Methods for estimating disease transmission rates: Evaluating the precision of Poisson regression and two novel methods

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Supplementary material

Supplementary table

Symbol	Name	Description	Value	Reference
β	Transmission rate	Transmission (infection) rate for individuals	0.0179	1
		entering subclinical or clinical state		
$1-\rho$	Probability of clinical state	Probability of acquiring clinical infection	0.83	2
		when infected		
ρ	Probability of subclinical	Probability of acquiring clinical infection	0.17	3
	state	when infected		
γs	Flare up rate	Rate of subclinical individuals going to clin-	0.008	3
		ical state		
α_{S}	Spontaneous cure probability	Probability of spontaneous cure for subclin-	0.0064	1
		ical individuals		
α_{C}	Recovery rate	Rate of recovery for clinical individuals that	0.33	4
		are treated going to either susceptible or		
		subclinical individuals		
η	Recovery probability	Probability of recovery for clinical individ-	0.40	4
		uals that are treated		
$1-\eta$	Remission probability	Probability of remission of individuals go-	0.60	4
		ing from clinical to subclinical state		

Table 1. Rates and probabilities used in the SIScom simulation model. All parameters are implemented in daily time steps, for all quarters. The parameters are shown in Figure 1.

References

1. References

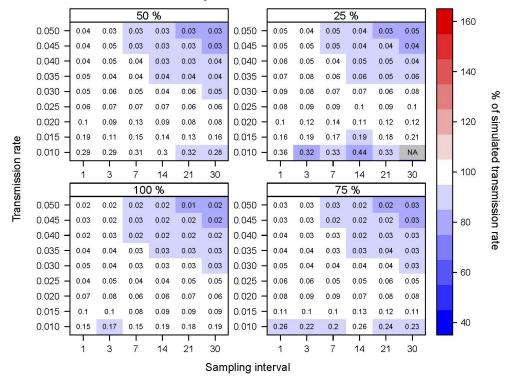
- 1. van den Borne, B. H., Halasa, T., van Schaik, G., Hogeveen, H. & Nielen, M. Bioeconomic modeling of lactational antimicrobial treatment of new bovine subclinical intramammary infections caused by contagious pathogens. *J. dairy science* **93**, 4034–4044 (2010).
- 2. Swinkels, J., Hogeveen, H. & Zadoks, R. A partial budget model to estimate economic benefits of lactational treatment of subclinical staphylococcus aureus mastitis. *J. dairy science* **88**, 4273–4287 (2005).
- 3. Halasa, T., Nielen, M., Huirne, R. & Hogeveen, H. Stochastic bio-economic model of bovine intramammary infection. *Livest. Sci.* 124, 295–305 (2009).
- 4. Steeneveld, W., van Werven, T., Barkema, H. W. & Hogeveen, H. Cow-specific treatment of clinical mastitis: An economic approach. *J. Dairy Sci.* 94, 174–188 (2011).

