture/vetmanual/submission/lab-charges#Virology

NSW Hansard (2000) Newcastle disease clean up costs
http://www.parliament.nsw.gov.au/prod/parlment/hansart.nsf/V3Key/LC20010306030

12 Appendix 3. Interpreting mean and medians in skewed distributions and how to read box-and-whisker plots

As demonstrated in Figure A2, mean or average values can be greatly influenced by a small number of high value data points in a skewed distribution. The median value is more representative of the central tendency of a skewed population. Figure A3 provides advice on interpreting a box-and-whisker plot.

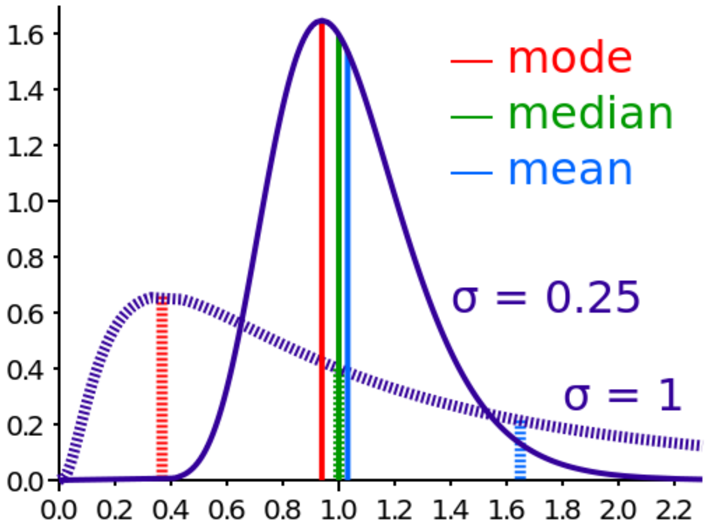

Figure A2 Probability density functions illustrating the mean, mode and median of a log normal distribution with a minor positive skew (solid line) and a log normal distribution with a more extreme positive skew (dotted line). (Source: en.wikipedia.org/wiki/Median).

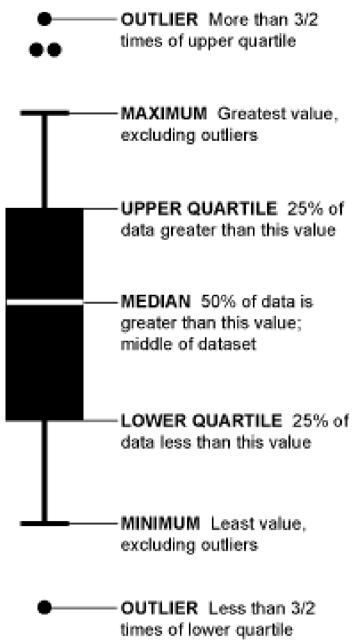

Figure A3 How to read a box-and-whisker plot. (Source: flowingdata.com/2008/02/15/how-to-read-and-use-a-box-and-whisker-plot/).

13 Appendix 4. Results.

Table A3 presents results of the number of infected farms, epidemic duration, number of farms and birds with welfare problems, number of birds and farms culled for animal welfare purposes and the number of birds and farms process slaughtered from all combinations of disease control strategies and welfare strategies in the Mornington peninsula. Table A4 presents similar results for Sydney.

Table A3 Median number of infected farms, epidemic duration, welfare farms and birds, farms and birds culled for welfare reasons and farms and birds process slaughtered for outbreak scenarios in the Mornington Peninsula. [a]

