Calf health monitoring in Norwegian dairy herds

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ABSTRACT

The aims of this study were to estimate the incidence of calf diseases in Norwegian dairy herds, improve calf health recordings in the Norwegian Cattle Health Recording System (NCHRS), and investigate different methods for validation of calf health data. A longitudinal, cross-sectional survey of calf health in Norway was performed between September 1, 2004, and January 31, 2007. The participating dairy herds were randomly selected from among herds registered in the Norwegian Dairy Herd Recording System as having at least 15 cow-years. Each herd participated for 1 yr. Diseases and treatments of calves of up to 180 d of age in 135 dairy herds were reported using the NCHRS. In total, 6,668 calves were born in the participating dairy herds during the project period. A total of 573 (29.6%) of the 1,936 calf health recordings reported were recordings of diseases and 1,363 (70.4%) were events of preventive therapy, dehorning, or castration. The recorded incidence of diarrhea and respiratory disease was 3.8% and 2.9%, respectively. The median age of occurrence of diarrhea and respiratory disease was 17 and 37 d, respectively. Three different methods, based on sampling of diseased calves, dehorning as an indicator of a well-functioning recording system, or feedback on degree of commitment to calf health recording, were tested to assess validation of the calf health records. The 3 methods indicated an underestimation of calf health records in the NCHRS of approximately 40% and an estimated “true” incidence of diarrhea and respiratory disease of 5.5 and 4.1%, respectively. The results from this study demonstrate the importance of encouraging farmers to conduct calf health recordings. They also indicate that finding a standardized method for validation of health data is a considerable challenge.

Key words: calf disease, monitoring, validation

INTRODUCTION

Healthy calves form the basis of any successful cattle production system, from both an economic and an animal welfare point of view. In addition to leading to increased veterinary expenses and increased mortality rates (Waltner-Toews et al., 1986a; Kaneene and Hurd, 1990; Svensson et al., 2006a), disease during the first months of a calf’s life has been found to reduce average daily weight gain (Virtala et al., 1996) and increase the risk of disease later in life (Svensson et al., 2006b).

The focus on disease prevention, rather than on curative actions, means that an efficient health surveillance system is necessary (Wiggans, 1994; De Kruif et al., 2007). The use of computers is of increasing importance in all aspects of dairy production, and as the size of production units increases, the time spent physically looking after each animal gradually decreases. During the last decade, computer processing of data has increased the opportunities to record, store, and evaluate massive amounts of information (James, 2005). Analyses of farm-specific data may lead to earlier detection of problem areas and thereby, more cost-effective disease control (Bartlett et al., 1986; Noordhuizen and Wentink, 2001). The advantages of an on-farm registration system have been addressed by numerous researchers (Frei et al., 1997; De Kruif et al., 2007). Based on results from the National Animal Health Monitoring System in Michigan (United States), Kaneene and Hurd (1990) concluded that data quality is a function of assurance of confidentiality and feedback information to producers, the morale of the veterinarians, and critical checking of the data. Unfortunately, according to LeBlanc et al. (2006), standardized, valid, and systematically recorded health data at the herd level, and especially at the regional or national levels, are often limited or nonexistent.

Most Nordic countries have national health recording systems for dairy cattle. The Norwegian Cattle Health Recording System (NCHRS) was started nationally in 1975 (Østerås et al., 2007). Today, approximately 95% of Norwegian dairy farmers are members of this system, and recording of common diseases in dairy cows is well established. However, the recording of calf diseases is

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currently considerably less accurate. Monitoring of calf diseases on a national level is seldom reported from any country (LeBlanc et al., 2006). During the last decade, the Norwegian Cattle Health Services (**NCHS**) has expended considerable efforts toward improving calf health recordings in Norway.

Strict validation of the data is necessary when health recordings are used for research purposes. Bartlett et al. (1986) chose "failure to record inseminations" as an indicator of an erroneous cow record, whereas Salman et al. (1988) concluded that disease events that were not considered of economic importance to the farmer were often underestimated. Accurate recordings on calf health are valuable in herd health preventive work and genetic improvement, as well as for research purposes. The aims of the current study were to estimate the incidence of calf diseases in Norwegian dairy herds, improve calf health recordings in the NCHRS, and investigate possible methods for validation of calf health data.

