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The validity of a monitoring system based on routinely collected dairy cattle health data relative to a standardized herd check

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ABSTRACT

Dairy cattle health is often assessed during farm visits. However, farm visits are time consuming and cattle health is assessed at only one point in time. Moreover, farm visits are poorly comparable and/or repeatable when inspection is carried out by many different professionals.

Many countries register cattle health parameters such as bulk milk somatic cell count (BMSCC) and mortality in central databases. A great advantage of such routinely available data is that they are uniformly gathered and registered throughout time. This makes comparison between dairy cattle herds possible and could result in opportunities to develop reliable tools for assessing cattle health based on routinely available data.

In 2005, a monitoring system for the assessment of cattle health in Dutch dairy herds based on routinely available data was developed. This system had to serve as an alternative for the compulsory quarterly farm visits, which were implemented in 2002. However, before implementation of the alternative system for dairy cows, the validity of the data-based monitoring system and the compulsory quarterly visits relative to the real health status of the herd should be known. The aim of this study was to assess the validity of the data-based monitoring system and the compulsory quarterly visits relative to a standardized herd check for detecting dairy herds with health problems.

The results showed that routinely available data can be used to develop an effective screening instrument for detecting herds with poor cattle health. Routinely available data such as cattle mortality and BMSCC that were used in this study had a significant association with animal-based measurements such as the general health impression of the dairy cows (including e.g. rumen fill and body condition). Our study supports the view that cattle health parameters based on routinely available data can serve as a tool for detecting herds with a poor cattle health status which can reduce the number of expensive farm visits. Veterinarians and other herd health advisors could use this tool to target visits to those farms that are identified as at risk for poor cattle health. The development of similar tools in other countries seems possible because many countries have similar data in central databases.

1. Introduction

The EU regulations RL64/432/EEG and RL97/12/EG state, among other, that milk has to come from healthy cows. To comply with these regulations, since 2002 all Dutch dairy herds are visited every quarter by a veterinarian specialized in ruminant health to assess a number of pre-described cattle health aspects. These visits intend to detect farms with unacceptable cattle health. However, farm visits are often time consuming and thus expensive. In addition, cattle health is assessed at only one moment every quarter and subjective elements in the scoring system make comparison between herds difficult due to the large number of professionals involved.

Many stakeholders in Europe are increasingly aware of the need for harmonised and accessible cattle health data within and across countries. There is a great interest in monitoring cattle health and welfare using data that are already available in central databases recorded by National Cattle Registers (EADGENE, 2008; De Vries

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et al., 2011). A great advantage of such routinely available data is that they are cheap and usually uniformly gathered, because most data are registered using prescribed measurements. This makes comparison within and between dairy cattle herds possible. In addition, these parameters are collected continuously and not only at one point in time. With that, these data provide opportunities to develop reliable and effective tools for assessing cattle health throughout time. In Sweden, for example, routinely available data were used for the development of a monitoring system to identify dairy herds at risk of "welfare deficiency" (Sandgren et al., 2009; Nyman et al., 2011).

In the Netherlands, several organizations are engaged in registration of cattle health data, such as mortality and bulk milk somatic cell count (BMSCC). For each cattle health parameter only one organization is responsible for capturing data on a daily basis in a central database. These data are routinely available for all dairy herds. For example, the Milk Control Station (MCS) analyzes bulk milk samples for SCC at each collection from every herd. Farmers are obliged to report dead animals for collection by the rendering plant and the Dutch cattle improvement organization (CRV) collects individual SCC from all cows in their test schemes. These data have a very high data quality because the data are primarily used for e.g. genetic improvement, payments for milk etc.

In 2005 and 2006, a monitoring system for the assessment of cattle health in Dutch dairy herds based on routinely available data (including e.g. mortality and BMSCC) was developed using expert opinion and an exploratory factor analysis to develop a weighted scoring system, the so-called Continuous Cattle Health Monitor (CCHM). This new system has to serve as an alternative for the compulsory quarterly visits. Before all dairy herds can join the data-based monitoring system, the validity of this system relative to the real health status assessed by a standardized health check of the herd should be known. Nowadays, mainly animal-based measurements are used to assess animal health and welfare in dairy herds (Keeling and Veissier 2005; Veissier and Evans, 2007). Therefore, it is also important to know the associations of the data-based monitoring system on herd level with the separate animal-based measures of the herd visit to verify which aspects of animal health are represented by the monitoring system.

