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Cumulative Risk of Bovine Mastitis Treatments in Denmark, Finland, Norway and Sweden

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Valde JP, Lawson LG, Lindberg A, Agger JF, Saloniemi H, Østerås O: Cumulative risk of bovine mastitis treatments in Denmark, Finland, Norway and Sweden. Acta vet. scand. 2004, 45, 201-210. – Data from the national dairy cow recording systems during 1997 were used to calculate lactation-specific cumulative risk of mastitis treatments and cumulative risk of removal from the herds in Denmark, Finland Norway and Sweden. Sweden had the lowest risk of recorded mastitis treatments during 305 days of lactation and Norway had the highest risk. The incidence risk of recorded mastitis treatments during 305 days of lactation in Denmark, Finland, Norway and Sweden was 0.177, 0.139, 0.215 and 0.127 for first parity cows and 0.228, 0.215, 0.358 and 0.204 for parities higher than three, respectively. The risk of a first parity cow being treated for mastitis was almost 3 times higher at calving in Norway than in Sweden. The period with the highest risk for mastitis treatments was from 2 days before calving until 14 days after calving and the highest risk for removal was from calving to 10 days after calving in all countries.

The study clearly demonstrated differences in bovine mastitis treatment patterns among the Nordic countries. The most important findings were the differences in treatment risks during different lactations within each country, as well as differences in strategies with respect to the time during lactation mastitis was treated.

Data recording; mastitis treatment; Nordic countries; dairy herds; cumulative incidence risk; culling.

Introduction

Mastitis is generally regarded as the most frequent and costly disease in dairy cows worldwide. Depending on differences in management practices and animal care, the impact of the disease varies between herds. Some farmers detect mastitis in their dairy cattle quite often, while others rarely treat their cows for clinical mastitis (CM) (*Barkema et al.* 1998). The rate of new infections within a herd is increased by management factors that facilitate the spread of pathogens from the environment to the cows or from cow to cow (*Østerås & Lund* 1988, *Barkema et al.* 1999). At herd level, a mastitis problem can be expressed as high bulk milk somatic cell count (BMSCC), high proportion of cows with high individual cow milk somatic cell counts (CMSCC), high rate of CM treatments or high culling rate because of mastitis.

Annual reports show substantial differences in frequencies of CM treatments among the Nordic countries, varying from 18.3 cases per 100 completed or terminated lactations in Sweden (Swedish Dairy Association, 2002) to 25.8 per 100 cow-years in Norway (Norwegian Cattle Health Services, 2002). Whether the calculated CM frequencies reflect the true risks of

CM depends on several factors, which could be:

1. Differences in calculation techniques used when presenting risk rates
2. Differences in the use of diagnostic criteria for mastitis classification
3. Differences in the efficiency and accuracy of the recording systems
4. Differences in the farmers' propensity to treat mastitis given different signs of disease and at different times during lactation
5. Differences in age distribution in different populations

It is difficult to compare the countries' disease levels because different methods are used for calculating national mastitis treatment rates. According to an International Dairy Federation (IDF) report, the choice of calculation technique could account for up to 30% of the reported differences in disease levels between countries (IDF, 1997). Another study has demonstrated that calculated disease rates may vary more than 55% depending on the methods used when calculating disease occurrence in the same population. (*Larssen et al.* 2000). There are also differences in case definitions of mastitis, populations at risk and the definition of new cases versus recurring cases. The organization of the recording system may also influence the correctness of the calculated CM frequencies.

The objective of the retrospective observational cohort study presented here was to use a uniform approach to calculate lactation-specific cumulative incidence risk of mastitis treatments in Denmark, Finland, Norway and Sweden in order to compare and discuss possible reasons for any observed differences between the countries. In addition, risks of being removed from the herds are compared and discussed, as mastitis is one of the main reasons for removal.