MATERIALS AND METHODS

Study Population

In February 2004, a longitudinal, cross-sectional survey of calf health in Norway was initiated. Herds recorded in the Norwegian Dairy Herd Recording System (**NDHRS**) as having at least 15 cow-years were included for further random sampling (number of cow-years = the sum of days from first calving to culling within 1 yr, divided by 365). A multistage sampling procedure was used to select the study herds. Relatively large herds, according to Norwegian conditions, were chosen for the study population to typify herd sizes anticipated in the future in Norway. Selection of different districts in Norway was based on geographic location, animal density, and that one or more veterinarians in the area had a health service agreement with the NCHS. In order that all parts of Norway would be represented, a total of 30 districts were selected. Herds located in the selected districts were stratified on herd size into the following 4 groups: 1) herds with 15 to 24.9 cow-years ($n = 1,807$); 2) herds with 25 to 49.9 cow-years ($n = 568$); 3) herds with 50 to 99.9 cow-years ($n = 62$); and 4) herds with more than 100 cow-years ($n = 6$). Using random computer sampling, 2 herds were selected from each district in the first group, 4 herds from each district in the second group, 2 herds from each district in the third group, and all herds in the last group. Altogether, 193 dairy herds from all parts of Norway were selected for inclusion in the survey.

Selected farmers were invited to join the project by written invitation and then contacted by telephone by the herd's veterinarian or project personnel to confirm

whether or not they were willing to participate. A total of 135 dairy farmers were willing to participate in the survey and each signed a written contract with the project. Each herd participated for one whole year (365 d), and the farmer was paid a symbolic reward of \$150 after completion of the project period. Of the invited farmers, 58 did not wish to participate. Of these, 37 gave no reason for not participating, 12 thought it involved too much work, 6 were planning on rebuilding or stopping dairy production in the near future, and 3 did not want to participate because of personal reasons. The selected dairy herds were divided into 3 different groups according to geographical location. Region 1 included dairy herds located in eastern Norway ($n = 62$), region 2 included dairy herds located in western Norway ($n = 23$), and region 3 included herds located in central and northern Norway ($n = 50$). For logistic reasons, herds in region 1 were enrolled during autumn 2004, herds in region 2 were enrolled during spring 2005, and herds in region 3 were enrolled during autumn 2005. The overall study period lasted from September 1, 2004, to January 31, 2007.

Health Registrations

Members of NCHRS are obliged to report regularly, to a central database managed by TINE Norwegian Dairies (Ås, Norway), information on diseases and any preventive treatments, including dehorning, for each individual animal. Each cow registered in the system receives an individual health card that is associated with the animal from birth until culling or slaughter. The design of the card is available for inspection at http://storfehelse.tine.no/dok/helsek_ku01.jpg. Disease in all calves intended for slaughter is recorded on a common health card. The health registrations are recorded according to a 3-digit code system provided by the NCHS. In 1989, a new organ-related health code system was introduced in the NCHRS (Østerås et al., 2007). This system divides the diseases in 3 categories: 1) group B diseases, which are to be reported to the government; 2) group C, which includes infectious diseases not to be reported to the government; and 3) group D, which includes the diseases not covered by the 2 former categories. Group D is then separated into diseases in 8 different organ systems: 1) diseases of the cardiovascular, hematopoietic and respiratory system; 2) diseases of the alimentary tract, including the liver, pancreas, and endocrine glands; 3) diseases of the skin, including claw diseases; 4) diseases of the udder; 5) diseases of the reproductive and urinary system; 6) diseases of the nervous system, the eye, and the ear; 7) diseases of bones, joints, tendons, muscles, and connective tissue; and 8) non-organ-related diseases, which includes all

diseases not covered by the other organ systems, such as abscesses, toxic disorders, and behavioral problems. In 2003, complete definitions for all 3-digit health codes were completed. All members of the NCHRS receive a separate health report every second month including herd incidence rates compared with the national yearly incidences, which are based on quarterly rolling animal periods. A separate line for calf disease is included in this report. Further details regarding the health recording system are described in Østerås et al. (2007).