The aim of the study was to assess the validity of the data-based monitoring system and the compulsory quarterly visits relative to a standardized herd check for detecting dairy herds with health problems.

2. Material and methods

2.1. Development and description of the data-based monitoring system

In 2005 and 2006, a monitoring system for the assessment of cattle health in Dutch dairy herds based on routinely available data was developed, the so-called Continuous Cattle Health Monitor (CCHM). Therefore, first uniform data concerning on-farm movements, mortality, bulk milk quality, milk production, udder health and herd status for infectious diseases were gathered. Cattle health information was averaged per herd and quarter of a year.

Second, an expert panel on cattle health was composed which consisted of two veterinarians, two dairy farmers, two epidemiologists and four representatives from a dairy cooperation. Expert opinion was used to select parameters in routinely available data which were considered to be associated with cattle health. The expert panel defined 15 different cattle health parameters. Third, an exploratory factor analysis was carried out to examine the interrelationships among these cattle health parameters. The interpretation focused on selecting parameters for monitoring cattle health in dairy herds that were not strongly related to one another, in other words each parameter had to represent a different cattle health aspect. The factor analysis resulted in eight factors and from each factor at least one parameter was selected for the data-based system, which resulted in the selection of 11 cattle health parameters (Table 1). These parameters were used for the development of a weighted scoring system, the CCHM.

The CCHM is based on minimum requirements that a herd has to meet for a sufficient cattle health status. Farmers earn points for a parameter if its value was equal to or below its threshold. Thresholds are based on the 90th percentile of the Dutch dairy herds in 2004, because it was assumed that the majority of the dairy herds had a sufficient cattle health status. No points are given to the herd, if the parameter is above its threshold. The division of the 100 points across the parameters is reflecting the expert panel's perceived importance of its association with cattle health in a herd. All points were summed up to a quarterly score for cattle health on a scale from 0 (worst) to 100 (best).

The intention of the CCHM is to detect herds with prolonged health problems in especially lactating cows. To reduce the effect of incidents and thus a single decreased quarterly score, the cattle health status of a herd is based on an annually moving average, which is determined by the average of the last four quarterly scores. Two cattle health statuses were initially distinguished:

1. Annually moving average <60 points = poor cattle health
2. Annually moving average ≥60 points = sufficient cattle health

The threshold of 60 points was based on the distribution of the 2004 moving average of all Dutch dairy herds. It showed that 5% of the herds had an annually moving average of less than 60 points and only a small proportion of herds was expected to have an unacceptable poor cattle health.

Follow-up actions are foreseen to confirm and improve cattle health in herds with poor cattle health. A farm visit has to be carried out by the veterinary practitioner of the herd and should result in a scheme to improve cattle health.

2.2. Herd check and compulsory quarterly visits

In the first half of 2007, herds that were member of the dairy co-operative FrieslandCampina (with 9500 members at that time) were approached to join the CCHM. Finally, 3677 herds voluntary joined the CCHM. Routinely available data of the participating herds were compiled from different organizations within the Dutch cattle industry over a one-year period (July 2006–June 2007, Table 1). These data were used to determine the herd's quarterly scores in the second half of 2006 and the first half of 2007 and were averaged to an annually moving average. Because the distribution of the CCHM's annually moving average of all Dutch dairy herds was similar over the years, the participating 3677 herds were initially classified into herds with sufficient and poor cattle health using the thresholds that were determined on the 2004 moving average of all Dutch dairy herds. To determine the validity of the CCHM relative to a standardized herd check, 200 herds were selected from the participating 3677 herds. A stratified random selection procedure was used to select enough herds with poor cattle health based on the CCHM of 2006–2007 to maximize the variation in cattle health between herds. From the group with a CCHM's poor cattle health status, 50 herds were randomly selected and from the group with a CCHM's sufficient cattle health status 150 herds were selected.

A standardized herd check was developed by an expert panel (consisting of two veterinarians, two dairy farmers, two epidemiologists and four representatives from a dairy cooperation which were also involved in developing the CCHM) which consisted of on-farm assessment of different cattle health aspects in a sample

Table 1
Mean, thresholds and weighted scores of the parameters within the Continuous Cattle Health Monitor (CCHM) to assess cattle health on a quarterly basis in dairy herds in the Netherlands in 2006/2007 (N = 16,100). Farmers earn points for a parameter if its value was equal to or below its threshold. No points are given to the herd, if the parameter is above its threshold.