	Infected farms	Epidemic duration (days)	Welfare farms	Welfare birds (1000)	Welfare farms culled	Welfare birds culled (1000)	Process slaughtered farms	Process slaughtered birds (1000)
	Median (95% probability interval)							
BCS+WS1	3 (1 to 116)	22 (16 to 88)	10 (6 to 98)	466 (191 to 7837)	n/a	n/a	n/a	n/a
BCS+WS2	3 (1 to 125)	22 (16 to 78)	10 (5 to 99)	458 (190 to 7605)	10 (5 to 70)	440 (187 to 5685)	n/a	n/a
BCS+WS3	3 (1 to 127)	22 (16 to 74)	0 (0 to 37)	0 (0 to 2875)	n/a	n/a	9 (4 to 57)	430 (167 to 5863)
BCS+WS4	3 (1 to 133)	20 (16 to 69)	0 (0 to 36)	0 (0 to 2450)	6 (2 to 35)	355 (64 to 3426)	5 (2 to 35)	221 (64 to 3419)
BCS+WS5	3 (1 to 129)	20 (16 to 68)	0 (0 to 92)	0 (0 to 7024)	13 (9 to 81)	560 (300 to 6134)	n/a	n/a
BCS+PEC+WS1	4 (1 to 123)	23 (16 to 91)	10 (5 to 95)	466 (190 to 7371)	n/a	n/a	n/a	n/a
BCS+PEC+WS2	4 (1 to 125)	23 (16 to 86)	10 (5 to 98)	459 (179 to 8015)	10 (4 to 75)	440 (169 to 6176)	n/a	n/a
BCS+PEC+WS3	4 (1 to 130)	25 (16 to 83)	0 (0 to 31)	0 (0 to 2073)	n/a	n/a	9 (4 to 59)	433 (167 to 5709)
BCS+PEC+WS4	4 (1 to 133)	20 (16 to 82)	0 (0 to 33)	0 (0 to 2216)	6 (2 to 40)	362 (92 to 3712)	5 (2 to 35)	225 (64 to 3236)
BCS+PEC+WS5	3 (1 to 129)	21 (16 to 77)	0 (0 to 92)	0 (0 to 7097)	13 (9 to 101)	577 (300 to 7429)	n/a	n/a
BCS+3km_cull+WS1	3 (1 to 127)	20 (16 to 76)	0 (0 to 92)	0 (0 to 7197)	n/a	n/a	n/a	n/a
EZCS+WS1	3 (1 to 108)	21 (16 to 66)	36 (23 to 146)	2247 (1326 to 11,631)	n/a	n/a	n/a	n/a
EZCS+WS2	3 (1 to 110)	22 (16 to 55)	35 (23 to 148)	2200 (1326 to 11,915)	33 (22 to 104)	2027 (1205 to 8413)	n/a	n/a
EZCS+WS3	3 (1 to 112)	22 (16 to 63)	0 (0 to 36)	0 (0 to 2517)	n/a	n/a	32 (21 to 94)	2190 (1295 to 8902)
EZCS+WS4	3 (1 to 114)	20 (16 to 54)	0 (0 to 36)	0 (0 to 2578)	18 (7 to 46)	1540 (790 to 4619)	19 (10 to 55)	1037 (553 to 5046)
EZCS+WS5	3 (1 to 120)	21 (16 to 62)	3 (0 to 116)	98 (0 to 9735)	46 (37 to 133)	2710 (2022 to 9688)	n/a	n/a