In the participating dairy herds, diseases and treatments of calves up to 180 d of age were recorded using the NCHRS. Written information encouraging performance of accurate calf health recordings was submitted to participating farmers and veterinarians. The participating herds received 12 health cards, one for each month, which were to be submitted to the project regardless of whether there was any information to register. In cases of disease for which veterinarians were not consulted, the farmers were told to record the events, based upon definitions provided by the project. Respiratory disease was defined as coughing or sneezing for 2 d or more, or as heavy breathing together with additional signs such as nasal discharge. Diarrhea was defined as soft or watery feces lasting for 2 d or more, or as soft or watery feces in combination with an impaired general condition and possible weight loss. Umbilical infection was defined as a warm swelling or abscess formation in the umbilical area. Arthritis was defined as warmth, swelling, or pain in one or several joints, possibly accompanied by lameness and fever. Abscesses were defined as localized collections of pus. In case of other diseases, the farmers were referred to the definitions given by the Norwegian Cattle Health Services at <http://storfelise.tine.no>.

All registrations were reported continually to a central database. The reporting was done either by the herd's own advisor or by the farmer. The corresponding author went through all submitted health cards manually and confirmed that all data had been reported, by comparing health events recorded on each health card with health information on each herd available in the central database. Health recordings missing in the database were then entered by the corresponding author. A periodic health report containing information on the health status of each particular herd was created by the project and mailed to the relevant farm.

Sampling of Diseased Calves

In cases of disease among calves or young stock in the participating herds, the veterinarian consulted was asked to sample 10 mL of jugular blood from each diseased calf and submit it to the National Veterinary

Institute in Oslo for serological examination. In cases of diarrhea, collection of fecal samples was also requested for parasitic examination.

Statistical Analysis

The data recorded were stored in Microsoft SQL Server (Microsoft, Redmond, WA) or in a central database managed by TINE Norwegian Dairies. Relevant data were extracted and transferred to SAS version 9.1 (SAS Institute Inc., Cary, NC) for descriptive statistics and statistical analysis. All calves born in the dairy herds within the project year of each herd were included ($n = 6,668$). Proportion of reported dehorning was calculated as a continuous variable by dividing the number of calves reported as dehorned by the number of horned calves born in each herd. Based on feedback from the farmers in a questionnaire designed by the project, a dichotomous (0/1) variable was created for the degree of commitment to calf health reporting during the project period. Separate Cox proportional hazard models (Cox, 1972) were fitted by using the PROC PHREG statement with diarrhea (0/1) or respiratory disease (0/1) as dependent variables, including the positive stable frailty models in the SAS macro available from Shu and Klein (1999) and Shu and Klein (2005). The significance of the frailty effect was assessed by the likelihood ratio test of independence [$H_0: \text{Theta}(\theta) = 1$]. The frailty effect equals the strength of association between 2 individuals within the same herd, measured by Kendall's $\tau(1 - \theta)$, and was considered significant at $P < 0.05$. The observation period was defined from birth until 180 d of age for all calves born during the year of project participation for each herd. The first occurrence of diarrhea or respiratory disease in a calf was defined as an event. Data were censored when a calf left the herd due to death, sale, or slaughter. Degree of commitment to calf health reporting and percentage of calves reported dehorned were included as predictors in the initial full models. Significant variables were selected by using manual backward stepwise elimination with $P < 0.05$ as inclusion criterion. The possible interaction between degree of commitment to calf health reporting and percentage of dehornings reported was tested. The model fit was evaluated by plotting the deviance residuals against the covariates (Allison, 2000). To check for the proportional hazard assumption, the log of the negative log of survival was plotted against time with the most important independent variable as strata. These assessments showed no evident violations of the proportional hazard assumption, extreme deviance residuals, or patterns in the models. Finally, survival analysis was used to test the association between dehorning and disease at individual calf-level. Two different models were fit-

ted with diarrhea (0/1) or respiratory disease (0/1) as dependent variables. For horned calves, date of dehorning was defined as the start of the observation period, and mean age at dehorning was defined as the start of the observation period for polled calves. Dehorning was then included as a fixed effect.