Materials and methods

Selection of Data

Disease data were obtained from each country's dairy cow recording system according to jointly agreed standard criteria. The national dairy cow recording systems comprised 84% of the herds and 88% of the cows in Denmark (Kvaegdatabasen), 64% of the herds and 70% of the cows in Finland (Kudatabasen), 87% of the herds and 92% of the cows in Norway (Kukontrollen) and 73% of the herds and 79% of the cows in Sweden (Kodatabasen). Herds were selected by a random procedure so that at least 50,000 cows from each country were included. In Finland all herds in the database were included in the analyses. All cows from the selected herds that calved at least once during 1997 were included. For each cow, information was obtained on calving date in 1997, parity, date of removal, disease date and disease code. The date of subsequent calving was also included. The data were checked for logical errors and unlikely values. For instance, records with culling date earlier than calving date were excluded. Six cows were excluded from the Norwegian dataset for this reason, none from the Swedish and 6 from the Danish dataset. Logical errors were automatically corrected in the Finnish database and no exclusions from the selected dataset were necessary. Unlikely values could be due to typing errors. A calving interval of less than 151 days was regarded as an abortion, and such records were excluded from the analyses. The numbers of cows excluded due to a calving interval of less than 151 days were 6 (0.011%), 43 (0.014%) and 6 (0.011%) in Denmark, Finland and Norway respectively. As the Swedish data had been checked for calving interval prior to selection, information on the number of cows excluded was not available in the dataset.

Each cow was monitored from 15 days before calving until either the first case of mastitis, removal or day 305 of lactation. Cows that calved a second time at the end of the year and thus started a new lactation were monitored through

Table 1. Disease codes used for mastitis treatments in the Nordic countries' national dairy cow recording systems for 1997.

Country	Disease code	Description
Denmark	11	Mastitis
	12	Mastitis in dry period
	13	Dry cow therapy
	14	Mastitis and teat lesion
	15	Acute mastitis
	72	Summer mastitis
	94	Toxic mastitis
	95	Subclinical mastitis
Finland	301	Acute clinical mastitis
	302	Subclinical mastitis
	303	Chronic mastitis
	821	Dry cow therapy
Sweden	270	Mastitis
	601	Mastitis and teat injury
	270+ subcode 6	Dry cow therapy
Norway	303	Acute clinical mastitis*
	304	Chronic clinical mastitis**
	305	Subclinical mastitis

* Changed to severe/moderate clinical mastitis (303) and **changed to mild clinical mastitis (304) in 1999.

both lactations. Cows that calved twice during 1997 comprised 1.7 %, 1.2 %, 0.9 %, and 1.0 % of the cows in Denmark, Finland, Norway and Sweden, respectively.

Mastitis treatments were categorized differently in the Nordic countries: the Swedish recording system had only 2 main codes for mastitis but used an additional code to denote dry cow therapy, while the Danish recording system split mastitis into 7 different sub-diagnoses and the veterinarians can choose either to use the code "mastitis" or one of the other codes which add more information to the record. The disease codes used for mastitis treatments in this study are presented in Table 1.

Risk of mastitis treatment

The mastitis risks were estimated separately for each parity group and country. The final dataset contained, for each day of lactation and parity group, the number of cows at risk, the number of removed cows and the number of mastitis treatments. For each day X of lactation the exact risk of mastitis treatment was calculated as the number of new treatments on day X divided by the number of cows at risk. The cumulative incidence risk of mastitis treatments was calculated according to Kleinbaum et al. (1982) as: 1-[(1-cumulative risk of mastitis on day X-1)*(1-risk of mastitis on day X)] and presented graphically as the lactation-specific cumulative risk of mastitis treatments throughout lactation (until day 305 of lactation).

To illustrate the differences in mastitis risks between countries, the relative risks of mastitis treatments were calculated. The country with the lowest risk was chosen as the baseline, and the relative risk for each day in lactation was calculated as the cumulative risk of mastitis that particular day divided by the cumulative risk of mastitis in the country with the lowest level. The results were presented graphically as the relative risk of mastitis treatments throughout lactation.

Similarly, the differences in mastitis treatment risks between first and second parity cows were presented graphically for each country as the relative risk of mastitis treatments (second parity cows vs. first parity cows) throughout lactation.

Risk of removal

Risk of removal was calculated by means of cumulative risk in the same way as for mastitis. In this context, removal comprised both removal for trade and removal for slaughter.

Data analyses

Descriptive analyses were performed using

Table 2. Descriptive statistics of herd variables in the data sets from the national dairy cow recording systems for 1997.

