



# German Farmers' Awareness of Lameness in Their Dairy Herds

**Katharina Charlotte Jensen<sup>1,2\*</sup>, Andreas W. Oehm<sup>3</sup>, Amely Campe<sup>4</sup>, Annegret Stock<sup>5</sup>, Svenja Woudstra<sup>2</sup>, Melanie Feist<sup>3</sup>, Kerstin Elisabeth Müller<sup>5</sup>, Martina Hoedemaker<sup>2</sup> and Roswitha Merle<sup>1</sup>**

<sup>1</sup> Department of Veterinary Medicine, Institute for Veterinary Epidemiology and Biostatistics, Freie Universität Berlin, Berlin, Germany, <sup>2</sup> Clinic for Cattle, University of Veterinary Medicine, Foundation, Hannover, Germany, <sup>3</sup> Clinic for Ruminants With Ambulatory and Herd Health Services, Ludwig-Maximilians Universität Munich, Munich, Germany, <sup>4</sup> Department of Biometry, Epidemiology and Information Processing (IBEI), WHO Collaborating Centre for Research and Training for Health at the Human-Animal-Environment Interface, University of Veterinary Medicine Hannover, Foundation, Hannover, Germany, <sup>5</sup> Clinic for Ruminants and Swine, Faculty of Veterinary Medicine, Freie Universität Berlin, Berlin, Germany

## OPEN ACCESS

### Edited by:

Lynette Arnason Hart,  
University of California, Davis,  
United States

### Reviewed by:

Marcia Endres,  
University of Minnesota Twin Cities,  
United States  
Jo Hockenull,  
University of Bristol, United Kingdom

### \*Correspondence:

Katharina Charlotte Jensen  
katharina.jensen@fu-berlin.de

### Specialty section:

This article was submitted to  
Veterinary Humanities and Social  
Sciences,  
a section of the journal  
Frontiers in Veterinary Science

**Received:** 31 January 2022

**Accepted:** 28 February 2022

**Published:** 24 March 2022

### Citation:

Jensen KC, Oehm AW, Campe A,  
Stock A, Woudstra S, Feist M,  
Müller KE, Hoedemaker M and  
Merle R (2022) German Farmers'  
Awareness of Lameness in Their Dairy  
Herds. *Front. Vet. Sci.* 9:866791.  
doi: 10.3389/fvets.2022.866791

Lameness is one of the most challenging problems in the dairy industry. Control is impeded because farmers often underestimate the number of lame cows. The objectives of this study were to assess German farmers' awareness of lameness in their herds and to determine the associations between farmers' awareness and their management practices, farm characteristics as well as with farmers' education, personality traits and attitudes. As a part of a large cross-sectional study, veterinarians visited farms in three structurally different regions of Germany: north ( $n = 253$ ), east ( $n = 252$ ), and south ( $n = 260$ ). The cows ( $n = 84,998$ ) were scored for locomotion and farmers were asked to estimate the number of cows that were lame or did not walk soundly. The ratio of farmers' estimated prevalence and the veterinarians' observed prevalence (Farmer's Detection Index; FDI) was calculated. The median lameness prevalence assessed by the veterinarians was 23.1, 39.1, and 23.2%, and the median prevalence of lame cows estimated by the farmers was 9.5, 9.5, and 7.1% in the north, east, and south, respectively. On average, farmers were conscious of only 45.3% (north), 24.0% (east), and 30.0% (south) of their lame cows. Farmers managing their herds according to organic principles had a higher FDI than farmers who managed their herds conventionally. Surprisingly, no significant associations between FDI and factors concerning claw health management could be detected. Therefore, increased awareness did not seem to be necessarily linked to improved management. Moreover, the FDI was not significantly associated with farmers' education or herd size. In the south, more extraverted farmers had a lower FDI. Those farmers who totally agreed with the statement, "I am satisfied with my herd's health," had a lower FDI than farmers who disagreed or were undecided. Moreover, farmers who disagreed or were undecided with the statement, "It affects me to see a cow in pain" had a higher FDI than those farmers who agreed to the statement. The results indicate that poor awareness of lameness was linked to the farmers' attitude and personality. Therefore, new approaches concerning the consultation regarding lameness control, such as the use of Motivational Interviewing, might be useful in the future.

