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Risk factors for unassisted on-farm death in Swedish dairy cows

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Abstract

Increased on-farm cow mortality (ie unassisted death and euthanasia) has been demonstrated in Swedish dairy herds during the last decade. Identifying risk factors associated with type of death is needed for future work in reducing cow mortality rates. The objectives of this case-control study were to quantify the relative proportion of unassisted dead cows among cows that die on-farm, and to identify risk factors associated with unassisted death (as opposed to euthanasia). In Sweden, cadavers and animal waste products are being processed into biofuel at destruction plants. Two destruction plants were visited three times in 2011–2012. All dairy cows (n = 556) entering the plants were examined. Farmers that had sent the cows were contacted by telephone to verify type of death. Of the 433 dairy cows included in the analysis, 30% had died unassisted. A stillbirth rate above or equal to the median in the study material (7%) increased the risk for unassisted death. The proportion of unassisted dead cows was lower than that found in other countries. The results indicate that it might be possible to study euthanasia and unassisted death as one group in Swedish dairy cows, because only one factor differentiating between the two types of death was identified. However, unidentified risk factors may still differ and, possibly more importantly, welfare implications may also differ between the two types of death which implies the need to separate them in future studies.

Keywords: *animal welfare, dairy cattle, destruction plant, interview, mortality, stillbirth*

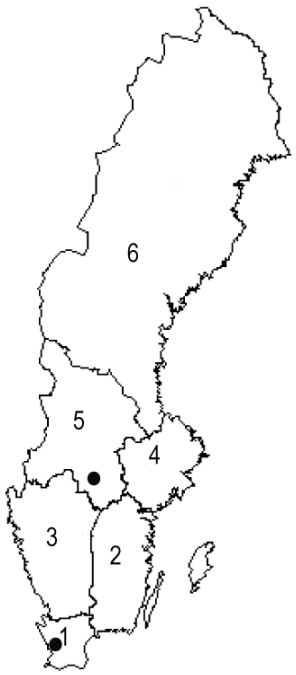
Introduction

A high rate of on-farm mortality (ie euthanasia and unassisted death) may be an animal welfare problem and is associated with high financial losses for the farmers. Increasing mortality rates have been reported in Denmark, Sweden, and the USA in the last decade (Thomsen *et al* 2004; Miller *et al* 2008; Alvåsen *et al* 2012). In Sweden, dairy cow mortality rates increased from 5.1 to 6.6 deaths per 100 cow-years between 2002 and 2010 (Alvåsen *et al* 2012). The underlying cause of the increase is unknown and unassisted death and euthanasia may well have different implications. Thus, a high proportion of unassisted death is likely an animal welfare problem as the animal often will suffer from fear or pain before death. A high proportion of euthanised cows may be an indication of a high number of seriously ill cows, which of course is problematic, but it may also be a consequence of a reduced threshold for euthanasia (ie euthanasia instead of treatment). A reduced threshold for euthanasia may be better from a welfare perspective if cows are euthanised at an early stage of disease and will therefore not have to go through a period of suffering from disease and treatment attempts. With the possible difference in implications it is also conceivable that factors increasing the risk for on-farm mortality may differ between unassisted death and euthanasia. Still, there are only a few studies of on-farm mortality that distinguish between euthanasia and unassisted death (Thomsen *et al* 2004; Thomsen & Sørensen 2008, 2009; McConnel *et al* 2009, 2010; Thomsen *et al* 2012).

To have a possibility of reversing the trend in increasing mortality rates, knowledge about the relative proportions of unassisted death and euthanasia is needed. Swedish dairy farmers are required by law to report births, movements between herds, death and culling of cattle to the central register of bovine animals. The proportion of euthanised cows and cows that die unassisted is not known in Sweden. The reason being that both types of death are reported with the same code, ie they are not distinguishable in the recording scheme.