Validity

The validity of the recordings was assessed in 3 ways: 1) number of diseased calves sampled compared with number of diseased calves registered in the NCHRS; 2) the use of records of dehorning as an indicator of a well-functioning recording system; and 3) reported disease incidence in herds confirming complete calf health records compared with disease incidence in herds not confirming complete records and disease incidence reported in the total study population. Confidence intervals (CI) for the degree of underestimation were calculated by $X/n \pm (1.96/n)\sqrt{X(1 - X/n)}$, where X = estimated number of missing cases and n = total number of estimated cases.

Method 1. As veterinarians were instructed to record disease events on health cards and sample diseased calves at the same time, method 1 was used to validate the recording and sampling capacity of the veterinarians. Calves sampled but without a health registration reported to the NDHRS on the sampling date were given the diagnosis of the last disease event reported within the last week ($n = 3$), if such was present. Only disease recordings done by veterinarians were included ($n = 336$). Assuming that all sampled calves should be reported to the NDHRS, the proportion of diseased calves both sampled and reported was compared with the proportion of diseased calves sampled, but not reported.

Method 2. In method 2, the proportion of reported dehorning in each herd was calculated by dividing the number of calves reported as dehorned by the number of horned calves born. The disease incidence in herds reporting >50% of all dehorning was compared with the disease incidence recorded in herds with <50% reported dehorning and with the disease incidence reported in the total study population. By assuming that herds reporting >50% of all dehorning had an appropriate reporting system, we also assumed that herds reporting <50% of all dehorning should have the same “true” disease incidence. Thus, disease incidence of those herds reporting <50% was adjusted to the same level as those reporting >50% of all dehorning. From this assumed “true” population incidence, the number of assumed true cases was then estimated by multiplying the number of calves at risk with the assumed “true” risk rate. The proportion of missing reported cases equaled the

estimated “true” number of cases minus recorded cases divided by the total number of estimated cases.

Method 3. At the end of the project period, each farmer was asked to answer a questionnaire designed to obtain information on the degree of commitment to calf disease recording and reporting during the project period. The questionnaire comprised a question concerning to which extent calf diseases had been recorded during the project period, divided into 3 categories: 1) to a small extent, 2) to some extent, and 3) to a large extent. It also contained a binary question (yes/no) if all calf disease recordings done during the project period had been reported to the NDHRS. Farmers of herds claiming that calf health events had been recorded to a large extent during the project period and that all diseases recorded were reported to the NDHRS were considered farms performing complete calf health records and reflecting the “true” disease rate. All other herds were considered to have incomplete records. We assumed that herds not claiming full reporting should have the same true disease incidence as herds confirming complete calf health records. Thus, the reported rates of diarrhea and respiratory disease of those herds claiming not proper recording were adjusted to the same level as those claiming complete calf health records. From this assumed “true” population incidence the number of assumed true cases was then estimated by multiplying the number of calves at risk with the assumed “true” risk rate. The proportion of missing reported cases were estimated as the “true” number of cases minus recorded cases all divided by the total number of estimated cases.

RESULTS

Disease Incidence

The final study population included health information on 6,668 calves born during a 1-yr (365 d) period in 135 Norwegian dairy herds between September 1, 2004, and January 31, 2007. In total, 1,936 calf health recordings on calves <180 d of age were reported to the NDHRS during the project period. A total of 573 (29.6%) of these were recordings of diseases, whereas 1,363 (70.4%) were preventive therapy, dehorning, or castration events. A complete overview of the different diseases and preventive treatments reported is presented in Table 1. Multiple events per calf were included. Altogether, 70 herds did not report any disease at all. The reported disease rate in the other 65 herds is displayed in Figure 1. A total of 137 (23.9%) of the disease recordings were done by the farmer, whereas 436 (76.1%) were treatments recorded by a veterinarian. At least one case of diarrhea or respiratory disease

