An economic analysis of leptospirosis vaccination in lambs

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Introduction

Leptospirosis causes outbreaks of mortality in weaned lambs and hoggets in New Zealand typically during warm, wet climatic conditions (Vermunt *et al.* 1994; Dorjee *et al.* 2005). These outbreaks may have significant economic impacts on affected farms. Lambs do not typically develop immunity to *Leptospira* until 8–15 months of age (Vallee *et al.* 2014) and are therefore at risk of leptospirosis from weaning until immunity is acquired. Commercial vaccines are registered for protection against leptospirosis in sheep (Leptoshield (Zoetis Animal Health, Auckland, New Zealand), Leptavoid 2(MSD Animal Health, Wellington, New Zealand), Ultravac 7-in-1 (Zoetis Animal Health, Auckland, New Zealand)) however uptake on New Zealand sheep farms is low (Dreyfus 2013). Currently the economic value of leptospirosis vaccination is considered equivocal due to the sporadic nature of leptospirosis outbreaks, however the climatic conditions that may precipitate leptospirosis outbreaks are likely to increase in frequency for several major sheep farming regions in New Zealand due to climate change (Wang *et al.* 2023). Therefore, it may be useful to reassess the economics associated with leptospirosis vaccination on New Zealand sheep farms.

The aim of this study was to determine the economic benefit associated with prophylactic vaccination of lambs/hoggets should a leptospirosis outbreak occur, the frequency that outbreaks need to occur for costs associated with prophylactic vaccination to breakeven with the economic benefits obtained during an outbreak, and to determine which farm level variables have the greatest impact on the economic value associated with prophylactic vaccination.

Methods

Partial budget (PB) analyses utilising assumed baseline values (Table 1a) under the assumptions outlined in table 1b in a hypothetical 1500 head replacement ewe hogget flock were developed to consider:

1. Prophylactic leptospirosis vaccination versus no prophylactic vaccination with no reactive management (i.e. “do nothing”) in the event of a leptospirosis outbreak event in a hogget flock (Table 2).
2. No prophylactic vaccination followed by the recommended reactive management protocol versus “do nothing” in the event of a leptospirosis outbreak in a hogget flock (Table 3).

Reactive management was considered to consist of administration of 0.04ml/kg of 500mg/ml Streptomycin/ Dihydrostreptomycin solution (Vibrostrep; Virbac New Zealand Limited, Hamilton, New Zealand) to clinical cases available for treatment once every 24 hours via intramuscular injection for three consecutive days and reactive vaccination of all in contacts (Virbac New Zealand n.d.; West *et al.* 1993). The expected financial consequences of the proposed interventions were compared against the economic consequences of “doing nothing”. Increases in expenditure and decreases in income associated with intervention in comparison to “doing nothing” were determined and summed to determine overall costs associated with intervention. Decreases in expenditure and increases in income associated with intervention in comparison to “doing nothing” were calculated and summed to determine overall benefits associated with intervention. The net economic benefit of intervention in comparison to “doing nothing” was calculated by subtracting overall cost of intervention (the sum of increased expenditure and decreased income) from overall benefit of intervention (the sum of decreased expenditure and increased income). One way sensitivity analyses were performed to determine the effect of alterations in the value of individual variables on expected monetary value (EMV) of the flock utilising assumed

maximum and minimum values (Table 1a). Breakeven analysis (Damaso and Rushden 2017) was performed to estimate how frequently an outbreak would need to occur to make annual prophylactic vaccination of lambs at weaning breakeven economically at farm level. The difference in partial budget between prophylactic vaccination and reactive management were calculated at assumed baseline figures and using the maximum and minimum plausible value of individual variables. These values were divided by the cost of annual prophylactic vaccination in the respective scenario.