	Number of herds selected	Number of cows included	Number of started lactations	Average number of cows per herd
Denmark	812	53,959	54,894	66.5
Finland	18,887	293,781	297,355	15.6
Norway	3,573	55,976	56,486	15.7
Sweden	2,132	73,599	74,370	34.5

PROC MEAN and PROC FREQ in the software programme SAS (*SAS Institute Inc.* 1990).

Results

Descriptive statistics

Descriptive statistics for herd variables are given in Table 2. The average number of cows per herd included in the analyses was 66.5 in Denmark, 15.6 in Finland, 15.7 in Norway and 34.5 in Sweden.

The distribution of cow age measured as parity number is shown in Fig. 1. Finland had more cows in higher parity groups than the other countries. In fact 12.0% of the cows in Finland started their fifth or higher lactation during the study year, compared to 9.7% in Denmark, 8.8% in Norway and 10.8% in Sweden. Norway had the highest proportion of cows in first lactation (37.8%) while Finland had the lowest proportion (34.0%). The percentages in Denmark and Sweden were 37.7 and 35.0, respectively.

The distribution of calving by month is shown in Figure 2. There was an increase in number of calvings in August, September and October in

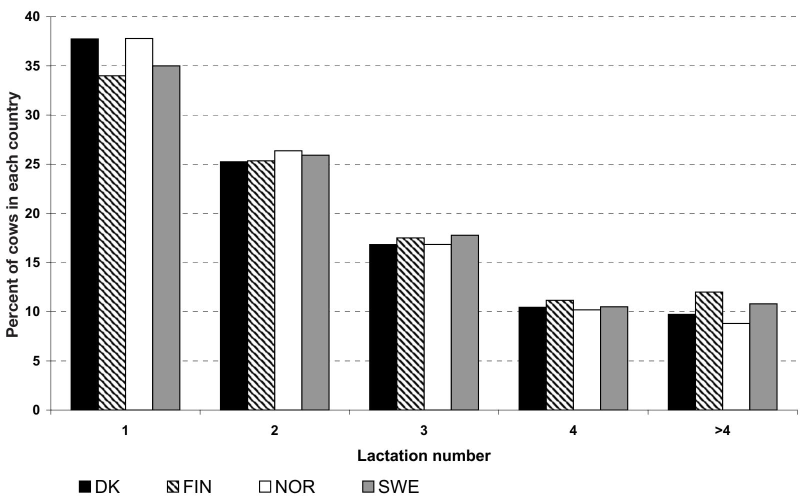


Figure 1. Parity distribution (per cent) by country for lactations started in 1997 among cows in the Nordic countries.

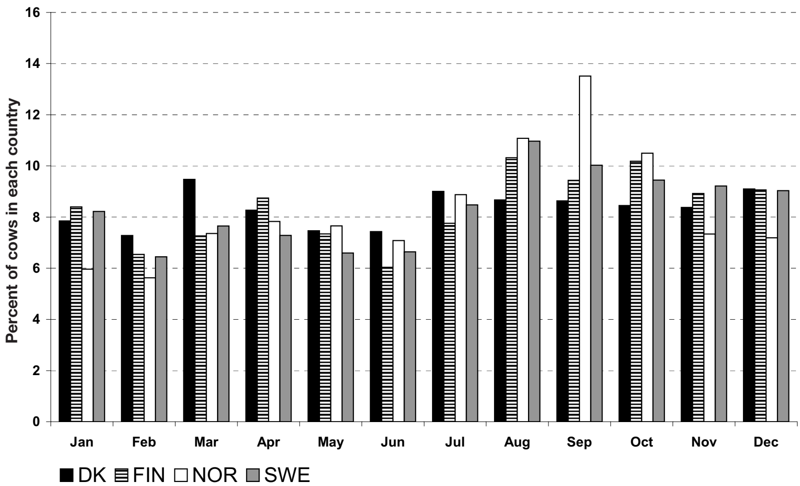


Figure 2. Birth distribution by country and month for calves born in 1997.

all countries except Denmark. This increase was more pronounced in Norway than in Sweden and Finland. Denmark had the highest birth rate for calves in March.

Mastitis treatment risk

The lactation-specific cumulative risk of recorded mastitis treatments during 305 days of lactation is given in Fig. 3 - 6 for Denmark, Finland, Norway and Sweden, respectively.

