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1 **Cost estimation of heifer mastitis in early lactation by stochastic modelling**

2

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19

20

21

21 **Abstract**

22

23 Heifer mastitis, reflected by an elevated somatic cell count (SCC) in early lactation
24 (SCC_{el}), results in a decreased milk production, a higher risk for subclinical and clinical
25 mastitis during lactation, and an elevated culling hazard. The aims of this study were to
26 calculate the costs of heifer mastitis defined as an elevated SCC in early lactation, and to
27 show the variation of these costs in the Dutch/Belgian dairy sector. A stochastic model, in
28 which the variation and uncertainty of heifer mastitis are taken into account, was developed
29 with input data from literature and expertise. Costs were estimated, using default values. The
30 mean costs for an elevated SCC_{el} that cured were on average €13/heifer present on a farm
31 (range: €0 to €118), for an elevated SCC at calving proceeding in subclinical mastitis on
32 average €5/heifer present on a farm (range: €0 to €82), and for a clinical heifer mastitis case
33 associated with an elevated SCC after calving on average €270. On average this results in
34 €13/heifer present on a farm (range: €0 to €137). Combined, these three cost aspects result in
35 a total cost of on average €31/heifer present on a farm (range: €0 to €220). The large variation
36 in the costs is very important regarding farm management and farm support. The difference in
37 costs reflects also the difference in room for investment. When the costs that can be prevented
38 are estimated at farm level, these data can be of help in setting goals in herd health advice and
39 farm management.

40

41 *Keywords:* costs, economics, heifer, mastitis,

42

43 **1. Introduction**

44

45 Although mastitis during lactation seems to be less prevalent in heifers than in older
46 cows, it is also in heifers a significant disease (Fox, 2007). In recent years heifer mastitis
47 received more attention. It is identified (e.g. Barkema et al., 1998, De Vliegheer et al., 2004)
48 that a large proportion of heifers is infected at the moment of calving, incorporating a threat to
49 production and udder health in the first and following lactations. During gestation impairment
50 of mammary development can have potential detrimental effects on future milk production
51 (De Vliegheer, 2004, Rupp and Boichard, 2000). It has been shown that an elevated SCC in
52 early lactation is associated with production losses (Coffey et al., 1986, De Vliegheer et al.,
53 2005a) and a higher risk for subclinical and clinical mastitis during lactation (Coffey et al.,
54 1986, Rupp and Boichard, 2000, De Vliegheer et al., 2004). Moreover, there is an increased
55 hazard of culling which can partially be explained by the production losses and an increased
56 risk for subclinical mastitis (De Vliegheer et al., 2005b). Subclinical and clinical mastitis cases
57 associated with an elevated SCC in early lactation will cause a decreased milk production and
58 additional costs for veterinarian, drugs, culling, discarded milk and extra labour. Although the
59 economics of mastitis has been covered in scientific literature (see for a recent overview
60 Halasa et al., 2007), apart from prepartum treatment effects (Oliver et al., 2003) little attention
61 has been paid to economical aspects of heifer mastitis. In the field of animal health
62 economics, the main goal of economic calculations is to support decisions on health
63 management. Management to specifically reduce the level of heifer mastitis should be
64 focussed on reducing the level of infection before or during calving of heifers. When advising
65 on management to reduce heifer mastitis, for most cases the starting point is the current farm
66 situation (i.e. Oliver et al., 2003). A correct economic analysis is therefore a marginal
67 analysis. Additional costs of improved management are compared with additional benefits
68 (i.e., reduced costs of heifer mastitis) of that management. Calculations of the costs of heifer
69 mastitis in the current situation, is the starting point for marginal economic analyses.

70 Knowledge on the costs of heifer mastitis in the current situation determines the maximum
71 room for investment in improved management. As such, it can support a decision whether or
72 not to improve management.

73 The aim of this study were to calculate the costs of heifer mastitis defined as an
74 elevated SCC in early lactation, both on farm and heifer level, and to show the variation of
75 these costs in the Dutch/Belgian dairy sector. These cost calculations can be used as an
76 indication of the room for investment in improved management on heifer mastitis.