was reported for 207 (3.1%) and 143 (2.1%) of the 6,668 calves, respectively. The median age for occurrence of diarrhea was 17 d, with the 10th, 25th, 75th, and 90th percentiles at 4, 9, 37, and 64 d, respectively. The median age for occurrence of respiratory disease was 37 d, with the 10th, 25th, 75th, and 90th percentiles at 6, 19, 69, and 102 d, respectively. The age distribution for occurrence of diarrhea and respiratory disease is presented in Figure 2. Frailty effects measured by Kendall's τ of 0.45 and 0.40 were found for diarrhea and respiratory disease, respectively.

Validity

Method 1. During the project period 90 cases of diseased calves were sampled; 6 calves were sampled twice. The second samples from these calves were excluded, as they were considered to belong to the same case of disease as the first sample. Altogether, 34 (13.1%) of the 259 cases of diarrhea reported to the NDHRS were sampled, and the corresponding number for reported cases of respiratory disease was 16 (11.1%) of 143. Eighty-four (25.0%) of 336 disease events recorded as veterinary treatments were sampled. A total of 50

(59.5%) of the 84 sampled calves were reported to the NDHRS, and the remaining 34 (40.5%) were not reported. Therefore, these results imply an underestimation of veterinary recordings in the NDHRS of 40.5% [95% CI: 30.0–51.0].

Method 2. Only 1 herd reported all dehornings during their period of participation in the project; 23 reported >50%, whereas 57 herd owners did not report any dehorning at all. Altogether, 146 (25.5%) of 573 disease recordings were done by herd owners reporting more than 50% of all dehorning. The proportion of calves with at least one reported case of either diarrhea or respiratory disease is presented in Figure 3. The total number of cases (incidence) of diarrhea and respiratory disease in the 1,144 calves born in herds reporting >50% of all dehorning was 57 (5.0%) and 71 (6.2%), respectively. In the 5,524 calves born in herds reporting <50% of all dehorning, a total of 202 (3.7%) and 124 (2.2%) recorded cases of diarrhea and respiratory disease were reported, respectively. Assuming that herds reporting >50% of all dehorning represent herds having a complete recording system, and thereby representing the “true” disease rates, in total 332 (5.0%) recordings of diarrhea and 413 (6.2%) recordings of re-

Table 1. Calf health-related events¹ reported in 6,668 calves of <180 d of age in 135 dairy herds during participation in a study on calf health in Norway from September 2004 through January 2007

Item	Events, n	Proportional rate, %	Recorded rate/100 calves	Method ²		
				Method 1: estimated true rate/100 calves if 40.5% lost	Method 2: estimated true rate/100 calves if 39.1% lost	Method 3: estimated true rate/100 calves if 39.1% lost
Health event						
Diarrhea	259	45.20	3.88	5.50	5.45	5.45
Respiratory disease	195	34.03	2.92	4.14	4.10	4.10
Arthritis	45	7.85	0.67	0.96	0.95	0.95
Wounds, abscesses, and flegmones	25	4.36	0.37	0.53	0.53	0.53
Indigestion/colic	13	2.27	0.19	0.28	0.27	0.27
Umbilical infection	5	0.87	0.07	0.11	0.11	0.11
Wounds caused by the interior	5	0.87	0.07	0.11	0.11	0.11
Claw diseases	3	0.52	0.04	0.06	0.06	0.06
Disease in or fractures of bones or tendons	4	0.70	0.06	0.08	0.08	0.08
Eye infection	4	0.70	0.06	0.08	0.08	0.08
Bloat	2	0.35	0.03	0.04	0.04	0.04
Heart disease	1	0.17	0.01	0.02	0.02	0.02
Skin disease	1	0.17	0.01	0.02	0.02	0.02
Other diseases	11	1.92	0.16	0.23	0.23	0.23
Total	573	100.00	8.59	12.17	12.05	12.05
Preventive treatment/surgery						
Dehorning	1,218	89.36	27.58			
Parasitic treatment	103	7.56	1.56			
Ringworm vaccination	30	2.20	0.45			
Malignant edema (gas gangrene) vaccination	9	0.66	0.14			
Castration	3	0.22	0.08			
Total	1,363	100.00	20.61			

¹Multiple events per calf are included. Each herd participated for 1 yr. Estimated true rates based on 3 different methods of data validation

²Method 1: based on comparison of number of diseased calves sampled to number of diseased calves registered in the Norwegian Cattle Health Recording System; method 2: based on the use of records of dehorning as an indicator of a well-functioning recording system; method 3: based on recorded disease incidence in herds confirming complete calf health records.