Supplementary figures

				50	%				25 %								
	0.050 -	0.03	0.02	0.02	0.01	0.01	0.02	0.050 -	0.04	0.02	0.03	0.02	0.02	0.02		- 160	
	0.045 -	0.03	0.03	0.02	0.02	0.01	0.01	0.045 -	0.03	0.03	0.03	0.02	0.02	0.02			
	0.040 -	0.03	0.03	0.02	0.02	0.02	0.02	0.040 -	0.03	0.03	0.03	0.03	0.02	0.02			
	0.035 -	0.03	0.03	0.03	0.02	0.02	0.02	0.035 -	0.04	0.04	0.03	0.03	0.03	0.03		- 140	
	0.030 -	0.02	0.04	0.03	0.02	0.02	0.03	0.030 -	0.04	0.04	0.04	0.03	0.03	0.03			%
	0.025 -	0.04	0.03	0.03	0.03	0.03	0.04	0.025 -	0.05	0.05	0.05	0.05	0.05	0.05			of
	0.020 -	0.06	0.05	0.07	0.05	0.05	0.04	0.020 -	0.07	0.08	0.09	0.08	0.07	0.07		- 120	sim
te	0.015 -	0.13	0.09	0.1	0.11	0.1	0.13	0.015 -	0.16	0.17	0.14	0.19	0.18	0.18			Iula
Transmission rate	0.010 -	0.25	0.24	0.24	0.28	0.24	0.23	0.010 -	0.36	0.37	0.5	0.39	0.31	NA			simulated
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nis		50	U	×	0 %	21	00			U	75	2.0	41	00			transmission
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La	0.050 -		0.02	0.01	0.01	0.01	0.01	0.030 -		0.02	0.02	0.01	0.01	0.01			Sic
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	0.035 -	0.02	0.02	0.02	0.01	0.02	0.01	0.035 -		0.02	0.02	0.02	0.02	0.02			(b
	0.030 -	0.02	0.02	0.02	0.02	0.02	0.02	0.030 -		0.02	0.02	0.02	0.02	0.02		- 60	
	0.025 -	0.03	0.03	0.02	0.02	0.02	0.02	0.025 -	0.03	0.03	0.03	0.03	0.03	0.03			
	0.020 -	0.04	0.06	0.04	0.04	0.04	0.03	0.020 -	0.05	0.06	0.05	0.05	0.05	0.04			
	0.015 -	0.1	0.09	0.07	0.08	0.08	0.07	0.015 -	0.1	0.08	0.08	0.11	0.09	0.1			
	0.010 -	0.14	0.16	0.14	0.19	0.17	0.2	0.010 -	0.25	0.2	0.19	0.24	0.22	0.21		- 40	
		1	3	7	14	21	30		1	3	7	14	21	30			
		1	3	1	14	21				3	/	14	21	30			
							Sam	pling inte	erval								

Epidemic: Poisson regression

Figure 5. SISsim model, epidemic situation, poisson regression: Heatmaps showing the estimated transmission rates as percentage of the simulated transmission rate. The estimates are shown for four subsampling levels: 100%, 75%, 50% and 25%. Values in each cell show the relative standard deviation of the estimated rate divided by the simulated rate.



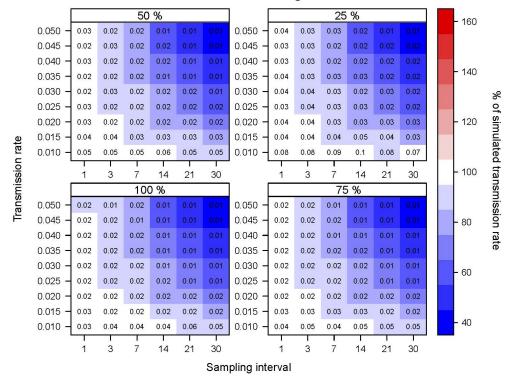
Epidemic: Method 1

Figure 6. SISsim model, epidemic situation, Method 1: Heatmaps showing the estimated transmission rates as percentage of the simulated transmission rate. The estimates are shown for four subsampling levels: 100%, 75%, 50% and 25%. Values in each cell show the relative standard deviation of the estimated rate divided by the simulated rate.