**Keywords:** locomotion score, personality trait, Farmers' Detection Index, attitude, claw health, mobility score

## INTRODUCTION

Lameness is a serious problem in the dairy industry worldwide. It is known to compromise animal welfare (1) and to lead to economic losses (2, 3). Lameness has gained increasing attention in the dairy sector, and numerous studies have identified several risk factors (4–6). However, lameness prevalence in dairy herds remains high. In the UK, the mean within-farm prevalence increased from 20.6% in 1989 to 1991 (7) to 36.8% in 2006 to 2007 (8), and was estimated to be at 31.6% in the years 2015 to 2016 (9). In other countries around the world, a similar or slightly lower prevalence has been observed (10–12).

Farmers frequently underestimate the percentage of lame cows within their herds (13–17), as well as the financial consequences (13). To date, there has been limited understanding of why farmers have a poor awareness of lameness in their herds. In a study by Leach et al. (13), the estimation of farmers corresponded to the number of cows diagnosed as severely lame by the researchers. It was hypothesized that farmers overlook cows with moderate lameness and often have another definition of “lameness.” This finding is supported by the observation that farmers avoid the term “lame” and prefer “impaired mobility” (18). A second hypothesis for the underestimation is that individual cows gain less attention from farmers (13) due to increasing herd sizes and other tasks apart from the stable, like, e.g., documentation.

Raising awareness is the first step in improving lameness in dairy herds (19). Farmers who stated that lameness was a major problem had a lower lameness prevalence in their herds than farmers who stated otherwise (14). This finding may appear surprising. However, as long as farmers are not aware of the lameness status of their herd, they are not likely to implement measures to improve the situation.

Although numerous studies have shown an underestimation of the proportion of lame cows by farmers, knowledge about how the awareness can be increased is limited. It is known that the personality and attitude of farmers are connected to their willingness for behavior change (20, 21). To further improve lameness prevention and control in dairy herds it is therefore necessary to better understand the connection of the farmers personality and the awareness of lame cows within their herds. Moreover, poor knowledge exists if the awareness differs between various types of farms and if it is associated with an improved or intensified claw health management. Therefore, the objectives of this work were to first describe farmers' awareness of lameness in their dairy herds in three structurally different regions in Germany. Secondly, this study aimed to determine which factors related to farm structure, claw health management, farmers' attitudes, education, and personality, were associated with the farmers' detection rate of lameness.

## MATERIALS AND METHODS

### Study Region

This study was conducted as part of a large cross-sectional study on the health, biosecurity, and housing environment of dairy farms in Germany (22). The project was initiated and funded by

the German Federal Ministry of Food and Agriculture (BMEL) through the Federal Office for Agriculture and Food (BLE).

The study was carried out in three regions of Germany with different structures of the dairy industry: in the north (including the federal states of Schleswig-Holstein and Lower Saxony), dairy farms are mostly family-run businesses with a mean herd size of 95 cows in Lower Saxony and 102 cows in Schleswig-Holstein (23). The east includes most parts of the former German Democratic Republic (federal states: Mecklenburg-West Pomerania, Brandenburg, Thuringia, Saxony-Anhalt). Here, mean herd sizes vary between 184 and 230 cows (23) and farms are partly run by cooperations. Most of these farms engage several employees. All farms in the south were located in Bavaria. There, dairy farms are small, mostly family-run businesses, and partly run part-time. Mean herd size is 42 cows (23).