Parameter	Source	Mean	Threshold	Weighted score (in points)
Cattle mortality (%/quarter)	Rendering plant, Identification & Registration organization	0.63	≤1.60	25
Young stock mortality (%/quarter)	Rendering plant, Identification & Registration organization	3.2	≤8.5	10
Incidence of subclinical mastitis (%/quarter)	Cattle improvement organization	10.0	≤12.5	20
Bulk milk somatic cell count (BMSCC in 10^3 cells/ml per quarter)	Milk Control Station	216	≤300	15
Decrease in Standard Peak production (ΔSPP in%/quarter)	Cattle improvement organization	0.3	≤10	15
closed farming system (no cattle moved on-farm in the previous 12 months, %herds/quarter)	Identification & Registration organization	52.7		10
Certified free or unsuspected status (%herds/quarter) for bovine virus diarrhoea (BVD), infectious bovine rhinotracheitis (IBR), leptospirosis, paratuberculosis, salmonellosis[a]	Animal Health Service	12.9 31.7 99.7 8.2 19.0		5 (1 point per certificate)
Total				100

[a] Both herds that participate in a program but have no free status and herds that are not participating do not earn points.

of cows from the herd. Two veterinarians, that were part of the expert panel as well, carried out all herd checks in the 200 selected herds in the second quarter of 2007. Each herd was visited by one of the veterinarians for the check. The herd check was used as the pseudo-gold-standard reference against which the results of both the compulsory quarterly visits and the CCHM were compared. First, the general impression of the dairy cows (including body condition, rumen fill, locomotion and cleanliness of skin and presence of skin injuries) was examined. Every aspect was scored on a scale from 1 (extremely poor)-10 (excellent) points, in accordance with the grading system in Dutch schools, and an average score across all aspects was determined for the general impression of the dairy cows. In addition, the status of the herd for claw and leg disorders (i.e. visible hock or knee lesions, Metz et al., 2015) was scored on a scale from 1 to 10 points. Moreover, the proportion of cows with a body condition score <2 (i.e. very thin cows with no fat reserves), the proportion of lame cows and the proportion of loser cows (i.e. cows with multiple problems, who have to be culled or euthanatized shortly, Thomsen et al., 2007) were determined. Finally, the general impression of youngstock (0–2 years old) was scored on a scale of 1–10 points. The average of all scored cattle health aspects (i.e. the overall herd check score, 1–10 points) was used to determine whether a herd had a sufficient or poor cattle health status. The threshold for a poor cattle health status was set at an overall herd check score <6 points, which is commonly seen as the threshold for a poor grade on a scale from 1 to 10. To obtain comparable and objective results, the two veterinarians that visited the 200 selected dairy herds did not know the farms nor the CCHM's annually moving average of the dairy herds beforehand. In addition, the veterinarians visited the first ten dairy herds together to obtain agreement in their scoring.

Farmers that participated in the CCHM were informed by the study team that they did not have to carry out a quarterly visit. However, a quarterly visit was carried out in 92 of the 200 selected herds in the second quarter of 2007 by their own veterinary practitioner, according to the already established routine for quarterly visits to meet EU requirements. The results of these visits are not meant to provide the farmer with information to improve the cattle health status of the herd, but they are above all a prerequisite for the export of Dutch dairy products (EU regulations RL64/432/EEG and RL97/12/EG). During these visits the numbers of lactating cows (1) that produce milk with abnormal organoleptic features, (2) with visible general health problems, (3) with abnormal uterine discharge, (4) with fever combined with diarrhoea, (5) with udder lesions, (6) with zoonotic diseases (leptospirosis, cryptosporidiosis, salmonellosis, listeriosis, brucellosis, tuberculosis, BSE and antrax) and (7) with notifiable diseases were registered. The total proportion of lactating cows with the above mentioned health disorders was determined for each herd.