	1	-		50	%						25			- 16	5			
	0.050 -	0.04	0.04	0.04	0.05	0.19	0.18	0.050 -	0.05	0.04	0.06	0.07	0.2	0.23			0	
	0.045 -	0.04	0.05	0.04	0.05	0.09	0.26	0.045 -	0.05	0.05	0.06	0.06	0.13	0.25				
	0.040 -	0.04	0.05	0.05	0.05	0.08	0.24	0.040 -	0.06	0.05	0.05	0.07	0.11	0.24				
	0.035 -	0.05	0.04	0.04	0.05	0.07	0.12	0.035 -	0.07	0.09	0.07	0.07	0.08	0.2		- 14	10	
	0.030 -	0.05	0.06	0.06	0.05	0.08	0.08	0.030 -	0.09	0.08	0.08	0.08	0.08	0.16				%
	0.025 -	0.06	0.07	0.07	0.07	0.08	0.08	0.025 -	0.08	0.09	0.09	0.1	0.1	0.14				of
	0.020 -	0.1	0.09	0.13	0.1	0.09	0.09	0.020 -	0.1	0.12	0.14	0.11	0.13	0.15		- 12	20	sin
te	0.015 -	0.19	0.11	0.15	0.14	0.14	0.16	0.015 -	0.16	0.19	0.17	0.19	0.18	0.22				slur
a	0.010 -	0.29	0.29	0.31	0.3	0.32	0.28	0.010 -	0.36	0.32	0.33	0.45	0.34	NA				atec
sion		1	3	7	14	21	30		1	3	7	14	21	30		- 10	0	d tra
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F	0.045 -	0.03	0.02	0.03	0.03	0.06	0.21	0.045 -		0.03	0.03	0.04	0.07	0.2		- 80	80	on rate
	0.040 -	0.03	0.03	0.03	0.03	0.04	0.24	0.040 -	0.04	0.04	0.04	0.03	0.05	0.19				
	0.035 -	0.04	0.04	0.03	0.04	0.05	0.1	0.035 -	0.04	0.04	0.04	0.04	0.06	0.1				Ð
	0.030 -	0.05	0.04	0.04	0.04	0.05	0.06	0.030 -	0.05	0.04	0.05	0.04	0.05	0.06		- 60	Ň	
	0.025 -	0.05	0.05	0.05	0.05	0.06	0.08	0.025 -	0.06	0.06	0.05	0.06	0.07	0.06				
	0.020 -	0.07	0.08	0.06	0.06	0.08	0.08	0.020 -	0.08	0.09	0.09	0.08	0.09	0.09				
	0.015 -	0.1	0.1	0.08	0.09	0.09	0.09	0.015 -	0.11	0.1	0.1	0.13	0.13	0.12				
	0.010 -	0.15	0.17	0.15	0.19	0.18	0.19	0.010 -	0.26	0.22	0.2	0.26	0.24	0.23		- 40)	
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							Sam	pling inte	erval									

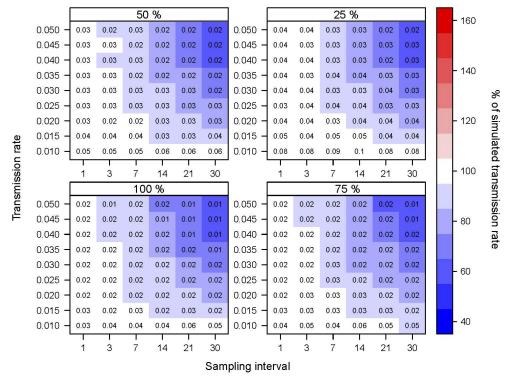
Epidemic: Method 2

Figure 7. SISsim model, epidemic situation, Method 2: Heatmaps showing the estimated transmission rates as percentage of the simulated transmission rate. The estimates are shown for four subsampling levels: 100%, 75%, 50% and 25%. Values in each cell show the relative standard deviation of the estimated rate divided by the simulated rate.



Endemic: Poisson regression

Figure 8. SISsim model, endemic situation, Poisson regression: Heatmaps showing the estimated transmission rates as percentage of the simulated transmission rate. The estimates are shown for four subsampling levels: 100%, 75%, 50% and 25%. Values in each cell show the relative standard deviation of the estimated rate divided by the simulated rate.