More than 95% of all dairy cows that die on-farm in Sweden are processed at destruction plants (except cows

Figure 1



Definition of the six geographical regions of Sweden included in the analyses of characteristics for unassisted death, as opposed to euthanasia, in 433 Swedish dairy cows. Numbers refers to: 1 = Södra Götaland; 2 = Östra Götaland; 3 = Västra Götaland; 4 = Östra Svealand; 5 = Västra Svealand; 6 = Norrland. Locations of the two destruction plants are marked with dots.

in sparsely populated areas where transport becomes too expensive), and such plants therefore offer the possibility of investigating the relative proportions of unassisted death and euthanasia. At the destruction plants, cadavers and other animal waste products are crushed and ground into slurry, and the slurry is later transported to thermal power stations for incineration.

The objectives of this study were to quantify the proportion of unassisted death among cows that die on Swedish dairy farms, and to evaluate risk factors at the cow and herd level that differentiate unassisted death from euthanasia.

Materials and methods

Study design and target population

In this case-control study the target population was cows in herds enrolled in the Swedish Official Milk Recording Scheme (SOMRS). In 2012, the SOMRS comprised approximately 273,000 cows which is 85% of all dairy cows in Sweden (Växa Sweden 2013). Cases were defined as cows identified at destruction plants that had died unassisted and controls were all euthanised cows found on the same destruction plant during the same sampling occasion.

Data collection at destruction plants

There are two main destruction plants in Sweden, Mosserud and Krutmöllan (Figure 1), which handle almost all cadavers sent for destruction (the only exception being cows that die on-farm on the island, Gotland). Mosserud was visited from 29th to 31st March, 21st to 23rd July and 27th to 29th October, 2011. Krutmöllan was visited from 14th to 16th July 2011, from 2nd to 4th November 2011 and on 21st to 23rd March 2012. The sampling occasions were spaced in time in order to capture potential seasonal effects. The grazing season in Sweden occurs between May and September and lasts for at least two months in the north, three months in the central and four months in the south region according to Swedish legislation. Cows were brought to destruction plants in containers, mixed with other species and slaughter waste. A crane grabber was used to move cadavers individually. All dairy cows with a well-developed udder, ie no heifers, were examined during the visits by the first author. The ear-tag number and whether the cow was euthanised or not were registered. A hole in the forehead (caused by a bullet or by a penetrating captive bolt) was used as an indication of euthanasia (Gilliam *et al* 2012), because these were believed to be the most common methods used in Sweden.

The necessary number of cows to examine for an estimation of the relative proportion of unassisted dead cows was calculated according to the following equation (Toft *et al* 2003):

$n = (Z_{1-\alpha/2})^2 \times p(1-p)/L^2$, where n is the number of cows to examine, $Z_{1-\alpha/2}$ is 1.96 for a confidence-level of 95%, p the probability for euthanasia and L the maximum allowable error. Because p was unknown at the start of the study it was set at 0.5, which gives the largest sample size, and L was set to 0.05. Therefore $n = 1.96^2 \times 0.5\ (1-0.5)/0.05^2 = 384$. There were no available figures for the number of cows entering the destruction plants per year, but based on the known mortality rate we estimated that approximately 30 dairy cows would be available each day at each destruction plant throughout the year and nine days per plant would then provide more cows than the minimum sample size.

Telephone interviews with farmers

Immediately after each visit to a destruction plant contact details for the farmers were retrieved from the Swedish Board of Agriculture. Farmers were contacted by mail with information about the study, that we would contact them for a telephone interview and that all information would be confidential. During the telephone interviews the farmers were asked questions from a questionnaire (modified after Thomsen *et al* 2004) regarding the specific cow examined at the destruction plant, and if they would grant access to data from the SOMRS. The farmer was asked whether the cow had died unassisted or was euthanised and the reason for euthanasia or unassisted death. Whether the cow died unassisted or was euthanised is hereafter referred to as type of death. If the cow was euthanised, we asked who

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Table 1 Descriptive statistics of the categorical herd-level explanatory variables used in evaluating risk factors for unassisted death in Swedish dairy cows that died on-farm[†].