Figure 1. Recorded disease rate per 100 calves in 65 (48.1%) Norwegian dairy herds during 1 yr in the period from September 2004 through January 2007. In total, 70 (51.9%) herds did not report any disease.

spiratory disease (745 cases overall), should have been reported from the 6,668 calves in the total population. This implies an underestimation of 73 (22.0%) diarrhea recordings compared with the 259 cases actually reported (Table 1) and a loss of 218 (52.8%) cases of respiratory disease compared with the 195 cases reported in this study (Table 1). Compared with the 454 cases [diarrhea (259) and respiratory disease (195)] reported, this implies a total underestimation of 291 (39.1%; 95% CI: 35.6–42.6) of the 745 cases (Table 1). Percentage of reported dehorning was not found to influence the risk of diarrhea or respiratory disease significantly when included in the statistical analysis. No association between date of dehorning and date of registered disease was detected.

Method 3. A total of 72 of the 135 (53.3%) dairy farmers completed and returned the questionnaire. Of these, 63 (87.5%) reported that calf health events were recorded and reported to a large extent during the project period. Calves born in herds confirming complete calf health records were found to have a higher risk of both diarrhea and respiratory disease [hazard ratio: 5.98 (95% confidence interval: 1.45–7.2) and 4.60 (95% confidence interval: 1.33–15.33), respectively] compared with calves born in herds not confirming complete records. Overall, 432 (75.4%) of 573 disease recordings were reported from herds confirming complete calf health records. The proportion of calves reported with at least one case of either diarrhea or respiratory disease is presented in Figure 3. The total number of cases (incidence) of diarrhea and respiratory disease in the

3,074 calves born in herds confirming complete records were 199 (6.5%) and 145 (4.7%), respectively. In the 3,594 calves born in herds not confirming complete records, a total of 60 (1.7%) and 50 (1.4%) recorded cases of diarrhea and respiratory disease were reported, respectively. Assuming that herds with farmers confirming complete calf health records represent the “true” disease rates, in total 433 (6.5%) recordings of diarrhea and 313 (4.7%) recordings of respiratory disease (746 cases overall) should have been reported from the 6,668 calves in the total population. This implies an underestimation of 174 (40.2%) diarrhea recordings compared with the 259 cases actually reported (Table 1) and a loss of 118 (37.7%) cases of respiratory disease compared with the 195 cases reported in this study (Table 1). Compared with the 454 cases of diarrhea and respiratory disease actually reported, this implies a total underestimation of 292 (39.1%; 95% CI: 35.6–42.6) of the 746 cases (Table 1). In herds reporting complete calf health records, a total of 108 (54.2%) of the 199 recordings of diarrhea were done by the farmer, and the corresponding number for respiratory disease was 16 (11.0%) of 145.

DISCUSSION

Disease Incidence

The most frequent diseases in calves in Norway were enteritis and respiratory disease, which accounted for more than 75% of all diseases reported. This is in ac-

Figure 2. Age distribution for first occurrence of diarrhea ($n = 207$) and respiratory disease ($n = 143$) in 6,668 calves of <180 d of age born during 1 yr in 135 Norwegian dairy herds in the period from September 2004 through January 2007.