Table A3 Median number of infected farms, epidemic duration, welfare farms and birds, farms and birds culled for welfare reasons and farms and birds process slaughtered for outbreak scenarios in the Mornington Peninsula. [a]								
	Infected farms	Epidemic duration (days)	Welfare farms	Welfare birds (1000)	Welfare farms culled	Welfare birds culled (1000)	Process slaughtered farms	Process slaughtered birds (1000)
	Median (95% probability interval)							
EZCS+PEC+WS1	3 (1 to 114)	24 (16 to 62)	36 (24 to 133)	2290 (1323 to 10,145)	n/a	n/a	n/a	n/a
EZCS+PEC+WS2	3 (1 to 114)	23 (16 to 63)	35 (24 to 145)	2236 (1323 to 10,952)	33 (22 to 112)	2169 (1198 to 8970)	n/a	n/a
EZCS+PEC+WS3	4 (1 to 112)	22 (16 to 64)	0 (0 to 30)	0 (0 to 1933)	n/a	n/a	33 (21 to 90)	2273 (1295 to 9204)
EZCS+PEC+WS4	3 (1 to 107)	22 (16 to 62)	0 (0 to 29)	0 (0 to 2003)	19 (9 to 52)	1564 (748 to 4923)	19 (10 to 63)	1037 (553 to 5136)
EZCS+PEC+WS5	4 (1 to 107)	23 (16 to 73)	5 (1 to 132)	216 (5 to 10,069)	46 (37 to 136)	2677 (2015 to 10,520)	n/a	n/a
EZCS+3km_cull+WS1	3 (1 to 112)	20 (16 to 68)	27 (17 to 135)	1783 (1058 to 10,364)	n/a	n/a	n/a	n/a
EZCS+3km_cull+WS2	3 (1 to 105)	20 (16 to 63)	27 (17 to 134)	1783 (1058 to 10,633)	35 (25 to 121)	2094 (1309 to 9406)	n/a	n/a
EZCS+3km_cull+WS3	3 (1 to 115)	20 (16 to 72)	0 (0 to 33)	0 (0 to 2308)	11 (0 to 17)	472 (0 to 1045)	24 (15 to 92)	1805 (980 to 8277)
EZCS+3km_cull+WS4	3 (1 to 113)	20 (16 to 59)	0 (0 to 38)	0 (0 to 2453)	23 (12 to 55)	1627 (855 to 4996)	16 (7 to 59)	984 (489 to 5688)
EZCS+3km_cull+WS5	3 (1 to 116)	21 (16 to 70)	5 (1 to 123)	202 (5 to 9821)	46 (37 to 142)	2593 (1998 to 10,776)	n/a	n/a

Table A4 Median number of infected farms, epidemic duration, welfare farms and birds, farms and birds culled for welfare reasons and farms and birds process slaughtered for outbreak scenarios in Sydney. [a]

	Infected farms	Epidemic duration (days)	Welfare farms	Welfare birds (1000)	Welfare farms culled	Welfare birds culled (1000)	Process slaughtered farms	Process slaughtered birds (1000)
	Median (95% probability interval)							
BCS+WS1	3 (1 to 68)	20 (15 to 88)	4 (1 to 77)	331 (52 to 6373)	n/a	n/a	n/a	n/a
BCS+WS2	3 (1 to 45)	20 (15 to 72)	4 (1 to 51)	331 (52 to 4024)	3 (0 to 46)	290 (52 to 3743)	n/a	n/a
BCS+WS3	3 (1 to 56)	20 (15 to 67)	0 (0 to 4)	0 (0 to 156)	n/a	n/a	4 (1 to 54)	315 (40 to 4568)
BCS+WS4	3 (1 to 89)	20 (15 to 87)	0 (0 to 5)	0 (0 to 402)	2 (0 to 33)	250 (0 to 3558)	2 (0 to 34)	132 (0 to 2572)
BCS+WS5	3 (1 to 42)	20 (15 to 73)	0 (0 to 16)	0 (0 to 1090)	4 (2 to 58)	398 (129 to 5237)	n/a	n/a
BCS+PEC+WS1	3 (1 to 67)	23 (14 to 76)	4 (1 to 61)	343 (52 to 4789)	n/a	n/a	n/a	n/a
BCS+PEC+WS2	3 (1 to 60)	21 (14 to 76)	4 (1 to 63)	344 (52 to 4599)	4 (0 to 60)	322 (52 to 4451)	n/a	n/a
BCS+PEC+WS3	3 (1 to 93)	20 (14 to 77)	0 (0 to 3)	0 (0 to 180)	n/a	n/a	4 (1 to 62)	335 (54 to 5463)
BCS+PEC+WS4	3 (1 to 100)	20 (14 to 75)	0 (0 to 2)	0 (0 to 81)	2 (0 to 34)	287 (0 to 3617)	2 (0 to 33)	132 (0 to 2196)
BCS+PEC+WS5	3 (1 to 71)	20 (14 to 57)	0 (0 to 20)	0 (0 to 1532)	4 (2 to 71)	427 (129 to 6113)	n/a	n/a
BCS+3km_cull+WS1	3 (1 to 53)	19 (14 to 58)	0 (0 to 11)	0 (0 to 703)	n/a	n/a	n/a	n/a
EZCS+WS1	3 (1 to 23)	20 (15 to 78)	29 (18 to 112)	2185 (1299 to 9341)	n/a	n/a	n/a	n/a
EZCS+WS2	3 (1 to 19)	20 (15 to 45)	29 (18 to 108)	2185 (1299 to 8627)	27 (17 to 106)	1994 (1137 to 8552)	n/a	n/a
EZCS+WS3	3 (1 to 21)	20 (15 to 55)	0 (0 to 1)	0 (0 to 145)	n/a	n/a	28 (17 to 92)	2121 (1199 to 7735)
EZCS+WS4	3 (1 to 23)	20 (15 to 47)	0 (0 to 1)	0 (0 to 20)	14 (8 to 46)	1576 (809 to 4738)	17 (8 to 49)	999 (475 to 3290)
EZCS+WS5	3 (1 to 15)	20 (15 to 38)	8 (3 to 48)	417 (121 to 3259)	33 (25 to 96)	2650 (1791 to 8370)	n/a	n/a
EZCS+PEC+WS1	3 (1 to 35)	21 (14 to 65)	29 (18 to 106)	2180 (1299 to 9136)	n/a	n/a	n/a	n/a
EZCS+PEC+WS2	3 (1 to 30)	20 (14 to 52)	29 (18 to 109)	2181 (1299 to	27 (17 to 103)	2073 (1137 to	n/a	n/a