The lowest risk of recorded mastitis treatments during 305 days of lactation was found in Sweden (Fig 6). The risk varied from 0.127 among first parity cows to 0.204 in parities higher than 3. The highest incidence risk was recorded in Norway, with 0.215 in first parity cows and 0.358 in parities higher than 3 (Fig 5). The incidence risk of mastitis during 305 days of lactation in Denmark was 0.177 for first parity cows and 0.228 for parities higher than 3 (Fig 3). In Finland the incidence risk was 0.139 for first parity cows and 0.215 for parities higher than 3 (Fig 4). The cumulative risk curves were similar in all countries; however, the data from Denmark and Finland showed a slight increase in mastitis risk from day 270 (Fig 3 and 4).

The risk of mastitis treatments for first parity cows in Denmark, Finland and Norway relative to Sweden is shown in Fig. 7. The risk of a cow being treated for mastitis was almost 3 times higher at calving in Norway than in Sweden. The risk of mastitis treatments in Norway also showed a pronounced increase on calving day relative to Denmark and Finland. Denmark had a marked peak in relative risk of mastitis treatments (RR = 2.50) 11 days before calving compared to Sweden. Finland had an increase in the risk of mastitis treatments from 15 to 60 days into first lactation relative to Sweden. After 305 days in lactation, the relative risk of mastitis therapy compared to Sweden was 1.09 for Finland, 1.40 for Denmark and 1.70 for Norway. The period with the highest risk was from 2 days before calving until 14 days after calving for all countries.

The risk of mastitis treatments for first parity cows were higher than the risk for second parity up to day 45, 64, 22 and 58 in Denmark, Fin-

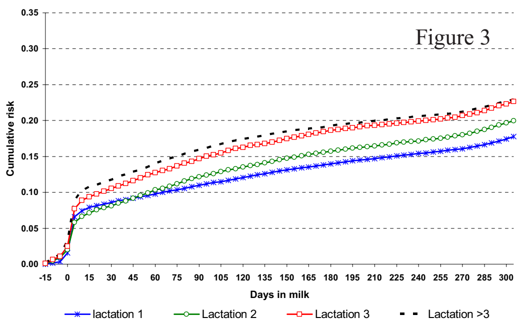
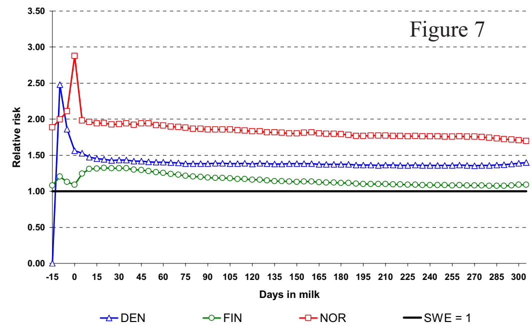


Figure 3



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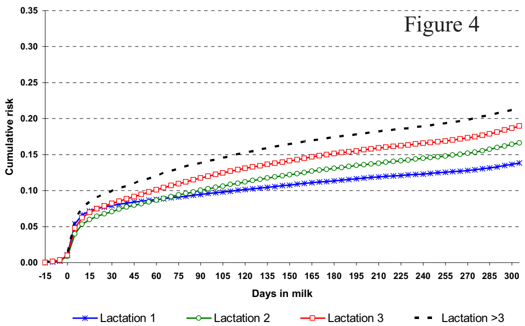

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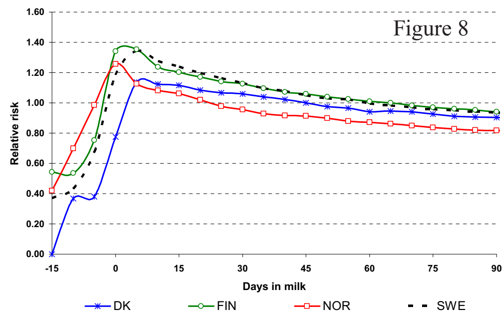