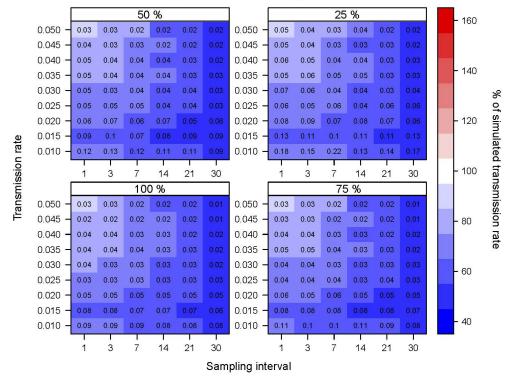
Endemic: Method 1

Figure 9. SISsim model, endemic situation, Method 1: Heatmaps showing the estimated transmission rates as percentage of the simulated transmission rate. The estimates are shown for four subsampling levels: 100%, 75%, 50% and 25%. Values in each cell show the relative standard deviation of the estimated rate divided by the simulated rate.

				50	%				25 %								160	
	0.050 -	0.03	0.03	0.04	0.04	0.11	0.15	0.050 -	0.04	0.05	0.05	0.1	0.13	0.17			100	
	0.045 -	0.03	0.04	0.03	0.05	0.06	0.16	0.045 -	0.04	0.04	0.04	0.07	0.12	0.15				
	0.040 -	0.03	0.03	0.04	0.04	0.06	0.1	0.040 -	0.04	0.04	0.04	0.06	0.09	0.17				
	0.035 -	0.03	0.03	0.03	0.03	0.04	0.08	0.035 -	0.04	0.04	0.05	0.06	0.08	0.14			140	
	0.030 -	0.03	0.03	0.03	0.04	0.04	0.06	0.030 -	0.04	0.05	0.04	0.04	0.08	0.09				%
	0.025 -	0.03	0.03	0.03	0.04	0.04	0.05	0.025 -	0.04	0.04	0.04	0.05	0.05	0.07				of
	0.020 -	0.03	0.03	0.03	0.03	0.04	0.05	0.020 -	0.04	0.04	0.04	0.04	0.06	0.06		ŀ	120	sin
ē	0.015 -	0.04	0.04	0.04	0.03	0.04	0.05	0.015 -	0.05	0.04	0.05	0.06	0.05	0.05				slur
Transmission rate	0.010 -	0.05	0.06	0.05	0.06	0.06	0.07	0.010 -	0.08	0.08	0.09	0.1	0.09	0.09				% of simulated transmission
ior		1	3	7	14	21	30		1	3	7	14	21	30			100	t
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F	0.045 -	0.02	0.02	0.02	0.03	0.04	0.07	0.045 -	0.02	0.03	0.03	0.03	0.06	0.09		ŀ	80	on
	0.040 -	0.02	0.02	0.03	0.03	0.03	0.06	0.040 -	0.02	0.02	0.02	0.03	0.04	0.06				rate
	0.035 -	0.02	0.02	0.02	0.03	0.04	0.04	0.035 -	0.03	0.03	0.02	0.04	0.04	0.06				e
	0.030 -	0.02	0.02	0.02	0.03	0.03	0.04	0.030 -	0.02	0.02	0.03	0.03	0.03	0.04			60	
	0.025 -	0.02	0.02	0.02	0.03	0.03	0.03	0.025 -	0.03	0.02	0.03	0.03	0.03	0.04			00	
	0.020 -	0.02	0.02	0.02	0.02	0.03	0.03	0.020 -	0.02	0.03	0.03	0.04	0.03	0.04				
	0.015 -	0.03	0.02	0.03	0.03	0.04	0.03	0.015 -	0.03	0.03	0.03	0.04	0.03	0.03				
	0.010 -	0.03	0.04	0.04	0.04	0.06	0.06	0.010 -	0.04	0.05	0.04	0.06	0.05	0.05			40	
		1	3	7	14	21	30		1	3	7	14	21	30				
Sampling interval																		