2.3. Comparison of the CCHM and the compulsory quarterly visits with the herd check

The main goal of the CCHM and compulsory quarterly visits is to detect herds with poor cattle health, thus a high sensitivity is preferred. However, a low specificity (i.e. a high number of false-positives) can cause high costs due to the control measures that have to be taken. The ability of the CCHM and compulsory quarterly visits to discriminate between an actual sufficient and poor cattle health status was examined by using non-parametric receiver operating characteristic (ROC) curves. The herd check was set as the reference test (0 = sufficient cattle health status when overall herd check score ≥6 points and 1 = poor cattle health status when overall herd check score <6 points). The cut points for poor cattle health determined by the CCHM were based on the annually moving average (the higher the better the cattle health status),

whereas cut points for poor cattle health determined by the compulsory quarterly visits were based on the percentage of lactating cows with health disorders (the higher the worse the cattle health status). The area under the curve (AUC) was determined as global summary statistic of the CCHM's and compulsory quarterly visits' accuracy (Greiner et al., 2000). According to Swets (1988), one could discriminate between non-informative (AUC = 0.5), less accurate (0.5 < AUC ≤ 0.7), moderately accurate (0.7 < AUC ≤ 0.9), highly accurate (0.9 < AUC < 1) and perfect tests (AUC = 1). The AUC of the CCHM was determined for all 200 study herds. The AUC of the compulsory quarterly visits was determined for the subset of 92 herds that joined the compulsory quarterly visits as well. To determine whether the overall diagnostic performance of the two tests was significantly different from the overall herd check score, the roc-gold procedure (χ^2–test, $P \leq 0.05$) was used in Stata/SE 13.1 (Stata Corporation, 2007). The Youden Index ($J = Se + Sp - 1$) was determined to investigate what cut-off value of the annually moving average (CCHM) optimized screening, given that our first interest was a high sensitivity of the CCHM. The sensitivity and specificity of the CCHM relative to the herd check were determined on all 200 study herds.

2.4. Association of CCHM with cattle health aspects assessed during the herd check

A linear regression was performed on the CCHM's annual moving average to determine the association of the CCHM with the cattle health aspects assessed during the herd check. First, all cattle health aspects were subjected to univariate analysis. Variables with a *P*-value <0.25 were used in the multivariate linear regression model. A backward selection procedure was used to select the cattle health aspects that were significantly associated ($P \leq 0.10$) with the CCHM's annual moving average and were selected for the final model. Because it was thought that herd size could bias the CCHM's annual moving average, this parameter was forced into the model. A skewness–kurtosis test (sktest, Stata/SE 13.1, Stata Corporation, 2007) was carried out on the residuals to check whether the data were normally distributed.

3. Results

3.1. Validity of the CCHM and compulsory quarterly visits

The herd check showed that 2.0% of the 200 herds had poor cattle health. The ROC plots for the CCHM and the compulsory quarterly visits in relation to the herd check are shown in Fig. 1, whereas the AUC for both tests are provided in Table 2. The AUC of the CCHM (0.81) was not significantly different from the AUC of the herd check (χ^2–test, $P = 0.09$). However, the AUC of the compulsory quarterly visits (0.52) was significantly different from the AUC of the herd check ((χ^2–test, $P = 0.03$).

A plot of the sensitivity and specificity against various annually moving averages for the CCHM is provided in Fig. 2. The initial cut-off value for a poor cattle health status was set at an annually moving average <60 points. The sensitivity and specificity for this cut-off value were 50.0% (95% CI: 39.8–60.2%) and 76.0% (95% CI: 67.3–84.7%), respectively. The optimal cut-off value with the highest Youden Index was reached at <70 points and 52% of the herds were correctly classified. The sensitivity for this cut-off value was 100% and the specificity was 51.0% (95% CI: 40.8–61.2%).

3.2. Association between CCHM and cattle health aspects assessed during the herd check

The results of the final linear regression model are provided in Table 3. The skewness–kurtosis test was not significant ($P = 0.14$), indicating that the residuals were normally distributed. Farm size, the presence of both seriously lame and loser cows and the general impression of the dairy cows and youngstock explained 35.4% (R^2) of the variation in the CCHM's annual moving average. The CCHM's annual moving average significantly increased with 6.3 points with each one point increase for the general impression of the dairy cows ($P = 0.002$). In addition, with each one point increase for the general impression of youngstock, the CCHM's annual moving average increased with 7.7 points ($P = 0.001$). The CCHM's annual moving average of herds with loser cows tended to be 4.8 points lower compared to herds without loser cows ($P = 0.07$). Moreover, herds with seriously lame cows tended to have a CCHM's annual moving average that was 4.3 points lower compared to herds without seriously lame cows ($P = 0.09$). The presence of cows with a body condition score <2 ($P = 0.92$) and the status of the herd for claw and leg disorders ($P = 0.62$) were not significantly associated with the CCHM's annual moving average.