### Recruitment of Farms and Farm Visit

Veterinarians visited 253 (north), 252 (east), and 260 (south) farms on a single occasion between December 2016 and July 2019. Farmers knew that a mobility scoring would be performed during this visit. Farms were recruited continuously during the study period to offer farmers a prompt date for the farm visit. The sample size was calculated as described by Dachrodt et al. (22). In brief, in the north and east, farms were randomly selected from the complete list of dairy cattle owners in the National Traceability and Information System for Animals (Herkunftssicherungs- und Informationssystem für Tiere); in the south, they were randomly selected from dairy farmers organized in the neutral auditing organization for Bavarian dairy farms (Milchprüfing Bayern e.V.). Based on the number of milking cows within each region, the farms were divided into three groups based on herd size to gain an equal distribution over all farm sizes. A separate sample size was calculated for every region, stratified by herd size and federal state (22). Selected farms received invitations to participate. Farmers voluntarily contacted the study teams via telephone, email, or postal mail, and a date for a farm visit was arranged. The participation rate ranged between 6 and 9%, depending on the region.

### Locomotion Scoring

On the occasion of the farm visit, locomotion scoring was performed, including lactating and dry cows. In free-stall barns, straw yards, and pastures, locomotion scoring was performed according to Sprecher et al. (24). This score ranges from 1 (normal gait) to 5 (severely lame). Whenever cows were kept tied and did not have access to pasture on the day of the farm visit, locomotion scoring was performed using the Stall Lameness Score [SLS; (25)]. In larger herds, a randomly selected sample size was scored: in the north, with up to a herd size of 213 cows, all cows were scored. In larger herds, at least 213 randomly selected cows were assessed per farm. In the east, 166 cows were scored in herds between 166 and 292. In smaller farms, all cows, and in farms with more than 292 cows, 292 cows were scored. In the south, a maximum of 130 cows were scored. The calculation of the sample sizes was based on an assumed lameness prevalence of 40%, a confidence level of 95%, a power of 80%, and the different cut-offs for small, medium and large farms in the three regions.

If a sample was scored and the farm had more than one pen for cows, the observers selected a similar percentage of cows in each pen. If for instance, 80% of a herd had to be scored, the veterinarians scored four cows standing next to them and marked a fifth cow without keeping records of this cow.

In total, 21 veterinarians assessed the locomotion of cows. They were trained using photos, videos and SOPs. Telephone conferences were held to discuss open questions—first weekly, later as required. To safeguard the reliability of the observations, veterinarians met on three different occasions during the study and inter-observer agreement was assessed by performing locomotion scoring on the same 36, 53, and 20 cows.

## Interview and Further Data Collection

A face-to-face, pen-and-pencil interview was conducted with the farmer or herd manager (following referred to as “farmer”). The farmer was asked to give an estimation of the number or the percentage of dry and lactating cows in their herd that were lame or “did not walk sound.” The interview was usually performed prior to or simultaneously with the scoring of the herd, so that the farmer did not gain any further information from the scoring. However, they were aware that veterinarians would perform locomotion scoring on the same day. Furthermore, farmers answered questions about additional aspects, such as their attitude, education, and management of their dairy farm.

After the interview, the veterinarian handed a brief HEXACO questionnaire to the farmer. The HEXACO questionnaire is an item-centered approach used to assess personality traits. We used the 24-item Brief HEXACO Inventory (26). Due to concerns regarding the acceptance of farmers, the items of the domain honesty-humility were removed. Therefore, the questionnaire consisted of 20 statements assessing the five traits emotionality, extraversion, agreeableness, conscientiousness, and openness to experience. Farmers rated their consent to each statement on a five-point Likert scale (“strongly disagree,” “disagree,” “neutral,” “agree,” “strongly agree”). The farmer was asked to fill it out on their own and hand it back in a closed envelope.

Housing conditions were assessed using protocols. These protocols as well as the questionnaires are available online ([https://ibei.tiho-hannover.de/praeiri/uploads/report/PraeRi\\_Anhang3\\_Handbuch.7z](https://ibei.tiho-hannover.de/praeiri/uploads/report/PraeRi_Anhang3_Handbuch.7z) and [https://ibei.tiho-hannover.de/praeiri/uploads/report/PraeRi\\_Anhang2\\_EB\\_FB.7z](https://ibei.tiho-hannover.de/praeiri/uploads/report/PraeRi_Anhang2_EB_FB.7z); only in German language). If available, data from the monthly milk recording (DHI) were included in the relational study database.