cordance with results from numerous other studies (Virtala et al., 1996; Svensson et al., 2003). The majority of the diarrhea cases were reported in calves of <4 wk, but the recordings of respiratory disease were from all age groups. This concurs with results from Svensson et al. (2003) who found that diarrhea in calves was diagnosed at a significantly lower age than respiratory disease. The incidences of calf diarrhea and respiratory disease found in our study are similar to those from Sweden (Svensson et al., 2003), but are low compared with reports from other countries. In studies of North American dairy farms, Waltner-Toews et al. (1986b) found that 20.5 and 15.4% of nearly 2,000 heifer calves were treated for diarrhea and pneumonia, respectively, whereas Gardner et al. (1990) found incidence rates of diarrhea and respiratory disease of 11.6 and 7.6%, respectively. Heringstad et al. (2008) reported an incidence of calf respiratory disease of 0.7% in calves born in Norwegian dairy herds between 2000 through 2006, including all herds registered in the NDHRS with records of dehorning. This is considerably lower than the results from the current study despite the project herds being selected from the same database in both studies. The low incidence of respiratory disease found by Heringstad et al. (2008) is probably due to the inferior quality of calf health records in the NCHRS in the

years before 2004. In the present study, only calves born during the project year for each herd were included, anticipating that the quality of calf health recordings during this period would be improved. Heringstad et al. (2008) found a heritability of respiratory disease of 0.05 in Norwegian dairy calves. Because of the low calf pneumonia incidence reported in that study, the authors state that the gain of genetic improvement is minimal regarding this disease in the Norwegian cattle population. Based on the incidence of respiratory disease reported from the current study, the potential for genetic improvement was probably underestimated by Heringstad et al. (2008).

Svensson et al. (2003) suggested that the lower calf disease incidence reported in Sweden and Norway might be partly due to low animal density and small herd sizes, compared with most other countries in Western Europe and North America. In addition, the animal health status in Nordic countries is clearly favorable compared with the situation in the rest of Europe; Norway is declared free from many serious infectious diseases, including infectious bovine rhinotracheitis (Kampen et al., 2007a) and bovine virus diarrhea (Kampen et al., 2007b), and bovine ringworm is also close to eradication (Plym Forshell et al., 2008). Also, according to preliminary results from another part of

Figure 3. Proportion of calves of <180 d of age reported with at least one case of diarrhea or respiratory disease in 135 Norwegian herds stratified according to degree of reported dehorning and different commitment to calf health recordings. Hatched bars indicate herds reporting >50% of all dehorning [N (herds) = 23, n (calves) = 1,144]; dotted bars indicate herds reporting <50% of all dehorning (N = 112, n = 5,524); black bars indicate herds confirming complete calf health records (N = 63, n = 3,074); and white bars indicate herds not confirming complete calf health records (N = 72, n = 3,594).

the present project (Lie et al., 2007), there have been no indications of the occurrence of *Mycoplasma bovis* in the Norwegian cattle population to date. The reasons behind the good infection status regarding calf health in Norway are multifactorial and include an isolated geographic position, restrictive rules for importation and trade of animals and animal products, and national surveillance and control programs for infectious diseases (Pedersen, 1996). Extrapolation from the results of the current study should therefore be restricted to countries with similar infectious status.

The macro of Shu and Klein (2005) was used to account for the expected cluster effect at herd level. The results confirmed a highly significant frailty effect at herd level both in diarrhea and respiratory disease. This implies a variation in infectious status between

participating herds, and that herd-specific factors are of major importance for the observed variation in reported calf disease incidence.

Validity

Method 1. Although the veterinarians involved in the study were instructed to sample all diseased calves, only 25.0% of cases reported as veterinary treatments were sampled. In this study, approximately 75% of the calf health recordings were registrations of veterinary treatment. It was anticipated that a greater proportion of diseased calves would have been sampled in the current study, as the majority of livestock treatments in Norway are performed by veterinarians, in contrast to the situation in many other countries. The fact that more than 40% of the cases sampled were not reported clearly reflects a lack of commitment from the veterinarians participating in the project. Also, there is a risk that the veterinarians were even worse at reporting cases of calf disease that were not sampled. Hence, the proportion of underreporting of calf diseases in the total population most probably exceeds the 40% reported here.