Variable	Category	Unassisted dead cows (%)	Number of cows	Number of herds	*P*-value[‡]
BMSCC[§#] (per ml)	< 255,000	29	186	165	0.79
	≥ 255,000	30	195	161	
Geographical region[¶]	Södra Götaland (1)	30	40	31	0.62
	Östra Götaland (2)	23	92	84	
	Västra Götaland (3)	34	175	145	
	Östra Svealand (4)	27	26	24	
	Västra Svealand (5)	30	30	25	
	Norrland (6)	31	70	59	
Housing system	Tie-stall	26	156	138	0.24
	Free-stall	34	223	180	
Management type	Conventional	31	387	329	0.34
	Organic	24	46	39	
Stillbirth 0–1 days[§] (deaths per 100 cow-years)	< 6.97	24	190	167	0.03
	≥ 6.97	35	190	158	

[†] Complete herd-level information was obtained for 379 cows from 318 herds.
[‡] Univariable analysis (Wald test).
[§] Yearly means for the period between 1st September 2010 and 31st August 2011.
[#] BMSCC = Bulk milk somatic cell count
[¶] Numbers in parentheses refer to different regions identified in Figure 1.

performed the euthanasia and which method was used. All telephone interviews were carried out by the first author and within three weeks of the date the cow was examined at the destruction plant to reduce recall bias.

Data from Växa Sweden

Available information from the SOMRS was retrieved for all cows examined at the destruction plant from herds that were enrolled in the SOMRS. These data contained the following cow-level information: breed, disease treatments, parity, and information about the latest calving. It also included the following information on herd level: bulk milk somatic cell count (BMSCC), stillbirth rate (stillborn calves and calves that died within 24 h after birth), calving interval, on-farm cow mortality rate (ie unassisted death and euthanasia), proportion of cows with a calving to first artificial insemination interval above 70 days, housing system, herd size, management type, milk yield, geographical region, and proportion of first parity cows. The different geographical regions are shown in Figure 1. The herd-level information was means based on the period between 1st September 2010 and 31st August 2011.

Data editing

A total of 556 dairy cows were examined at the destruction plants. Of the examined cows, 123 were excluded from the study because: two cows could not be found in the register of the Swedish Board of Agriculture; two cows because the farmers did not want to participate in the study; 14 cows because the farmer could not be reached by phone; 41 cows because the herds did not participate in the SOMRS; and 64 cows because the examination at destruction plant and information from the farmers did not match regarding type of death, or because the farmer did not remember the specific cow. The final dataset contained information on 433 cows from 368 different herds (every herd contributed with one to five cows). Complete herd-level information was obtained for 374 cows from 318 herds.

Statistical analysis

A multivariable conditional logistic regression model was used to study risk factors for a cow dying unassisted (as opposed to being euthanised). Conditional logistic analysis differs from regular logistic regression in that the data are stratified and the likelihoods are computed relative to each stratum (Dohoo *et al* 2009). In this analysis, sampling occasion and destruction plant formed six strata distributed as follows (cases and controls): 10 and 31; 15 and 35; 23 and 42; 13 and 54; 21 and 53; 30 and 53. Unassisted death (yes or no) was the outcome and the categorical and continuous herd-level risk factors (Tables 1 and 2, respectively) and cow-level risk factors were considered as potential explanatory variables (Table 3). Linearity between the continuous variables and the outcome (logit [*p*]) was checked using the lintrend command in Stata/SE 11.0 (StataCorp, College Station, TX, USA). Whenever this relationship was linear,

Table 2 Descriptive statistics (minimum, quartiles and maximum) of the continuous herd-level explanatory variables used in evaluating risk factors for unassisted death in Swedish dairy cows that died on-farm[†‡].

Variable	Min	Q1	Q2	Q3	Max	n[§]	*P*-value[#]
Calving interval (days)	354	391	405	424	537	318	0.50
Calving to first AI[¶] interval > 70 days (%)	5.1	15.8	22.5	31.4	100.0	327	0.91
Cow mortality (deaths per 100 cow-years)	0	4.2	6.6	9.3	29.5	327	0.33
First parity cows (%)	3.4	32.3	39.0	44.1	63.8	318	0.98
Herd size (n)	11	50	79	135	555	318	0.63
Milk yield (kg of ECM[¥])	4,443	8,836	9,516	10,273	13,029	318	0.95

[†] Complete herd-level information was obtained for 318 herds.
[‡] Yearly means for the period between 1st September 2010 and 31st August 2011.
[§] Number of herds. Each herd contributes with one value.
[#] Univariable analysis (Wald test).
[¶] AI = Artificial insemination.
[¥] ECM = Energy-corrected milk.