4. Discussion

The results of this study showed that a monitoring system based on routinely available data (CCHM) served as a better diagnostic tool for detecting herds with a poor cattle health status than the compulsory quarterly farm visits by the herds' veterinary practitioner. In this study a herd check was carried out to assess the cattle health in dairy herds. We used it as the pseudo-gold-standard for the assessment of cattle health in dairy herds. The herd check consisted of the assessment of well-defined and objective animal and farm level health aspects that were thought to give a good reflection of cattle health. However, aspects such as cattle behaviour were not determined because of time and budget constraints.

In a sensitivity analysis, the weighting of the cattle health parameters in the CCHM were adjusted to explore the change in overall accuracy and the sensitivity and specificity of the CCHM. The current weighting of the parameters in the CCHM was based on a system that optimized screening, given that our first interest was a high sensitivity of the CCHM.

According to the guidelines suggested by Swets (1988), the compulsory quarterly visits were less accurate, whereas the CCHM was moderately accurate. The initial cut-off value for a CCHM's insufficient status (annually moving average <60 points) resulted in a low sensitivity (50.0%), whereas a high sensitivity was preferred. Using a cut-off value of <70 points resulted in a 100% sensitivity and the highest Youden Index and therefore it was decided to use this cut-off value in the field. Herds with an annually moving average <60 points were still considered as herds with prolonged cattle health problems, whereas herds with 60–69 points were considered as herds at risk for prolonged cattle health problems. Because specificity (51.0%) was relatively low, follow-up actions are needed for herds below the cut point of 69 points to confirm and, if necessary, to improve the cattle health status in these herds. To compensate for the fairly low specificity, herds where the annual moving average is below 60 points for two consecutive quarters, have to carry out a farm visit by their own veterinary practitioner and are allowed to set up a tailor made scheme to improve the cattle health status of the herd. Herds with a CCHM's score between 60 and 69 points are advised to contact their veterinary practitioner to find out which aspects caused the lower score.

This study also shows that routinely available data have a relevant association with the general health impression of the dairy cows (including e.g. rumen fill and body condition) and youngstock. Nowadays, mainly animal-based measurements are used to assess animal health and welfare in dairy herds (Keeling and Veissier 2005; Veissier & Evans, 2007). Routinely available cattle health

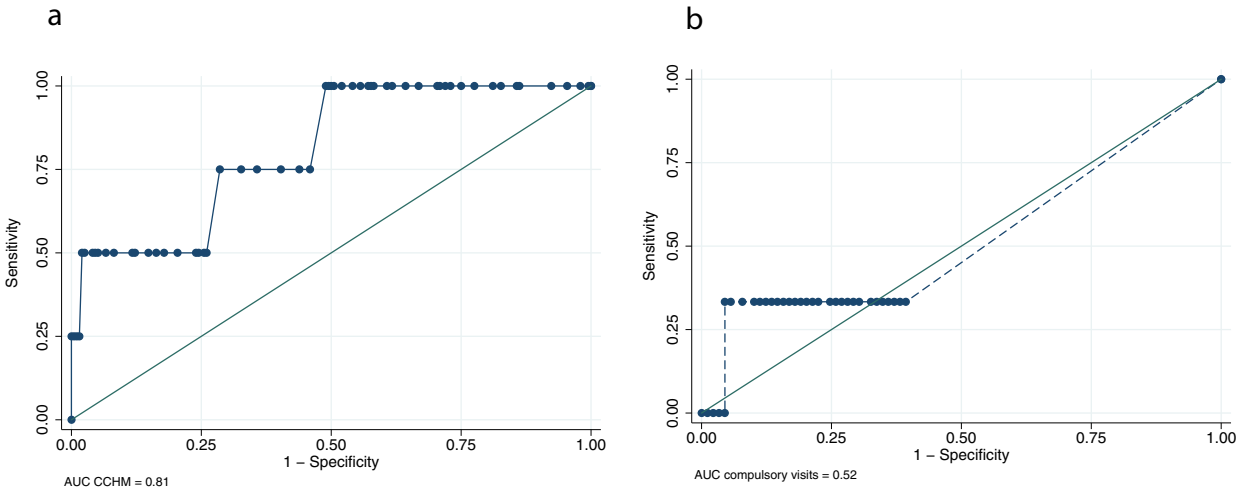

Fig. 1. Receiver operating characteristic (ROC) curves for the Continuous Cattle Health Monitor (CCHM, (a)) and the compulsory quarterly visits (b) for the detection of herds with a poor cattle health status. The grey solid line represents the 0.5 line, which is the limit for the ability of a test to discriminate between herds with a sufficient or poor cattle health status.