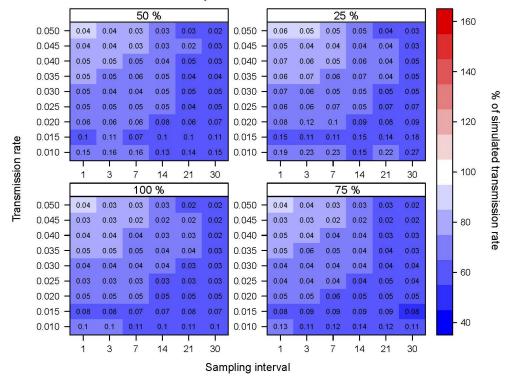
Endemic: Method 2

Figure 10. SISsim model, endemic situation, Method 2: Heatmaps showing the estimated transmission rates as percentage of the simulated transmission rate. The estimates are shown for four subsampling levels: 100%, 75%, 50% and 25%. Values in each cell show the relative standard deviation of the estimated rate divided by the simulated rate.



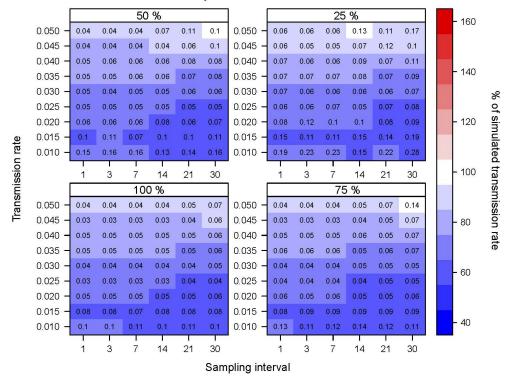
Epidemic: Poisson regression

Figure 11. SIScom model, epidemic situation, poisson regression: Heatmaps showing the estimated transmission rates as percentage of the simulated transmission rate. The estimates are shown for four subsampling levels: 100%, 75%, 50% and 25%. Values in each cell show the relative standard deviation of the estimated rate divided by the simulated rate.



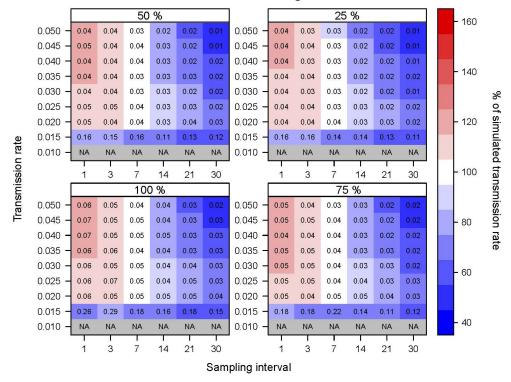
Epidemic: Method 1

Figure 12. SIScom model, epidemic situation, Method 1: Heatmaps showing the estimated transmission rates as percentage of the simulated transmission rate. The estimates are shown for four subsampling levels: 100%, 75%, 50% and 25%. Values in each cell show the relative standard deviation of the estimated rate divided by the simulated rate.



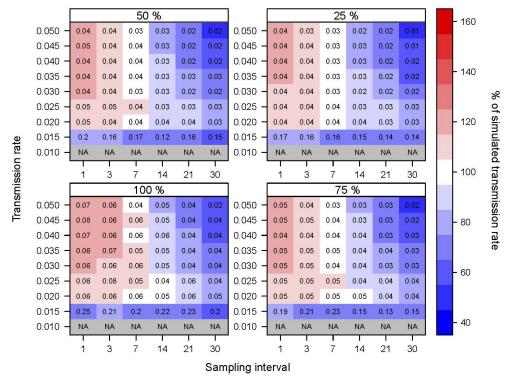
Epidemic: Method 2

Figure 13. SIScom model, epidemic situation, Method 2: Heatmaps showing the estimated transmission rates as percentage of the simulated transmission rate. The estimates are shown for four subsampling levels: 100%, 75%, 50% and 25%. Values in each cell show the relative standard deviation of the estimated rate divided by the simulated rate.