Table 3 Descriptive statistics of the cow-level explanatory variables used in evaluating risk factors for unassisted death in Swedish dairy cows that died on-farm[†].

Variable	Category	Unassisted dead cows (%)	Number of cows	*P*-value[‡]
Breed	Swedish Red	31	124	0.94
	Swedish Holstein	30	218	
	Other breeds[§]	29	91	
Disease diagnosis[#]	No	30	256	0.81
	Yes	29	177	
Parity	1	25	87	0.54
	2	32	109	
	3	34	93	
	≥ 4	28	144	
Parturition	Normal	30	392	0.64
	Abnormal	27	41	
Season[¶]	Winter-Spring	28	142	0.20
	Summer	35	150	
	Autumn-Winter	26	141	
Twin birth	No	31	413	0.15
	Yes	15	20	

[†] Complete cow-level information was obtained for 433 cows from 368 herds.
[‡] Univariable analysis (Wald test).
[§] Crossbreed, Swedish Polled, or Swedish Jersey.
[#] At least one disease diagnosis during the two last months before death.
[¶] Winter-spring (1st January to 30th April), summer (1st May to 31st August), and autumn–winter (1st September to 31st December).

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the explanatory variable was included in the analysis as a continuous variable (Dohoo *et al* 2009). All other explanatory variables were analysed as categorical variables. The continuous herd-level variables BMSCC and herd average stillbirth rate did not fulfil the assumption of linearity and were therefore classified into two categories based on the median: < median or ≥ median (Table 1). Breed had three categories: Swedish Holstein, Swedish Red and other breeds. The latter was mostly crossbred cows, but also Swedish Jersey or Swedish Polled. Parturition had two categories and gave information if the latest calving was normal, or if any complications occurred (dystocia with manual help or Caesarean section). Disease diagnosis had two categories: if the cow had one or more disease diagnoses during the period two months before death to the day of death the cow was categorised as 'Yes' and a cow with no diagnosis during the same period was categorised as 'No'. Parity had four categories: first, second, third, and fourth or later lactations. Season could not be included in the analysis as a conditional regression model cannot estimate coefficients for variables that are constant within matched sets, even if they vary between sets (Dohoo *et al* 2009).

Potential collinearities between the explanatory variables were assessed both by Spearman's rank order correlations and by regressing each explanatory variable on all other variables (using linear and logistic regression models as appropriate). Neither of the methods found evidence for strong collinearities. Each explanatory variable was first tested against the outcome in a univariable analysis. Then, a step-wise backward elimination procedure of the initial full model was applied and continued until all remaining effects had $P < 0.05$. Confounding was assessed at each step of elimination of a non-significant effect ($P > 0.05$) by inspecting changes in parameter estimates for the remaining effects. Any changes > 20% were considered to indicate confounding, but none were found. All two-way interactions were included after the model reduction but none were significant ($P < 0.05$). The data were analysed using the PROC LOGISTIC procedure with specified strata command in SAS v9.3 (SAS Institute Inc, Cary, NC, USA).

Results

Of the 433 cows examined at the destruction plants with confirmed information of type of death from the farmer, and with information from SOMRS, 130 cows died unassisted (30%) and 303 cows were euthanised. The farmer interviews showed that 76% of the euthanised cows were euthanised by the owner or employees at the farm, 8% by a veterinarian, and 16% by other persons (mainly knackermen or hunters). Methods used for euthanasia were: stunning with a captive bolt followed by immediate exsanguination (88%); stunning with a rifle followed by immediate exsanguination (11%); and injecting an overdose of an anaesthetic (1%). The reasons for death or euthanasia stated by the farmers are shown in Table 4.

The mean age of death was 1,858 days (minimum = 674; Q1 = 1,329; median = 1,770; Q3 = 2,246; maximum = 4,780) and 161 of the 433 examined cows were younger than 48 months. Death occurred, on average, 145 days after calving (minimum = 0; Q1 = 20; median = 78; Q3 = 233; maximum = 1,004). The distribution of mortality after calving is shown in Figure 2. The yearly on-farm cow mortality in the herds included in the study was on average 7.31 deaths per 100 cow-years. The mean herd size and milk yield of the herds with cows included in the study were 108 cows and 9,462 kg energy-corrected milk (ECM), respectively. Descriptive statistics of the euthanised and unassisted dead cows according to explanatory variables and results from the univariable analysis are reported in Tables 1, 2 and 3.