77

78 **2. Materials and methods**

79

80 Based on calculation rules for mastitis described earlier (Huijps et al., 2007), a Monte
81 Carlo simulation model has been developed using @Risk software (Palisade Corporation,
82 Ithaca, NY, USA) to calculate the costs of heifer mastitis in a Dutch/Belgian situation. Monte
83 Carlo simulation is a computer technique to simulate the reaction of a model under repeated
84 measures. By taking different values from appropriate distributions of a parameter, the model
85 becomes stochastic and thus can take the variation and risk into account. The model
86 ultimately aims at supporting management decisions around heifer mastitis. We assume that
87 this type of management should reduce the risk of infection before or during calving of
88 heifers. In this study, heifer mastitis is therefore defined as heifers having an SCC higher than
89 200,000 cells/ml between 5 and 14 days in lactation (De Vliegher et al., 2004), referred to
90 through this paper as SCC in early lactation (SCC_{el}).

91

92 *2.1. Model description*

93

94 The model consists of 2 parts: the dynamics of heifer mastitis and the economic effects
95 of heifer mastitis. First the model simulates the dynamics of heifer mastitis. Either the
96 elevated SCCel cures or it remains elevated (De Vliegher et al., 2004). In the latter case
97 proceeding into “subclinical mastitis in lactation”. Alternatively, an elevated SCCel can be
98 associated with a case of clinical mastitis during lactation (Rupp and Boichard, 2000).
99 Secondly, the economic effects of heifer mastitis, using the outcome of the simulation of
100 dynamics, were calculated. Economic effects are expressed as costs per average farm with 20
101 heifers and per average heifer present on the farm. Figure 1 shows a graphical representation
102 of the model. Because of our definition there are relations (dashed arrows in Figure 1) that are
103 not included in the model.

104

105 **Figure 1 near here**

106

107 All discrete events and variability at the cow level were triggered stochastically, using
108 random numbers drawn from relevant distributions. Normal distributions were used when
109 data were available and variables were normally distributed. When precise data were not
110 available, minimum, most likely, and maximum values were put into a Pert distribution
111 (Vose, 2000) to prevent overestimation of the extreme values. For parameters with a yes/no
112 output (represented in the calculation as 1/0) a discrete variable was used. By changing the
113 variables that describe farm characteristics (number of heifers, number of heifers with
114 elevated SCC, etc.) the variability of parameters can be controlled using these different
115 distributions.

116

117 **Table 1 near here**

118

119 2.2. *Input data*

120

121 All input data were based on references, values in other papers, information provided
122 by six bovine practitioners or on the authors' expertise. Input data for the dynamics of heifer
123 mastitis, e.g. probabilities of getting mastitis, milk production losses, losses associated with
124 discarding milk and culling are given in Table 1. Input data for the economic part, e.g. costs
125 of production losses, veterinary costs, cost of treatment and drugs, labour costs, and culling
126 costs are given in Table 2.

127

128 **Table 2 near here**

129

130 2.3. *Dynamics of heifer mastitis*

131

132 The model simulates the dynamics of heifer mastitis of individual heifers. For a
133 default situation 20 heifers are simulated per farm. These heifers are simulated at the same
134 time. It is assumed that a heifer (i) can have only one case of mastitis at a time. A number of
135 consecutive simulation steps are taken per heifer. At first, each heifer is assigned with a milk
136 production, which is normally distributed with an average milk production and an average
137 standard deviation. Based on the assigned milk production, a relative milk production level is
138 calculated, where 100 is the average milk production level of the farm. There are five groups
139 of production levels made, group 1 with a low relative production level (75-90), group 2 with
140 a relative production level just below average (90-98), group 3 with a relative production
141 level around average (98-102), group 4 with a relative production level just above average
142 (102-110) and group 5 with a high relative production level (110-125).

143 Every heifer between 5 and 14 days after calving is assigned to one of four SCCel
144 groups (group 1 is corresponding with a SCCel < 200,000 cells/ml, group 2 is corresponding
145 with a SCCel between 200,000 and 500,000 cells/ml, group 3 is corresponding with a SCCel
146 between 500,000 and 1,000,000 cells/ml and group 4 is corresponding with a SCCel
147 >1,000,000 cells/ml). The probability of being in group 1, 2, 3 or 4 is 35, 25, 22 and 18%,
148 respectively (De Vliegher et al., 2004, experts).

149 Heifers with an elevated SCCel (SCCel group = 2, 3, or 4) can cure fast but also have
150 a probability of developing subclinical mastitis during the first weeks of lactation as a result
151 of this elevated SCCel. These cases of subclinical mastitis can be related with different SCC
152 levels, 50% of the heifers are at the level of 50,000 cells/ml, 25% at the level of 200,000
153 cells/ml, 17.5% at the level of 500,000 cells/ml, 5% at the level of 1,000,000 cells/ml and
154 2.5% at the level of 2,500,000 cells/ml (De Vliegher et al., 2004, experts).