Endemic: Poisson regression

Figure 14. SIScom model, endemic situation, poisson regression: Heatmaps showing the estimated transmission rates as percentage of the simulated transmission rate. The estimates are shown for four subsampling levels: 100%, 75%, 50% and 25%. Values in each cell show the relative standard deviation of the estimated rate divided by the simulated rate.



Endemic: Method 1

Figure 15. SIScom model, endemic situation, Method 1: Heatmaps showing the estimated transmission rates as percentage of the simulated transmission rate. The estimates are shown for four subsampling levels: 100%, 75%, 50% and 25%. Values in each cell show the relative standard deviation of the estimated rate divided by the simulated rate.

				50	%				25 %								- 160	
	0.050 -	0.04	0.05	0.05	0.07	0.09	0.13	0.050 -	0.04	0.04	0.05	0.05	0.09	0.09			100	
	0.045 -	0.06	0.05	0.06	0.07	0.08	0.13	0.045 -	0.05	0.05	0.05	0.05	0.06	0.06				
	0.040 -	0.05	0.04	0.05	0.06	0.07	0.08	0.040 -	0.04	0.04	0.04	0.05	0.05	0.09				
	0.035 -	0.04	0.05	0.05	0.05	0.07	0.09	0.035 -	0.04	0.04	0.04	0.05	0.05	0.06			- 140	
	0.030 -	0.04	0.05	0.04	0.04	0.05	0.07	0.030 -	0.04	0.04	0.04	0.03	0.04	0.04				%
	0.025 -	0.05	0.05	0.05	0.05	0.05	0.06	0.025 -	0.04	0.04	0.04	0.04	0.05	0.05				of
	0.020 -	0.05	0.05	0.05	0.05	0.05	0.05	0.020 -	0.04	0.04	0.04	0.04	0.05	0.04		ł	- 120	sin
e	0.015 -	0.2	0.17	0.18	0.13	0.17	0.16	0.015 -	0.17	0.17	0.16	0.16	0.15	0.15				nula
Transmission rate	0.010 -	NA	NA	NA	NA	NA	NA	0.010 -	NA	NA	NA	NA	NA	NA				of simulated
ion		1	3	7	14	21	30		1	3	7	14	21	30			- 100	đ
lise		5	3	2) %	21	30	1 1	L.	5		20.00	21	30				transmission
LS I		and the second second				-												mi
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F	0.045 -	0.09	0.08	0.11	0.13	0.16	0.23	0.045 -	0.06	0.06	0.06	0.09	0.12	0.12		ł	- 80	on
	0.040 -	0.07	0.07	0.09	0.11	0.15	0.14	0.040 -	0.05	0.05	0.06	0.1	0.11	0.09		_		rate
	0.035 -	0.07	0.08	0.07	0.1	0.12	0.14	0.035 -	0.06	0.06	0.06	0.07	0.11	0.11				Ð
	0.030 -	0.06	0.07	0.07	0.09	0.1	0.11	0.030 -	0.05	0.06	0.05	0.06	0.07	0.09			- 60	
	0.025 -	0.06	0.08	0.07	0.07	0.11	0.09	0.025 -	0.06	0.05	0.06	0.06	0.06	0.08			00	
	0.020 -	0.06	0.06	0.07	0.06	0.08	0.09	0.020 -	0.05	0.05	0.06	0.06	0.06	0.06				
	0.015 -	0.25	0.21	0.2	0.23	0.24	0.21	0.015 -	0.19	0.21	0.23	0.16	0.14	0.17				
	0.010 -	NA	NA	NA	NA	NA	NA	0.010 -	NA	NA	NA	NA	NA	NA			- 40	
		1	3	7	14	21	30		1	3	7	14	21	30				
Sampling interval																		

Endemic: Method 2

Figure 16. SIScom model, endemic situation, Method 2: Heatmaps showing the estimated transmission rates as percentage of the simulated transmission rate. The estimates are shown for four subsampling levels: 100%, 75%, 50% and 25%. Values in each cell show the relative standard deviation of the estimated rate divided by the simulated rate.