Table 4 Primary reasons for mortality in Swedish dairy cows stated by the farmer in telephone interview.

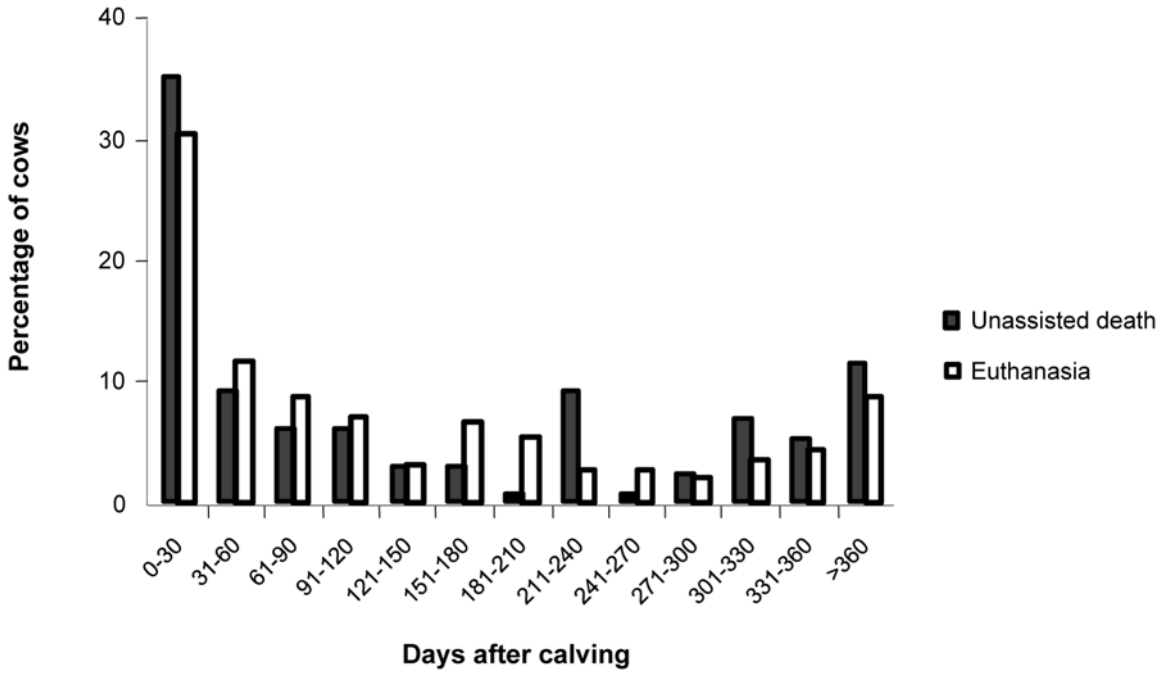
	Unassisted dead cows (% of n = 130)	Euthanised cows (% of n = 303)
Accidents	5	15
Digestive disorders	12	9
Locomotor disorders	0	23
Metabolic disorders	9	9
Udder/teat disorders	15	14
Calving disorders	9	11
Other reasons	1	6
Unknown reasons	48	14

In the multivariable conditional logistic regression model a high stillbirth rate in the herd was the only statistically significant risk factor for unassisted death as opposed to euthanasia. Odds ratio of unassisted death was 1.57 (95% confidence interval 1.00–2.47, $P < 0.05$) for cows in herds with a stillbirth rate of 7% or greater. Model evaluation was performed by inspecting plots of leverage, delta χ^2 and delta β. No divergent observations were found which indicates appropriate overall fit of the model.