155 An elevated SCCel is associated with an increased risk of clinical mastitis; subclinical
156 mastitis can develop into clinical mastitis. A heifer can also get a clinical mastitis
157 immediately after calving. The probability of getting clinical mastitis directly after calving
158 has a Pert distributed value with a most likely value of 15%, a minimum value of 10% and a
159 maximum value of 20%. The probability of getting clinical mastitis as a flare up of subclinical
160 mastitis with a SCC of 50,000 cells/ml, 200,000 cells/ml, 500,000 cells/ml, 1,000,000 cells/ml
161 or 2,500,000 cells/ml are 5, 5, 5, 10 and 25%, respectively (experts).

162 The production losses (expressed as a percentage loss of kg milk during the whole
163 lactation) are dependent on the mastitis state. Production losses are respectively 1.1%, 1.8%,
164 2.4% and 3.1% for SCCel group 1, 2, 3 or 4. When a heifer has subclinical mastitis with a
165 SCC of 50,000 cells/ml, 200,000 cells/ml, 500,000 cells/ml, 1,000,000 cells/ml or 2,500,000
166 cells/ml the production losses are 0, 2, 5, 8 and 10%, respectively (De Vliegher et al., 2005b).
167 For a clinical mastitis the production losses are 5%.

168 All clinical cases are treated by the farmer or the veterinarian. According to the
169 practitioners in 5% of the clinical mastitis cases the veterinarian is consulted, the rest of the
170 cases are treated by the farmer. The percentage of subclinical mastitis cases treated by the
171 farmer is estimated at 5%, the probability of consulting a veterinarian is estimated at 2%. The
172 treatment of clinical or subclinical mastitis is estimated to take 45 minutes per treated case.
173 When a heifer is treated there will be discarded milk for the period of treatment (estimated to
174 be 4 days) and waiting days (estimated to be 5 days) (experts).

175 Every heifer has a probability of being culled, dependent on the mastitis state and the
176 production level. The probabilities of being culled for the different combinations of
177 production level and mastitis status are given in Table 3.

178

179 **Table 3 near here**

180

181 *2.4. Economics*

182

183 Mastitis costs are caused by production losses, culling, visits of the veterinarian, drugs,
184 discarded milk, and labour (Table 2). Costs of production losses are calculated by multiplying
185 the amount of production losses (kg) caused by an elevated SCCeI, subclinical or clinical
186 mastitis with the costs per kg of production losses. Costs of production losses within the
187 Dutch quota system are estimated to be €0.12 per kg (Huijps et al., 2007).

188 Veterinary costs were calculated by multiplying the number of veterinary treatments with the
189 costs per visit. Antibiotic costs are calculated by multiplying the number of treatments with
190 the costs for drugs. The total costs for discarded milk (DM) occur for the treated cases:

191

192
$$DM_t = \sum DM_i * (\text{costs of production losses} + 0.05)$$

193

194 where Dm_i is the amount of discarded milk for heifer i .

195 Treatment of mastitis is labour intensive. Costs for labour is calculated by multiplying

196 the time spend on treatments with the hourly rate.

197 The costs for culling are dependent on the production level and are calculated by

198 multiplying the number of cases culled with the culling costs per case. The culling costs per

199 case are dependent on the production level of that heifer and can vary. The culling costs are

200 estimated per relative production level defined as a Pert distribution with a minimum, most

201 likely and maximum value (Table 3).

202 During the simulation many iterations are carried out. Each iteration consists of a

203 calculation of all heifers of a farm, representing one year. Because of the distributions,

204 outcomes per iteration (year) can vary. Outcomes were updated with results from each

205 iteration until they reached a steady state, by monitoring the convergence of the outcomes.

206 Monitoring convergence was done by calculating the percentiles (0 to 100% in 5%

207 increments), mean, and standard deviation on the data generated for each output parameter at

208 regular intervals throughout the simulation. These statistics were then compared with the

209 same statistics calculated at the prior interval during the simulation. The amount of change in

210 statistics due to the additional iterations was then calculated. When the convergence

211 percentage reached 1.5%, the outcome was regarded as having reached a steady state and the

212 simulation was ended.

213

214 *2.5. Sensitivity analyses*

215

216 All input factors described above represent a default situation. All input factors can be

217 changed by the user of the model to simulate different situations. In this research next to the

218 default situation, a situation with more heifers and a situation with a higher probability of
219 mastitis were carried out. To show the importance of the value of input factors a sensitivity
220 analysis was carried out. All input variables were checked for values between -10% and
221 +10% of the base value.