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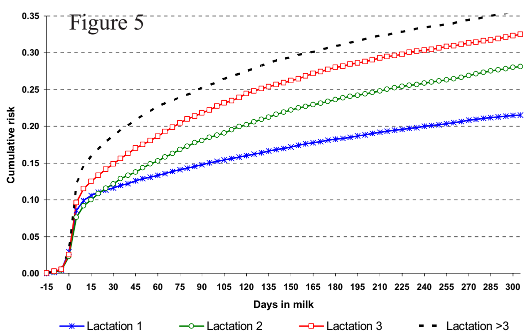

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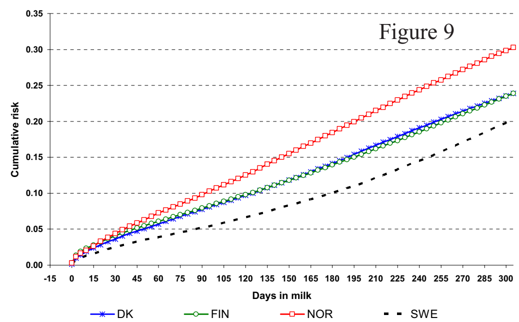

Figure 9

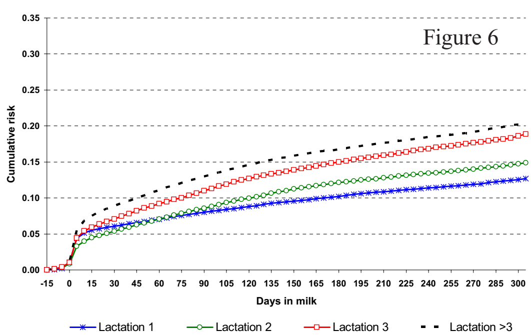

Figure 6

Figure 3. Parity specific cumulative risk of bovine mastitis treatments, in Denmark based on data from the national dairy cow recording system for 1997.

Figure 4. Parity specific cumulative risk of bovine mastitis treatments, in Finland based on data from the national dairy cow recording system for 1997.

Figure 5. Parity specific cumulative risk of bovine mastitis treatments, in Norway based on data from the national dairy cow recording system for 1997.

Figure 6. Parity specific cumulative risk of bovine mastitis treatments, in Sweden based on data from the national dairy cow recording system for 1997.

Figure 7. Relative risk of mastitis treatments for first parity cows in 1997 in Denmark, Finland and Norway compared to Sweden as baseline.

Figure 8. Risk of mastitis treatments in first lactating cows relative to the risk in second lactation among the Nordic countries in 1997.

Figure 9. Cumulative risk of removal for cows that started a new lactation in 1997.

land, Norway and Sweden respectively (Fig. 3 - 6). The risk curves for first lactation also exceeded the risk curves for third lactation in the period from 1 day before calving to day 21 in Finland and day 1 to 4 in Sweden (Fig. 4 and 6). The risks of mastitis treatments in first lactation relative to the risks in second lactation during the first 3 months in milk are given in Fig 8.

Removal from the herd

The cumulative risk of removal by 305 days of lactation is given in Fig. 9. The risk of removal over all lactations was 0.239, 0.239, 0.303, and 0.202 in Denmark, Finland, Norway and Sweden respectively. The period with the highest risk for removal was from calving to 10 days after calving in all countries. The risk curves were flattest in the period from approximately 10 to 160 days of lactation indicating a higher daily incidence risk outside this time interval. This was more pronounced in Sweden than in the other countries. The risk curve for Denmark showed a decrease in risk of removal in the 4th lactation month.

Discussion

Our study demonstrated considerable differences in recorded mastitis treatment risks between the Nordic countries. The calculated risks were based on data routinely collected by farmers and veterinarians, and our results could be biased if there were different recording or reporting rates between the countries.

In the Nordic countries, administration of antibiotics to dairy cows is strictly regulated. Only veterinarians are allowed to initiate mastitis treatments using antibiotics. Recording and reporting is compulsory when a veterinarian is called to a mastitis case, which yields a higher mastitis reporting rate than if the treatments were at the discretion of the farmers. In general, correct information on prevalence and incidences of diseases in cattle in the dairy industry is difficult to obtain. To a large extent, the Nordic countries are the only countries worldwide that have a system for annual reporting of treatment rates and risks. The disease recording systems form the basis for health monitoring at the local, regional and national level. It provides sufficient data to estimate disease frequencies in each country (*Olsson et al.* 2001).