Table A4 Median number of infected farms, epidemic duration, welfare farms and birds, farms and birds culled for welfare reasons and farms and birds process slaughtered for outbreak scenarios in Sydney. [a]

	Infected farms	Epidemic duration (days)	Welfare farms	Welfare birds (1000)	Welfare farms culled	Welfare birds culled (1000)	Process slaughtered farms	Process slaughtered birds (1000)
	Median (95% probability interval)							
				9454)		9085)		
EZCS+PEC+WS3	3 (1 to 37)	19 (14 to 57)	0 (0 to 1)	0 (0 to 1)	n/a	n/a	28 (17 to 106)	2154 (1199 to 8689)
EZCS+PEC+WS4	3 (1 to 42)	20 (14 to 51)	0 (0 to 1)	0 (0 to 30)	15 (8 to 43)	1616 (861 to 4392)	17 (8 to 58)	995 (475 to 4301)
EZCS+PEC+WS5	3 (1 to 20)	21 (14 to 48)	5 (1 to 50)	153 (10 to 2845)	34 (25 to 105)	2693 (1791 to 8652)	n/a	n/a
EZCS+3km_cull+WS1	3 (1 to 24)	19 (15 to 56)	26 (16 to 103)	1817 (1054 to 8548)	n/a	n/a	n/a	n/a
EZCS+3km_cull+WS2	3 (1 to 28)	19 (15 to 59)	26 (16 to 113)	1817 (1054 to 10,367)	30 (22 to 117)	2134 (1418 to 10,111)	n/a	n/a
EZCS+3km_cull+WS3	3 (1 to 23)	19 (15 to 58)	0 (0 to 2)	0 (0 to 76)	8 (0 to 14)	491 (0 to 870)	25 (16 to 100)	1952 (1022 to 9090)
EZCS+3km_cull+WS4	3 (1 to 16)	19 (15 to 39)	0 (0 to 0)	0 (0 to 0)	19 (12 to 42)	1758 (1009 to 4044)	16 (8 to 47)	898 (461 to 3123)
EZCS+3km_cull+WS5	3 (1 to 24)	20 (15 to 52)	5 (1 to 67)	145 (13 to 4344)	38 (30 to 114)	2846 (1983 to 9683)	n/a	n/a

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