222

223 **3. Results and Discussion**

224

225 *3.1. Costs of heifer mastitis*

226

227 The purpose of economic calculations is to support decision making. Before
228 considering changes in management on a certain disease, it is important to have insight in the
229 room for investment for that particular disease. The total cost of a disease however, is not the
230 same as the room for investment, which equals the preventable costs, given the constraints of
231 a specific farm. Examples of such constraints are the farming system, the environment and the
232 available housing. Given the constraints there exists some base level of mastitis that one
233 should view as not preventable. When the total costs of a disease are known, determining the
234 level of preventable and non-preventable costs, and thus the room for investment, requires
235 expertise of the farmer and his advisor. Thus when considering taking measures against heifer
236 mastitis, it is important to know what the costs of heifer mastitis on a specific farm are and
237 which reliable goals can be set. Specific management around heifer mastitis is directed to the
238 period before and during calving. The economic effects of heifer mastitis take place in
239 primiparous cows. For primiparous cows having mastitis which does not originate from the
240 period before or during calving, management is roughly the same as management for mastitis
241 in multiparous cows. Therefore, in this study heifer mastitis was defined as primiparous cows
242 having an elevated ($>200,000$ cells/ml) between 5 and 14 days after calving. The economic

243 calculations were based on these cases of mastitis, and on subclinical and clinical mastitis
244 cases potentially associated with it during lactation. This means that subclinical and clinical
245 mastitis cases occurring during lactation in heifers with a normal SCCel (<200,000 cells/ml)
246 are not included (these are the dotted lines in Figure 1). The use of a threshold of 200,000
247 cells/ml to define SCCel is debatable. Lower thresholds (150,000 cells/ml) are also used as
248 threshold to define an increased level of SCC in primiparous cows. The somewhat higher
249 threshold was used because the availability of effect estimations using this threshold (De
250 Vlieghe et al., 2004), which might have led to a slight underestimation of the costs of heifer
251 mastitis. Because of the lack of good transmission data, the costs of transmission of infections
252 has also not been taken into account in the model. This might also have led to an
253 underestimation of the costs of heifer mastitis as presented in this paper.

254 Using default values, the total costs of heifer mastitis are €626 per farm level per year
255 and €31 per heifer per year. These costs are distributed over an elevated SCCel after calving
256 which cures (€260 and €13), subclinical mastitis (€94 and €5) and clinical mastitis (€270 and
257 €13). The most important factors causing these costs are culling and production losses (Table
258 4). For all factors a large variation is present which is important to take into account. For
259 instance, the total costs caused by heifer mastitis per average heifer present on a farm was
260 only a small proportion of the total costs of mastitis per average cow on a farm, which was
261 estimated to be €140 (Huijps et al., 2007). When comparing these costs, in addition to the
262 definition being used in this study, the possibility of long term effects of heifer mastitis have
263 to be taken into account. Rupp et al. (2000) showed that heifers with udder health problems
264 during first lactation are more likely to have udder health problems in the second lactation as
265 well, and Barker et al.(1998), showed that clinical mastitis during early lactation has a
266 negative effect on the reproductive performance of the animals. The costs calculated in our
267 study will therefore underestimate the real costs of mastitis in heifers.

268 On farm level, the total costs of heifer mastitis for a farm with 20 heifers calving per
269 year are on average €626 per year. However, the 5% percentile is €85 and the 95% €1,657.
270 Some farmers may have many problems with heifer mastitis and for these farmers the costs
271 will be much higher. A farm with 120 cows and 40 heifer calvings per year, will have higher
272 total costs (on average €1,220 per year), but the variation is relatively smaller (€184 - €2,008
273 per year) A farm with 65 cows (20 heifers) but with a very high risk of mastitis will have
274 higher average costs (€1,220) and a very large variation (€314 - €4,367 per year). Figure 2
275 shows the total costs per average heifer present on a farm for these three different farm types
276 (default, large farm and high risk farm). Important is that the average costs for the default and
277 the large farm are more or less the same while the 5% and 95% interval is smaller for the
278 larger farm due to the larger number of animals. For the farm with the high risk, the average
279 costs as well as the 5% and 95% interval are higher.