The Norwegian dairy cow recording system was evaluated in a study in 2000 (*Østerås & Grave* 2002). This study found no significant difference in the incidence rate of mastitis between herds that were monitored intensively compared to herds that were monitored through the regular health recording system. Thus, these findings indicated that the Norwegian dairy cow recording system is of good quality.

The differences in diagnostic criteria between the countries were managed by using a broad definition of mastitis in this study. Within each country, all mastitis treatments, irrespective of their designated disease code, were merged into one group. Thus, the diagnostic criteria became as identical as possible in all countries. Dry cow therapy was also included in the mastitis group. As shown in Table 2, there was no harmonization with respect to mastitis nomenclature within the Nordic countries. This table illustrates the need to adapt the recent IDF recommendations for mastitis nomenclature (IDF, 1997).

One crucial factor contributing to the apparent differences in mastitis treatment risks could be the farmers' treatment strategy. The true risk of a cow contracting mastitis may not vary as much as the data in this study indicated, but the risk of being treated for mastitis – and thus being reported – may vary significantly depending on the farmer's propensity to choose different treatment strategies for mastitis. (e.g. culling, drying off diseased quarters, frequent milking). Thus the calculated risks should not be regarded as the true risks of mastitis, but rather as measures of the degree of investment in veterinary treatments of mastitis. The calculated risks will thus be a combination of the level of infection (which is due to exposure or lack of exposure to certain risk factors), the farmers' ability to detect mastitis and their management strategies. It should be noted that the mastitis treatment rate has decreased dramatically in Norway in recent years, with a decline in the annual incidence rate from 0.42 cases of mastitis treatments per cow-year in 1997 to 0.28 cases per cow-year in 2001 (Norwegian Cattle Health Services, 2002, annual report).

Quality payment schemes may influence the farmers' ability and willingness to treat their cows. For example, increasing demands from the dairy industry to keep the BMSCC at a low level may lead to a higher frequency of mastitis treatments. Such requirements vary between countries. Mastitis treatment can thus be regarded as an investment in production to achieve good quality milk in terms of somatic cell count.

Incidence rates defined as number of new cases per cow-day at risk may be influenced by population age distribution and average length of lactations. The fact that the risk of CM treatments is highest around calving (Barkema et al., 1998) and increases by parity suggests that lactation-specific cumulative incidence should be used when comparing mastitis levels between different countries. Using this approach, differences in parity distribution between the countries will not bias the results and equivalent calculation procedures are ensured.

The risk of mastitis treatments varied according to parity and lactation stage. Older cows were at higher risk of mastitis than younger cows, and cows around calving were at higher risk than cows later in lactation. In a cow population with a high culling/replacement rate one would expect to find higher incidence rates of mastitis than in a population with low culling rate, because the distribution of cows over the days in lactation would be skewed towards the early postpartum period. On the other hand, in a cow population with a high culling rate the cows will be younger and less susceptible to mastitis, and this may in turn lead to a lower incidence rate. In this study, mastitis risk was calculated for each lactation and presented as cumulative risk of mastitis treatments from 15 days before calving to 305 days after calving and thereby controlled for any differences in distribution of parity or stage in lactation.

Risk of mastitis by 305 days of lactation increased with increased parity. However, the risk of mastitis in heifers was higher than the risk in second parity cows early in lactation. In Finland and Sweden, the risk of heifer mastitis was even higher than in third-parity cows up to day 4 in Sweden and day 21 in Finland. This was an interesting finding and must be seen in relation to culling strategies. Heifers treated for mastitis in early lactation would probably be culled and did not reach second lactation at all. The average mastitis resistance early in lactation would then be higher in second-parity cows than in first-parity cows. If this is true, mastitis early in lactation must be caused by other risk factors than mastitis later in lactation. The high risks of mastitis in first lactation relative to the risks in second lactation in Sweden and Finland (Fig 8) may indicate that heifers were exposed to more unfavourable environmental factors compared to older cows in these 2 countries.