Results

A net benefit of 16952 New Zealand Dollars (NZD) associated with prophylactic vaccination versus "do nothing" (Table 2a), and a net benefit of $3245 NZD associated with reactive treatment and vaccination versus "do nothing" (Table 2b), in a 1500 hogget flock during a clinical leptospirosis outbreak with 10% morbidity and 10% mortality was identified. Prophylactic vaccination remains the decision with the greatest PB value at the extreme values of variables analysed. Lamb/hogget value and morbidity greatly impact EMV. Flock size has a moderate to great impact on EMV value at farm level. The magnitude of effect on EMV value of lamb/hogget value is much greater than all other variables considered (Figure 1). Using assumed values, a leptospirosis outbreak would need to occur more frequently than every 2.5 years for annual prophylactic vaccination of hoggets to be economically profitable at farm level compared to reactive treatment/vaccination. Breakeven points are subject to considerable change depending on the values of associated variables, particularly hogget value and morbidity (Table 3).

Table 1a. Assumed values utilised in partial budget and sensitivity analyses.

Variable	Unit	Baseline	Max	Min
Population (flock) size	Individual hoggets	1500	2500	800
Sheep vaccinated/hour	Individual hoggets	375	NA	NA
Hoggets with clinical leptospirosis identified and treated/hour	Individual hoggets	20	NA	NA
Mean hogget weight	Kg	20	60	15
Live hogget value/head	NZ Dollar	150	400	100
Dead hogget value/head	NZ Dollar	0	NA	NA
Labour unit cost/hour	NZ Dollar	-28	-37.5	0
Cost of vaccine/dose	NZ Dollar	-1.7	-1.28	-2.13
Cost of treatment medication/dose	NZ Dollar	-1.92	-5.76	-1.44
Vet investigation cost	NZ Dollar	-900	NA	NA
Morbidity	Percent	10	20	5
Mortality (i.e. 100% of untreated clinically affected cases die)	Percent	10	NA	NA
Vaccine efficacy	Percent	100	NA	NA
Treatment efficacy	Percent	90	NA	NA
Proportion of hoggets with clinical leptospirosis available to treat	Percent	50	80	5
Labour units required to vaccinate	Unit	2	NA	NA
Labour units required to identify clinical leptospirosis cases and administer treatment	Unit	2	NA	NA

Table 1b. Assumptions utilised in partial budget analyses.

The study period was from vaccination at weaning for a 12-month period covering the duration of immunity afforded by vaccination. Individuals were assumed to remain for the entire study.
No variation in hogget weight or value throughout the study period.
No impacts associated with subclinical infection.
The value of surviving individuals was equal to non-affected individuals.
The impact of foetal loss due to leptospirosis post-tupping in surviving individuals was not considered.
A leptospirosis outbreak was considered to span the entire study period.
Vaccination was assumed to represent completion of a primary course of a bivalent *Leptospira* vaccine registered for use in sheep for protection against *Leptospira* serovars Hardjo and Pomona.
Individuals identified with clinical leptospirosis were assumed not to undergo vaccination.
All individuals that commenced treatment completed the three day course.
Veterinary investigation was considered necessary to diagnose leptospirosis as the cause of disease in the flock for reactive management.

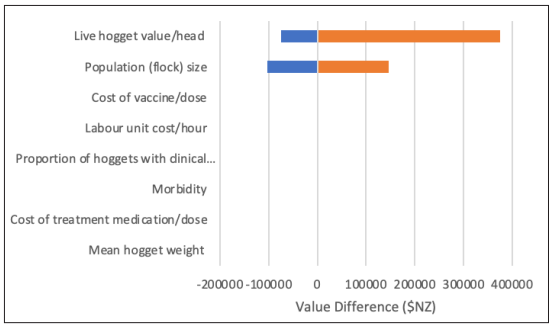
Table 2a. Partial budget analysis associated with prophylactic vaccination versus 'do nothing' in a 1500 hogget flock during a clinical leptospirosis outbreak with 10% morbidity and 10% mortality using assumed values.