Discussion

This study demonstrated that 30% of the 433 studied cows died unassisted. This is a lower proportion of unassisted death compared with other countries. The Danish Cattle Database has, since 2007, distinguished between unassisted death and euthanasia. In 2008, 83% of the Danish cows that died on-farm died unassisted according to farmer reports to the Danish Cattle Database (Thomsen & Sørensen 2009). Earlier Danish figures of unassisted death were 42 and 45% in 2002 and 2006, respectively (Thomsen *et al* 2004; Thomsen & Sørensen 2008), but these were based on telephone interviews with farmers. The high proportion of unassisted death in 2008 in Denmark might be because the reporting system was relatively new and that farmers were not aware of the new, divided, codes. One commercial dairy herd in USA had 94 dead cows during one year, out of these

Figure 2



Distribution of unassisted death and euthanasia in relation to days after calving in 433 Swedish dairy cows.

55% died unassisted (McConnel *et al* 2009). In another study in the USA, McConnel *et al* (2010) demonstrated that 76% of 174 cows from three different dairies died unassisted. One explanation for the high proportion of euthanasia in the Swedish herds may be a lower threshold for euthanasia. Another explanation may be that Swedish farmers use euthanasia as an alternative to call for a veterinarian more frequently than in Denmark and USA. Such behaviour may be explained by geographical factors, eg distance to veterinary services, but we did not find any effects of geographical region in the multivariable model. Whether euthanasia or unassisted death is better from a welfare perspective differs between cases and depends on farmers' attitudes and decisions (Yeates 2010). At the same time that euthanasia can be used to shorten painful conditions it can also indicate a farmer's unwillingness to try to treat the illness because of lack of compassion, financial constraints, or apathy towards animal life, etc. In other cases, unassisted death may be so quick that preceding clinical signs go unnoticed, which also might imply a limited amount of suffering. Also, animal handling and restraining for euthanasia may also cause fear in some cases. However, euthanasia indicates that someone has taken action and therefore we believe it is generally better from an animal welfare perspective.

In Denmark, a higher proportion (42%) of euthanasia was carried out by a veterinarian and it is also more common to use an overdose of an anaesthetic (23%) as a method for euthanasia (Thomsen *et al* 2004). In Sweden, most of the farmers euthanise cows by themselves when necessary. Reasons for this might be to minimise the animals' suffering time and to reduce the veterinary costs. This supports the hypothesis that the Swedish farmers' attitudes towards euthanasia are affected by geographical, economic and social factors.

The cows died, on average, 145 days after calving, but 50% occurred already within 78 days, ie the distribution is highly skewed to the left (Figure 2). There is also a small increase in mortality after 300 days post-partum which can be related to late pregnancy and approaching calving. The mortality distribution shows the importance of managing cows during the transition period and preventing fresh cow diseases. The relatively high frequency of euthanasia around 150–210 days post-partum might be related to failure to conceive. In other words, if a cow has a problem at this time, the decision between euthanasia or treatment is likely influenced by the cow's pregnancy status.

Cows that died on farms with a high stillbirth rate, ie above the median of the included herds, were more likely to have died unassisted than being euthanised. Stillbirth rate has been shown to be a good indicator for general animal welfare standards on a farm (Nyman *et al* 2011) and a high risk for unassisted death is likely also to be an indication of poor welfare, maybe as a consequence of sub-optimal management. A high on-farm cow mortality, which has also been identified as a strong indicator of animal welfare (Nyman *et al* 2011; Walker *et al* 2012), was not associated with an increased risk of unassisted death and the associa-

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tion between herd average stillbirth rate and unassisted death that we found in this study should therefore be treated with some caution. Also, the multiple comparisons made in the statistical analysis increase the family-wise Type I error rate and the association found may thus be spurious. Thomsen and Sørensen (2009) found that a greater herd size, an increased milk yield, and a higher number of disease recordings were associated with higher odds for euthanasia compared with unassisted death. This suggests that differences in relation to on-farm mortality in Sweden and Denmark may exist although the milk production conditions are rather similar in many other aspects. This may, again, be related to differences in attitudes towards euthanasia between farmers in the two countries. The lack of risk factors that distinguished between cows that were euthanised and died unassisted indicates that on-farm mortality may possibly be studied as one entity under Swedish conditions. However, unidentified risk factors may still differ and, possibly more importantly, welfare implications may also differ between the two types of death which implies the need for separating them in future studies.