## Statistical Analyses

The statistical unit was the farm. The three study regions were analyzed separately due to the structural differences in dairy industry.

## Lameness Prevalence and Farmers Awareness

A cow was considered lame with a locomotion score according to Sprecher et al. (24) of 3 or more or if she displayed two or more criteria of the SLS. As aforementioned, farmers may have another definition of “lame cow” and experience cows as lame when they are in fact severely lame. Therefore, the prevalence of lameness and severe lameness (score 4 or 5) was calculated (veterinarians’

prevalence; VP/ VP\_severe). On some farms, not all cows could be scored based on their locomotion. Herds with more than 10% missing values were excluded from further analyses.

In cases where the farmer stated a number of cows, the estimated prevalence for the farmer was calculated by dividing the number by the herd size. If the farmer stated a percentage, this number was defined as the farmers’ prevalence (FP). The agreement of FP with VP and VP\_severe was described using Lin’s concordance correlation coefficient [CCC; (27)] and Spearman’s correlation coefficient, respectively. The quotient of FP and VP, called Farmers’ Detection Index [FDI; (28)], described the percentage of the lame cows the farmer was aware of.

## Factors Associated With Farmers’ Awareness

Concerning the second objective, the following factors were assessed as follows:

### (1) farm characteristics:

- herd size (sum of lactating and dry cows; source: DHI or interview)
- culling rate due to lameness (number of cows culled due to lameness during the 12 months prior to the farm visit divided by herd size; source: questionnaire)
- milk yield (mean milk yield (kg) per cow and year; source: DHI or if unavailable, questionnaire)
- housing system (more than 80% of the cows in one of the following systems: tie stalls, pen with cubicles, straw pen, pasture, or mixed (<80% of cows in one system); source: scoring)
- Husbandry (conventional or organic; source: questionnaire)

### (2) claw health management (source: questionnaire):

- use of a veterinary herd health management program (VHHMP; no participation, participation in a general VHHMP, participation in a VHHMP including claw health)
- detection of lameness (no lameness detection, lameness detection during stable work, or lameness detection as a separate work task)
- person performing the claw trimming (farmers themselves or professional claw trimmer/veterinarian)
- frequency of regular claw trimming events/year (once a year or less, twice a year, or three times a year or more often)

### (3) attitude and education (source: questionnaire):

- highest professional education (no professional education as a farmer, agricultural apprenticeship, further agricultural education, or university degree in agricultural science)
- further education (agreement with the statement “I regularly attend technical seminars.”)
- satisfaction with herd health (agreement with the statement “I am satisfied with my herd’s health.”)
- relationship toward cows (agreement with the statement “I have an emotional relationship to my cows.”)

- empathy toward cows (agreement with the statement “It affects me to see a cow in pain.”)
  - mental workload (agreement with the statement “My job as a farmer puts weight on me.”)
  - claw health as a breeding goal (yes/no)
- (4) personality (source: HEXACO-questionnaire; median of the depending items):
- Emotionality
  - eXtraversion
  - Agreeableness
  - Conscientiousness
  - Openness

First, descriptive analyses were conducted. The FDI was not normally distributed, and log transformation did not result in a normal distribution of residuals when using linear regression. Therefore, due to the explorative nature of the analyses, the associations between FDI and the factors were calculated using Spearman's correlation coefficient for quantitative factors and Kruskal-Wallis tests for categorical factors.

Owing to the large number of factors, multiple testing existed due to the second objective. The  $p$ -value of 0.05 was divided by the number of variables ( $n = 21$ ). Therefore, significance level concerning the associations was assumed if  $p < 0.0024$  [Bonferroni method; (29)].

For statistical analyses, SAS 9.4© (SAS Institute Inc., Cary, North Carolina 27513, USA) was used. Figures showing the distribution of FP, VP, and FDI were created using R 4.0.3 (“Bunny-Wunnies Freak Out”) using the R Studio interface and the packages *ggplot2* (30) and *dplyr* (31).