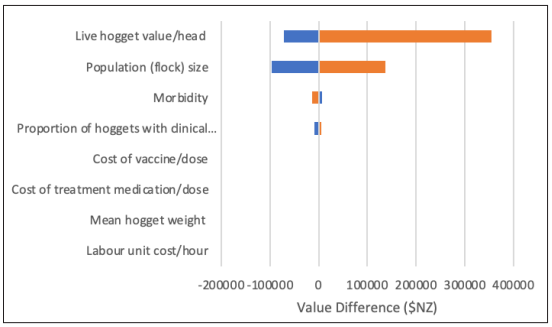
Costs				Benefits			
Increased expenditure		Value ($)	Decreased income	Decreased expenditure	Increased income		Value ($)
Vaccination	3000 doses @$1.70/dose	5100	None	None	Additional 150 hoggets	150 hoggets @$150/head	22500
	2 labour units @$28/hour for 8 hours	448					
Total		5548					22500
Net benefit per flock		**$16952**					

Table 2b. Partial budget analysis associated with reactive treatment/vaccination versus "do nothing", in a 1500 hogget flock during a clinical leptospirosis outbreak with 10% morbidity and 10% mortality using assumed values.

Costs				Benefits			
Increased expenditure		Value ($)	Decreased income	Decreased expenditure	Increased income		Value ($)
Treatment of 75 clinically diseased hoggets	75x 3 antimicrobial doses @$1.92/dose	432	None	None	Additional 68 hoggets	68 hoggets @$150/head	10200
	2 labour units @$28/hour for 11.25 hours	630					
Vaccination of 1350 hoggets	2700 doses @$1.70/dose	4590					
	2 labour units @$28/hour for 7.2 hours	403.2					
Veterinary investigation	Veterinarian and lab fees @$900	900					
Total		6955.2					10200
Net benefit per flock		**3244.8**					

Figure 1. Sensitivity analysis displaying the difference between expected monetary value at maximum and minimum values of the plausible range of individual variables, and at baseline values for prophylactic vaccination (top), "do nothing" (middle), and reactive vaccination/treatment (bottom) in a clinical leptospirosis outbreak in a hogget flock.





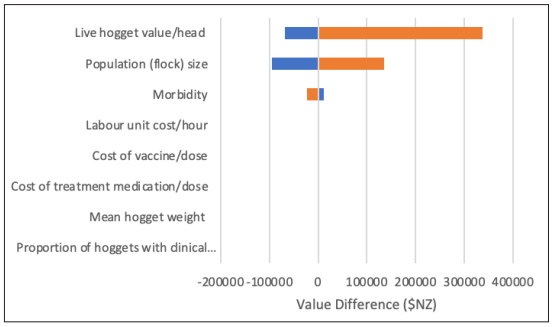


Table 3. Breakeven analysis to estimate required leptospirosis outbreak frequency (years) for annual vaccination of hoggets to break even economically at farm level.

	Difference between prophylactic vaccination and reactive management ($)	Breakeven frequency (years)
Baseline	13782	2.48
Population (flock) size min	7770	2.63
Live hogget value/head min	9657	1.74
Mean hogget weight min	13674	2.46
Cost of treatment medication/dose min	13674	2.46
Cost of vaccine/dose min	13908	3.24
Labour unit cost/hour min	13197	2.59
Morbidity min	7341	1.32
Proportion of hoggets with clinical leptospirosis available to treat min	21939	3.95
Population (flock) size max	22370	2.42
Live hogget value/head max	34407	6.20
Mean hogget weight max	14646	2.64
Cost of treatment medication/dose max	14646	2.64
Cost of vaccine/dose max	13653	2.00
Labour unit cost/hour max	13981	2.45
Morbidity max	26664	4.81
Proportion of hoggets with clinical leptospirosis available to treat max	8344	1.50

Summary

Findings are consistent with existing literature that describe prophylactic leptospirosis vaccination as difficult to justify economically on most farms in typical conditions. However, prophylactic leptospirosis vaccination is likely to be economically justifiable on farms with valuable stock, or where conditions mean that the risk of

leptospirosis outbreak occurrence could be more frequent than every three years. It is important to acknowledge that leptospirosis vaccination on farm is likely to have benefits beyond those that are fiscal, and these should be taken into account when discussing leptospirosis vaccination with farmers.

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