280 In the costs mentioned above, the labour costs were included at €18 per hour.
281 However, it is a difficult factor to quantify an hourly rate, and thus labour, in this type of
282 calculations. On many (family) farms, opportunity costs of relatively small amounts of labour,
283 such as in treatment of clinical mastitis cases, are zero. However, the work associated with
284 mastitis is regarded as annoying (Kuiper et al., 2005). Therefore, in the default calculations,
285 labour was included as a cost factor. When not including labour in the calculation, the total
286 costs of heifer mastitis for a 65 cow farm with 20 heifers are on average €11 per year less.

287 The costs calculated in this study apply to the Dutch/Belgian dairy sector including a
288 quota system. Results of these calculations might therefore not be valid for other countries.
289 For implementation in other dairy systems or countries, the input variables should be adapted.

290

291 **Figure 2 near here**

292

293 Besides the total costs of a disease, it is important to know which part of these costs
294 can be prevented. If we know the amount of costs that can be prevented and the measures
295 necessary to prevent them, this can be implemented in an advice and a change in farm
296 management. Knowledge on the costs at herd level will support decisions how to prevent
297 these costs. Regarding our default calculations, room for investments to improve the
298 incidence of heifer mastitis is limited. But for farms with many problems there certainly is
299 room for investment. Although dependent on the farm situation a theoretical base level for the
300 room for investment for problem herds consists of a maximum of around €900 (the difference
301 between the 90% and 10% farms).

302

303 *3.2. Sensitivity analysis*

304

305 Figure 3 shows the difference in total costs per year per average heifer present on a
306 farm when varying the different input values with +/- 10% of the base value. Sensitivity
307 analysis showed that the model is most sensitive for changes in the probability of calving with
308 an elevated SCC, the probability of culling, culling costs, and production losses.

309

310 **Figure 3 near here**

311

312 In this paper we presented average costs and showed, with the sensitivity analysis, the
313 importance of certain input factors. When using a cost calculation for a specific farm, it is
314 important to adjust the calculations for that specific farm. The probability of calving with an
315 elevated SCCel is an available parameter at farm level. The probability of culling, and culling
316 costs are factors which are very uncertain and difficult to predict at farm level, but are very
317 important in the model calculations. Historic data on culling are available but it is sometimes

318 hard to judge the cause of culling. Another important factor is milk production. Heifers with
319 an elevated SCC at calving that do not remain subclinically infected will have production
320 losses (De Vliegher et al., 2005b). The production level of the farm is known, but production
321 losses are difficult to see, because it is milk that is never produced and is therefore regarded as
322 a hidden cost which is difficult to estimate. To develop stable and reliable model outcomes it
323 is important to optimize the information of the factors which can be influenced on farm level
324 and to estimate the other factors as good as possible by modelling, expertise, and available
325 data. This can be further developed by using good farm management records.

326

327 **4. Conclusions**

328

329 Having knowledge on the costs of heifer, mastitis supports decision making. With a
330 definition of heifer mastitis being primiparous cows having an elevated SCCel ($> 200,000$
331 cells/ml) after calving, the average costs of heifer mastitis are under default circumstances
332 €626 on farm level (€85 - €1657) and €31 (€4.29 - €82.86) per heifer present on a farm. The
333 variation between the costs of farms is very large, which means that the room for investment
334 in improved management on heifer mastitis differs between farms.

335

336 **Acknowledgement**

337

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339 Centre and was financially supported by the Dutch Dairy Board. The authors would like to
340 thank the six bovine practitioners who gave input for the model.

341

342 **Conflict of interest**

343

344 None of the authors (K. Huijps, S. De Vliegheer, T.J.G.M. Lam, H. Hogeveen) has a
345 financial or personal relationship with other people or organizations that could inappropriately
346 influence or bias the paper entitled “Cost estimation of heifer mastitis in early lactation by
347 stochastic modelling”.

348

349 **References**

- 350 Barkema, H.W., Schukken, Y.H., Lam, T.J.G.M., Beiboer, M.L., Wilmink, H., Benedictus,
351 G., Brand, A., 1998. Incidence of clinical mastitis in dairy herds grouped in three
352 categories by bulk milk somatic cell counts. *J. Dairy Sci.* 81, 411 – 419.
- 353 Barker, A.R., Schrick, F.N., Lewis, M.J., Dowlen, H.H., Oliver, S.P., 1998. Influence of
354 clinical mastitis during early lactation on reproductive performance of jersey cows. *J.*
355 *Dairy Sci.* 81, 1285 – 1290.
- 356 Coffey, E.M., Vinson, W.E., Pearson, R.E., 1986. Somatic cell counts and infection rates for
357 cows of varying somatic cell count in initial test of lactation. *J. Dairy Sci.* 69, 552 – 555.
- 358 De Vliegheer, S., 2004. Udder health in dairy heifers: some epidemiological and
359 microbiological aspects. PhD thesis, UGent, Belgium.
- 360 De Vliegheer, S., Barkema, H.W., Stryhn, H., Opsomer, G., de Kruif, A., 2004. Impact of early
361 lactation somatic cell count in heifers on somatic cell counts over the first lactation. *J.*
362 *Dairy Sci.* 87, 3672 – 3682.
- 363 De Vliegheer, S., Barkema, H.W., Opsomer, G., de Kruif, A., Duchateau, L., 2005a.
364 Association between somatic cell count in early lactation and culling of dairy heifers
365 using Cox frailty models. *J. Dairy Sci.* 88, 560 – 568.