A farmer's perception of reason for death can be seriously flawed. This has been evaluated by comparing farmers' perception with results from necropsy examination (McConnel *et al* 2009; Thomsen *et al* 2012). McConnel *et al* (2009) showed that a farmer reported the correct reason for death in only 55% of the dead cows, and for those cows that died unassisted the farmer was correct in only 37% of the cases. Thomsen *et al* (2012) demonstrated that causes of death stated by farmers agreed with necropsy results in only 50% (unassisted death) to 64% (euthanasia) of the 79 cows included in that study. It is likely that the Swedish farmers are equally skilled in identifying the reason for death, so our results should be treated with caution. However, it is not surprising that 'unknown reasons' was the most common statement for cows that died unassisted. Also, the high proportion of locomotor disorders in euthanised cows is in agreement with previous studies (Thomsen *et al* 2004, 2012). In similarity with Thomsen and Sørensen (2008), some farmers stated that the veterinary inspections at slaughterhouses have become stricter during the last years. This has affected their behaviour and some of the cows that were sent to slaughter a few years ago would now probably be euthanised on-farm instead.

Identification of euthanised cows at the destruction plant was based on examination of the forehead. It is obvious that it is not a perfect procedure, because the classification did not agree with the farmers' recollection in 64 of the 556 cows examined (the classification could not be verified in another 18 cases). In most cases the discrepancy was due to the fact that euthanised cows were erroneously identified as having died unassisted at the examination. Only three cows were euthanised by an overdose of an anaesthetic and the discrepancy was thus caused by failure to find a bullet hole in the forehead or because we received incorrect information from the farmer. In our study only the verified cows were used, but the misclassification is likely to be non-differential, ie not associated with the risk factors, and would therefore not lead to any bias. Exclusion of non-verified cows could result in selection bias if the reason for exclusion was related to the risk factors. The distribution of explanatory variables was, however, similar among included and excluded cows (data not shown).

The mean milk yield of the herds in the study material was slightly lower than that of SOMRS herds (9,532 kg ECM), and the mean herd size was greater than the mean (72 cows) in SOMRS herds (Växa Sweden 2013). This could be an effect of the greater risk for on-farm mortality found in low-producing herds compared to high producing, and in larger herds compared to smaller herds (Alvåsen *et al* 2012), but the latter simply because larger herds contribute with more dead cows to the destruction plant than small herds. The distribution of cows according to parity differed from the target population, with a greater proportion of older cows in the study material. This could be expected because the mortality risk has been shown to be higher in older cows (Thomsen *et al* 2004). Another explanation for a lower proportion of young cows in the study material is that containers that were known to contain only young cows may occasionally have been tilted directly into the grinder without individual handling of cadavers. Individual handling of cadavers are mandatory in Sweden for cows older than 48 months in Sweden because they are sampled for Bovine spongiform encephalopathy, but most cows younger than 48 months are also handled individually. As 37% of the study material were cows younger than 48 months, the possible loss of some young cows could not have been common and such losses are not likely to be related to whether she was euthanised or died unassisted.

The incidence of unassisted dead cows that arrive at destruction plants may be used as a surveillance tool for emerging (infectious) diseases (Frössling *et al* 2013), because an unexpectedly high proportion of unassisted deaths could indicate a potential 'outbreak'. Even though there were some discrepancies between the observations at the destruction plants and the information from the farmers, the misclassification is likely to be non-differential, ie not associated or influenced by risk factors that may be relevant in a surveillance situation. The examinations would thus probably be sufficiently accurate for that purpose, especially as there were only a few cows euthanised by an overdose of an anaesthetic, although the misclassifications would lead to a loss in precision.

Animal welfare implications and conclusion

The proportion of unassisted death in Swedish dairy cows was lower than corresponding figures from the USA and Denmark which may be advantageous from an animal welfare perspective. A large proportion of unassisted death and euthanasia occurred in early lactation which reinforces the need for proper management during the transition period. There were few differences in characteristics between cows that died unassisted and cows that were euthanised, indicating that it may be possible to study on-farm mortality as one entity. Still, welfare implications

between the two types of death may differ which implies the need to separate them in future studies. To get a better understanding of factors that influence cow mortality, farmers' attitudes and strategies towards, eg euthanasia and treatments needs to be investigated further.

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