In our experience, farmers differ in their criteria for requesting the assistance of a veterinarian in cases of calf disease. The economic aspect of a veterinary visit cannot be excluded in the current study, as the project only paid for the additional sampling. Approximately 40% of the samples from diseased calves were from farms located in the eastern parts of Norway. The distances between the farms in this area are usually relatively short, especially compared with farms situated in the western and northern parts of the country, making them more accessible to veterinarians in the district. Also, these farms are situated closer to the Norwegian School of Veterinary Science, which might have led to closer contact with the project personnel and thereby more commitment to the project among the farmers and veterinarians. Consequently, these samples are probably not randomly distributed. Thus, the calculated underestimation of reported calf diseases based on these samples might not fully represent the whole study population.

Method 2. Several farmers and veterinarians might consider it unnecessary to report dehorning as a preventive treatment, but nevertheless be consistent when it comes to the reporting of cases of calf disease. This was supported by the fact that there was no association between the percentage of reported dehorning and the reported incidence of diarrhea or respiratory disease. There was no reason to believe that the calf health in these herds was poorer than that of other participating herds. The high incidence of respiratory disease

reported from herds reporting >50% of all dehorning might be somewhat overestimated due to project enthusiasm among those farmers. Therefore, our results suggest that a high degree of reported dehorning may be unreliable as an indicator of a well-functioning recording system for disease.

Method 3. Higher frequencies of both diarrhea and respiratory disease were reported from herds confirming complete calf health records, even though some of these herds verified that the reason for no registrations during their project year was absence of calf disease in the herd. The majority of cases of diarrhea reported from these herds were done by the farmer, in contrast to the majority of recordings in the NCHRS, which are usually registrations of veterinary treatments of disease. Norwegian dairy farmers are not allowed to administer any drugs or perform intravenous fluid therapy, but a veterinarian is seldom consulted for cases of diarrhea believed by the farmer to be relatively harmless. This often includes short-term cases of diarrhea caused by viral infections, malnutrition, or rapid changes in diet, which could be treated by oral fluid therapy and electrolyte solutions. These cases are probably seldom recorded in the NCHRS, but farmers in this project were instructed to record all cases of diarrhea occurring during participation. This might explain the high diarrhea incidence reported from these herds. As reported for Swedish dairy calves (Pettersson et al., 2001), the majority of young calves in Norway are housed individually, and older calves are kept in groups (S. M. Gulliksen, unpublished data). It might be more difficult for the animal caretaker to recognize disease in animals kept in groups than in single-housed animals. As the diarrhea incidence was higher in young calves, whereas respiratory disease was reported in all age groups, this might explain the lower frequency of farmer-reported respiratory diseases in the current study, as compared with diarrhea. Lundborg et al. (2005) found that the risk of respiratory disease was increased on farms with poor record-keeping. Consequently, the actual incidence of calf disease in herds considered to have poor recording ability in the current study might actually be even higher than the reported disease incidence in herds considered to perform high-quality record-keeping. Based on the results from the current study, farmers confirming complete calf health records were considered to be the most reliable measure of maintenance of high-quality calf health records.

Calf health advisories should be based on high-quality data. From 2005 to 2006, disease recordings in the NCHRS of female and male calves increased by 12.1 and 24.2%, respectively (NCHS, Annual Report 2006). Both the quality and quantity of calf health recordings in the NCHRS are gradually improving, but ongoing work on

calf health is necessary. The number of calf diseases and treatments currently reported to the NCHRS is still an underestimate of the actual situation, despite the use of individual health cards. The NCHRS is presently being upgraded to a system in which veterinarians will be able to report diseases directly to a central database after a herd visit. It is anticipated that this system will increase the number of calf diseases reported and improve the accuracy of the recordings.

CONCLUSIONS

All 3 methods of validation used in the current study showed an underestimation of calf disease records in the NDHRS of approximately 40% and an estimated "true" incidence of diarrhea and respiratory disease of 5.5 and 4.1%, respectively. Herd owners confirming complete calf health records were believed to be the most reliable measure of maintenance of high-quality records. The results from the current study emphasize the importance of encouraging farmers to perform calf health recordings and demonstrate that identifying a standardized method for validation of health data still is a considerable challenge.

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