Table 2
The area under the curve (AUC) of the non-parametric receiver operating characteristic (ROC) analysis for the Continuous Cattle Health Monitor (CCHM) and the compulsory quarterly visits.

Test	No. herds	AUC	Standard error	95% Confidence interval	
CCHM	200	0.81	0.11	0.58	1.00
Compulsory quarterly visits	92	0.52	0.22	0.09	0.95

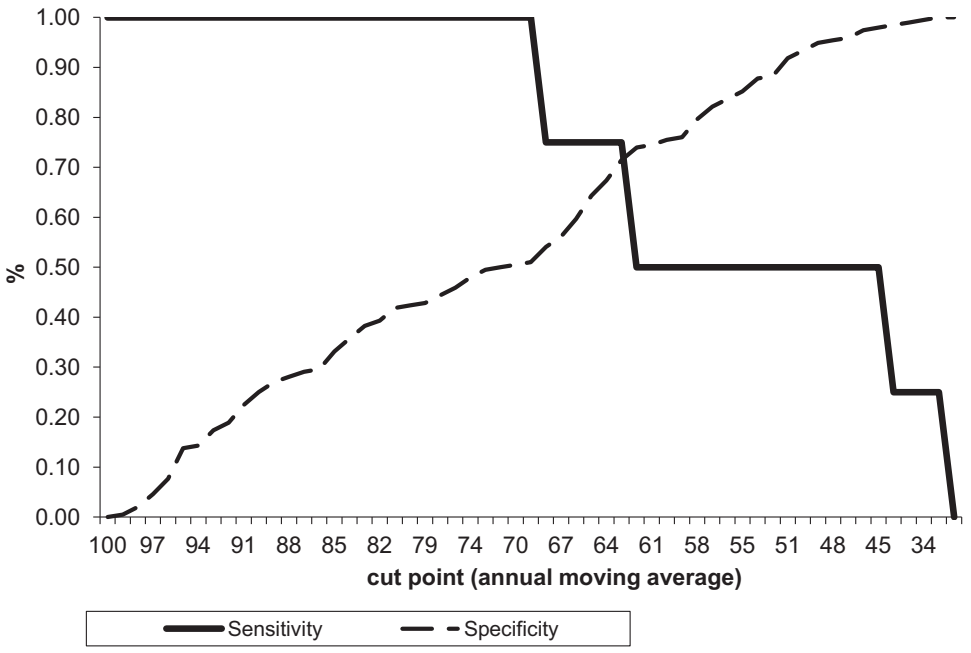

Fig. 2. Plot of the sensitivity and specificity against various annually moving averages for the Continuous Cattle Health Monitor (CCHM) based on 200 Dutch dairy herds.

Table 3
Results of the final linear regression model of the CCHM's annual moving average and significant cattle health aspects ($P \leq 0.10$) measured during the herd check.

Cattle health aspect	Class	Coefficient (no. points)	*P*-value	95% Confidence interval	
Farm size					
	<47 Dairy cows	−11.2	0.00	−16.0	−6.3
	47–92 dairy cows	Reference			
	>92 Dairy cows	0.01	1.00	-4.8	4.9
Presence of seriously lame cows	No	Reference			
	Yes	−4.3	0.09	−9.2	0.6
General impression of dairy cows	Per 1 point increase	6.3	0.00	2.4	10.2
Presence of loser cows	No	Reference			
	Yes	−4.8	0.07	−10.1	0.4
General impression of young stock	Per 1 point increase	7.7	0.00	3.2	12.3

data could therefore be an efficient tool for preselecting herds with specified health problems in cows or youngstock.