- 366 De Vliegher, S., Barkema, H.W., Stryhn, H., Opsomer, G., de Kruif, A., 2005b. Impact of
367 early lactation somatic cell count in heifers on milk yield over the first lactation. *J. Dairy*
368 *Sci.* 88, 938 – 947.
- 369 Fox, L.K., 2007. Prevalence and incidence of clinical and subclinical heifer mastitis. In:
370 *Proceedings Heifer mastitis conference 2007*. Ghent, Belgium. pp. 62 – 64.
- 371 Huijps, K., Lam, T.J.G.M., Hogeveen, H., 2007. Costs of mastitis: facts and perception. *J.*
372 *Dairy Res.* 75, 113-120.
- 373 Kuiper, D., Jansen, J., Renes, R.J., Leeuwis, C., Van der Zwaag, H.G., 2005. Social factors
374 related to mastitis and control practices: The role of dairy farmer's knowledge, attitude,
375 values, behaviour, and networks. *Mastitis in Dairy Production. Current knowledge and*
376 *future solutions*. 4th IDF International Mastitis Conference Maastricht. Pp. 567 – 582.
377 The Netherlands: Wageningen Academic Publishers.
- 378 Oliver, S.P., Lewis, M.J., Gillespie, B.E., Dowlen, H.H., Jaenicke, E.C., Roberts, R.K., 2003.
379 Parturient antibiotic treatment of heifers: milk production, milk quality and economic
380 benefit. *J. Dairy Sci.* 86, 1187 – 1193.
- 381 Rupp, R., Boichard, D., 2000. Relationship of early first lactation somatic cell count with risk
382 of subsequent first clinical mastitis. *Liv. Prod. Sci.* 62, 169 – 180.
- 383 Van den Borne, B.H.P., Van Schaik, G., Nielen, M., Lam, T.J.G.M., 2007. Prevalence and
384 incidence of (sub)clinical mastitis in heifers in a random sample of dairy herds in the
385 Netherlands. In: *Proceedings Heifer Mastitis Conference 2007*, Ghent, Belgium. Pp. 65
386 – 66.
- 387 Van der Walle, K., 2004. Gebruikswaarde van melkvee. Internal report. Animal Science
388 Group Wageningen UR, Lelystad, the Netherlands.
- 389 Vose, D., 2000. Defining distributions from expert opinions. In: *Risk Analysis: A quantitative*
390 *guide*. 2nd ed. John Wiley & Sons. Chichester, UK. Pp. 262 – 271.
- 391

391 Table 1

392 Input data of the stochastic simulation model for the dynamics of heifer mastitis for an
 393 elevated somatic cell count in early lactation (between 5 and 14 days in milk) (SCCel) which
 394 cures, an elevated SCCel proceeding into subclinical mastitis (Sub.), and an elevated SCCel
 395 associated with clinical mastitis (Clin.).

		SCCel	Sub.	Clin.	Reference
Probability of occurrence	Minimum		0.10	0.10	De Vlieghe et al., 2004
	Most likely	0.35	0.15	0.15	Van den Borne et al., 2007
	Maximum		0.2	0.2	
Production losses		0 – 3.1% ¹	0 – 10% ¹	5%	De Vlieghe et al., 2005b Hortet and Seegers, 1998
Probability treatment vet		0	2%	5%	Bovine practitioners
Probability treatment farmer		0	5%	All	Bovine practitioners
Withholding period		9	9	9	Bovine practitioners
	- Treatment days	4	4	4	Bovine practitioners
	- Waiting days	5	5	5	Bovine practitioners
Labor time farmer (minutes)		45	45	45	Bovine practitioners
Probability culling		1 – 10% ²	8 – 13% ²	8 – 13% ²	De Vlieghe et al., 2005a

396 ¹The production losses depend on the individual SCC of the heifer

397 ²The probability of culling is depends on the production level of the heifer

398

398 Table 2

399 Input data of the stochastic simulation model for the general and economic input of heifer
 400 mastitis for an elevated somatic cell count in early lactation (between 5 and 14 days in milk)
 401 (SCC_{el}) which cures, an elevated SCC_{el} proceeding into subclinical mastitis, and an elevated
 402 SCC_{el} associated with clinical mastitis.