Data from all the Nordic countries demonstrated an elevated risk of mastitis treatments around calving. Fifty per cent of the treatments in first lactation were administered before day 36 in Denmark, day 13 in Finland, day 17 in Norway and day 39 in Sweden. Understanding why the distribution of mastitis treatments were skewed more towards the first 2 weeks of lactation in Finland and Norway compared to Denmark and Sweden requires further research. Part of the reason may be that Norway and Finland have by far the smallest herds among the Nordic countries (Table 2). Thus, the BMSCC are relatively more vulnerable to sudden increases in individual SCC. The farmers may therefore monitor the milk more closely during the colostrum period before it goes into the bulk tank and small deviances from normal values may lead to treatment. In small herds it may be more common to monitor each cow using individual CMT-tests just after calving. The use of CMT-scores at farm level, which is common in Norway, could be one of the reasons for the relatively large difference in mastitis treatment risk between Norway and the other countries, provided that the use of CMT scores lead to more frequent treatments.

The risk of mastitis showed a marked increase from around day 270 both in Finland (Fig 4) and in Denmark (Fig 3). In Finland this was due to dry cow therapy, but in Denmark only 312 cases were related to dry cow treatment, which had no effect on the risk calculated – due to the large amount of data. The fact that Norway and Sweden did not have a separate disease code for dry cow therapy indicates that these two countries devoted less attention to and did not recommend dry cow therapy as much as in Finland.

Both risk of removal from the herd and mastitis treatment risk were highest in Norway and lowest in Sweden. A cost-effective curve of optimal culling indicated that the selection of cows for culling should be done between the 3rd and 5th month of first lactation and that replacement costs increase after the 5th or 6th lactation month (*Østerås* 2000). Fig 9 demonstrates that the risk of removal was evenly distributed throughout lactation in Norway, while the curves for Sweden and Finland showed an increase towards the end of lactation. The risk curve for Denmark showed a decrease in risk of removal in the 4th lactation month, hence the risk of removal was lowest when the replacement cost was lowest. Removal early in lactation is probable necessitated by disease problems. Removal late in lactation could be due to cows failing to conceive. Differences in prices of meat and milk, production subsidies and milk quotas also influence the risk of removal.

Our study clearly demonstrated differences in bovine mastitis treatment patterns between the Nordic countries. The most interesting findings were the differences in treatment risks during different lactations within each country, as well as differences in strategies with respect to the time during lactation mastitis was treated. In this study bias caused by effects from data extraction, calculations, age and stage of lactation and different diagnostic codes was controlled during the process. Further research is necessary to obtain more thorough knowledge about the differences in mastitis treatment risks among the Nordic countries.

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Sammendrag

Kumulativ risiko for mastittbehandlinger i Danmark, Finland, Norge og Sverige.

Nasjonale kukontolldata ble brukt til å kalkulere kumulativ risiko for mastittbehandlinger og kumulativ risiko for utrangering i Danmark, Finland, Norge og Sverige. Den lågeste risikoen for mastitt i løpet av 305 dager i laktasjon ble funnet i Sverige hvor risikoen varierte fra 0,127 for kyr i første laktasjon til 0,204 for fjerdelaktasjonskyr og eldre. Den største risikoen ble funnet i Norge med 0,215 for kyr i første laktasjon og 0,358 for fjerdelaktasjonskyr og eldre. Tilsvarende tall for Danmark og Finland var henholdsvis 0,177 og 0,139 for førstekalvs kyr og 0,228 og 0,215 for fjerdelaktasjonskyr og eldre. Risikoen for mastitt i første laktasjon var nesten 3 ganger større omkring kalving i Norge enn i Sverige. Risikoen for en mastittbehandling i Norge viste også en markert økning på kalvingsdagen sammenliknet med de andre landene i Norden. Størst risiko for mastittbehandling var i perioden fra 2 dager før kalving til 14 dager ut i laktasjonen og størst risiko for utrangering var fra kalving til 10 dager ut i laktasjonen for alle land. Undersøkelsen fant klare forskjeller i mastittmønsteret i de nordiske land. De viktigste funnene var forskjellene i behandlingsrisiko for mastitt mellom de ulike laktasjonene innenfor hvert land og forskjellene i behandlingsstrategi landene i mellom med hensyn på tidspunktet i laktasjonen risikoen for mastittbehandling var størst.

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