The CCHM was meant to replace the compulsory quarterly visits. Therefore, the parameters that were used in the alternative system, had to be available for the majority of the Dutch dairy herds. However, udder health information of 20% of the Dutch dairy herds was missing, because they did not participate in the cattle improvement programme of CRV Holding. Because milk production and individual somatic cell counts are important parameters in the alternative system, these herds can not participate unless they join a test-day scheme. The CCHM can be an alternative monitoring system for 80% of Dutch dairy herds and the other 20% of herds are obliged to join the compulsory quarterly visits to monitor their cattle health. The CCHM was implemented in 2008 and dairy farmers were given the choice to join the CCHM or the compulsory quarterly visits. Currently 8400 Dutch dairy herds (45% of the dairy herd population) are participating in the CCHM. For the development of a monitoring system based on routinely available data, it is important to know beforehand for how many herds data will be available. Other countries could determine their own set of relevant parameters in accordance with the methods proposed in our study.

The scoring of herds was done by two veterinarians who were blind to the CCHM score and the cattle health situation in the study herds. In addition, they were trained to uniformly score the health status of the herds which makes comparison of cattle health between herds possible. The compulsory quarterly visits are carried out by a large number of veterinary practitioners who know the cattle health situation of their clients and together with subjective elements in the scoring systems makes comparison within and between herds difficult.

The prior believe was that a very low percentage of dairy herds had poor cattle health. Therefore, a stratified random selection procedure, based on the CCHM's cattle health status, was carried out to select enough herds with poor cattle health. Despite our efforts to select enough herds with poor cattle health, we detected four herds (2%) with poor health in the herd check and these were all detected by the CCHM leading to a point estimate for the sensitivity of 100%. However, the precision on the sensitivity with four herds is low and needs to be checked regularly. Currently, the validity of the CCHM is determined every three years. To select enough herds with poor cattle health and to get a more precise estimate of the CCHM's sensitivity relative to a farm visit, it is recommended to use herd advisor's knowledge.

In the Dutch dairy population around 5% of all Dutch dairy herds are classified in the CCHM with an insufficient cattle health status. These herds receive a warning that they have to improve the health status of their herd. About 0.5% of the herds have two consecutive annual moving averages below 60 points. These herds are obliged to design and present a herd health improvement plan with the veterinary practitioner. Compared to 100% of the herds that are assessed by the veterinary practitioner during the compulsory quarterly visits, costs for farm visits can be reduced using routine herd data to assess cattle health in dairy herds.

The data-based monitoring system has been developed on one year of data. In addition, the association found with the true health status in dairy herds was based on the assessment of cattle health in a single quarter of the year (second quarter of 2007), whereas seasonal differences may influence the association found. The strength of the association with the true health status in dairy herds should be determined at regular intervals, to check whether the association changed as a result of changes in the dairy industry (e.g. changes in governmental rules, management, housing and farm size) or as a result of seasonal differences. Moreover, when other routinely available census data will become available, they could be incorporated in the system, if they clearly improve the predictive value of the system for cattle health. Because the validity of the CCHM is determined every three years, the effect of changes in the dairy industry and the predictive value of new data sources on the CCHM's performance can also be investigated with a standardized herd visit in a representative sample of herds.

Worldwide, the development of efficient and reliable systems for assessing animal health and welfare has a high priority (De Vries et al., 2011; Sandgren et al., 2009; Nyman et al., 2011). Weighed sums of scores are often used for the measurement of animal health and welfare (Bartussek, 1999; Keeling and Svedberg, 1999; Horning, 2001; Scott et al., 2001; Bracke et al., 2002). In addition, these scores are easily understood by non-scientists and could be used as useful management information (Botreau et al., 2007). Each CCHM participant receives an overview of the CCHM's status. In addition, the farmer can compare the performance of his herd with the average Dutch dairy herd.

As more and more countries are aware of the importance to register cattle health and welfare parameters in central databases, this could result in opportunities to develop reliable tools for assessing animal health based on routinely available data that are applicable in many countries. In addition, the development of such tools makes objective comparison of health parameters between herds across countries possible.

5. Conclusions

From this study can be concluded that an objective monitoring system based on routinely available data served as a better diagnostic tool for detecting herds with a poor cattle health status than compulsory quarterly farm visits by the herds' veterinary practitioner. Our study supports the view that cattle health parameters based on routinely available data can serve as a tool for detecting herds with a poor cattle health status which can reduce the number of expensive farm visits. Cattle health advisors could use this type of tool to target visits to those farms that are identified as at risk for prolonged cattle health problems.

Conflict of interest

None of the authors of the above manuscript have declared any conflict of interest which may arise from being named as an author of the manuscript.

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