	Value	Reference
Yearly (365 days) milk production (kg)	8300	De Vliegher et al., 2005a
Variance in milk production (%)	5	Huijps et al., 2007
Veterinary costs (€/visit)	40	Bovine practitioners
Antibiotic costs (€/case)	75	Bovine practitioners
Culling costs (€/culled case)	300 – 900 ¹	Van der Walle, 2004
Labor costs (€/hour)	18	Huijps et al., 2007
Costs production losses (€/kg)	0.12 / 0.17 ²	Huijps et al., 2007

403 ¹The culling costs depend on the production level of the heifer and are all pert-distributed
 404 with a minimum, most likely, and maximum value.

405 ²The costs of production losses are €0.12 per kg milk, while the costs of discarded milk are
 406 €0.17 per kg milk because feed costs are included as well.

407

407 Table 3

408 Probabilities of being culled and culling costs (minimum, most likely, maximum) for the
 409 different combinations of production level and elevated somatic cell count in early lactation
 410 (SCC_{el}), subclinical or clinical mastitis, based on De Vliegher et al., 2004 and expert opinion,
 411 as used in the stochastic model.

Production level	SCC _{el}	Subclinical or clinical mastitis	Culling costs (€/culled case)		
			minimum	most likely	maximum
1	10%	13%	300	400	500
2	7%	12%	400	500	600
3	5%	11%	500	600	700
4	3%	10%	600	700	800
5	1%	8%	700	800	900

412

413

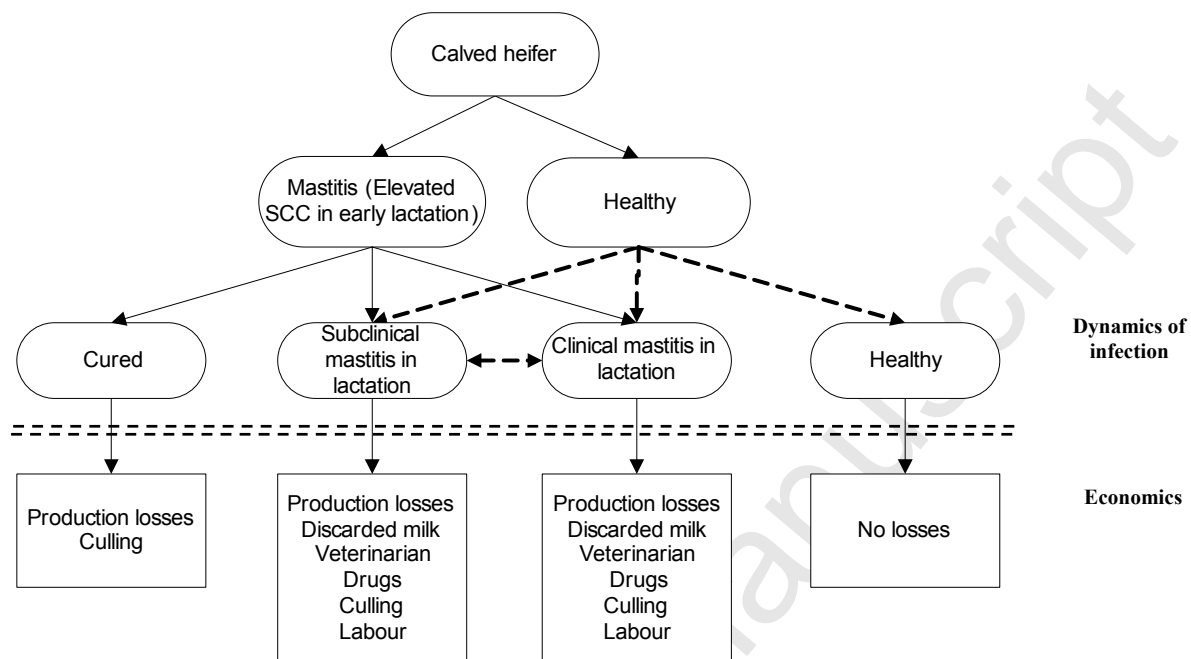
413 Table 4

414 Costs for an elevated somatic cell count in early lactation (SCCel) which cures, and for
 415 subclinical and clinical mastitis associated with an elevated SCCel. Given are the averages
 416 (minimum and maximum) in € per average heifer present.

Cost Factor	SCCel		Subclinical		Clinical	
	Farm	Heifer	Farm	Heifer	Farm	Heifer
Production	112.38	5.61	17.12	0.86	59.31	2.94
losses	(0 – 291.66)	(0 – 14.58)	(0 – 258.05)	(0 – 12.90)	(0 – 432.60)	(0 – 18.46)
Discarded	-	-	2.70	0.14	39.36	1.95
milk			(0 – 82.55)	(0 – 4.12)	(0 – 287.12)	(0 – 12.25)
Veterinarian	-	-	0.96	0.05	1.88	0.11
			(0 – 80)	(0 – 4)	(0 – 80)	(0 – 5.33)
Drugs	-	-	5.55	0.28	83.82	4.15
			(0 – 150)	(0 – 7.5)	(0 – 600)	(0 – 25)
Culling	150.31	7.51	67.37	3.37	70.95	3.49
	(0 – 2257.85)	(0 – 112.89)	(0 – 1590.12)	(0 – 79.51)	(0 – 2064.14)	(0 – 104.29)
Labour		-	0.67	0.03	14.45	0.71
			(0 – 27)	(0 – 1.35)	(0 – 108)	(0 – 4.5)
Total	262.70	13.13	94.37	4.72	269.78	13.49
	(0 – 2375.52)	(0 – 118.78)	(0 – 1637.48)	(0 – 81.83)	(0 – 2756.19)	(0 – 137.81)

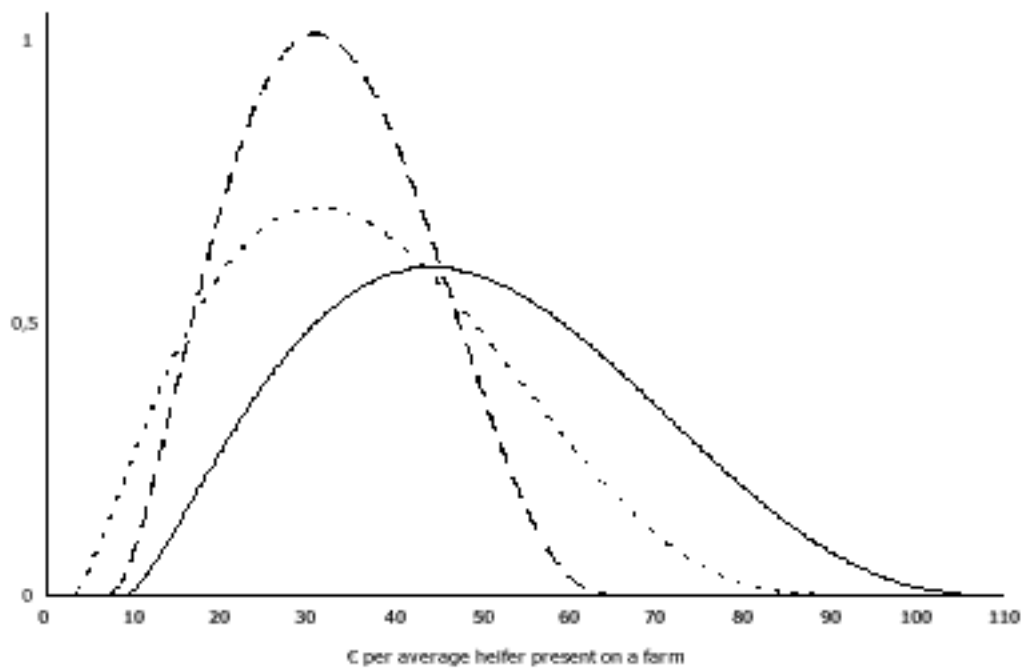
417

417 Fig. 1. Graphical representation from one heifer of the stochastic model to simulate the
 418 dynamics of heifer mastitis and its economic consequences. The dashed arrows are relations
 419 that are not included in the calculation.



420

421 Fig. 2. Farm level costs for three different types of farms: average farm with 65 cows and 20
422 heifers (---); large farm with 120 cows and 40 heifers (—), and a farm with 65 cows and 20
423 heifers with a high risk of mastitis (—)



424

425 Fig. 3. Results in € per average heifer present on a farm of the sensitivity analysis for different
426 input values with +/-10% deviation from the default value.