## RESULTS

### Observer Agreement and Study Population

Three meetings between the observers were conducted during the study period. The weighted kappa measuring the agreement between the observers concerning the ordinal locomotion score according to Sprecher et al. (24) varied between 0.4 and 0.6, indicating a moderate agreement (32).

Milk yield, herd size, and average age of cows in the herds are shown in **Table 1**. As expected, herds in the south were much smaller, and the milk yield was lower than that in the other regions. The average age of the cows in the herd was lower in the east than in the other regions. In the north and east, Holstein Friesian was the predominant (>80% of cows in the herd) breed: 90.1 and 86.1%, respectively. In the south, 55.4% of the farmers mostly kept Simmental, and only five farmers (1.9%) preferred Holstein Friesians the most. The other farmers in the south kept other breeds (7.3%) or a mix of breeds (35.4%).

Locomotion scoring was performed on 85,549 cows from 765 farms (north: 253; east: 252; and south: 260). Scoring data from 14 farms were excluded from further analyses due to missing data. Finally, 84,998 cows (north: 24,395; east: 49,675; south: 10,928) from 751 farms (north: 251; east: 251; south: 249) were included in further analyses. Except for three farmers, all estimated the proportion of lame cows within their herds.

### Lameness Prevalence and Farmers' Awareness

VP, VP\_severe, and FP are shown in **Figure 1**. The percentages classified as lame by the study veterinarians were similar in the north and south (Q25/Q50/Q75: north, 14.9/23.1/34.9%; south, 14.4/23.2/33.3%), but higher in the east (30.9/39.1/47.8%). Twenty-seven of 757 farms (3.6%) had no lame cows (north: 9 farms [3.6%], east: 7 farms [2.8%], south: 11 farms [4.4%]).

The estimated lameness prevalence by the farmers was below 10% on average (**Figure 1**; Q25/Q50/Q75: north, 4.8/9.5/16.1%; east, 3.8/9.5/20.0%; south, 3.3/7.1/11.5%). Fifty-eight of 762 farmers (7.7%) estimated no lame cows (north: 11 farmers [4.4%], east: 15 farmers [6.0%], south: 32 farmers [12.4%]). Of these farmers, 20 really had no cows. Twelve of these 58 farmers had a VP of  $\geq 25\%$ . Seven farmers stated to have at least one lame cow, but no lame cows were observed. The FDI could not be calculated for the farmers with no lame cows.

The agreement between FP and VP is presented in **Table 2**. A slight to fair agreement was achieved (32). The agreement between FP and VP\_severe was slightly higher (**Table 2**).

The underestimation of lame cows was corroborated by low FDI (**Figure 2**). On average, farmers were conscious of every second to fourth lame cow (Q25/Q50/Q75: north, 22.9/42.9/73.3%; east, 11.2/24.0/49.7%; south, 14.8/30.0/53.9%). However, 62 farmers also overestimated the proportion of lame cows in their herds (FDI > 100: north, 30; east, 14; south, 18 farmers). The half of this group overestimated the prevalence only slightly by up to 20%, but the other half of this group overestimated the percentage by more than 20% and nine farmers stated to have two-times more lame cows than the researchers observed.

### Factors Associated With the Farmers' Awareness

The associations between farm characteristics, claw health management, farmers' education, attitude, personality, and FDI are shown in **Tables 3–7**.

Regarding the farm characteristics (**Tables 3, 4**), farmers working according to organic principles had a higher FDI in the north and south (north,  $p = 0.0152$ ; east,  $p = 0.8457$ ; south,  $p = 0.0461$ ). In the east, farmers who stated that they had a higher percentage of cows culled due to lameness had a higher FDI ( $p < 0.0001$ ). Significant associations between milk yield or the housing system and FDI could not be detected. In the south, lower FDI was observed in larger herds ( $p = 0.0400$ ). This association was not observed in the other regions where the herds were generally larger.

Surprisingly, there were no significant associations between the factors of claw health management and FDI (**Table 5**).

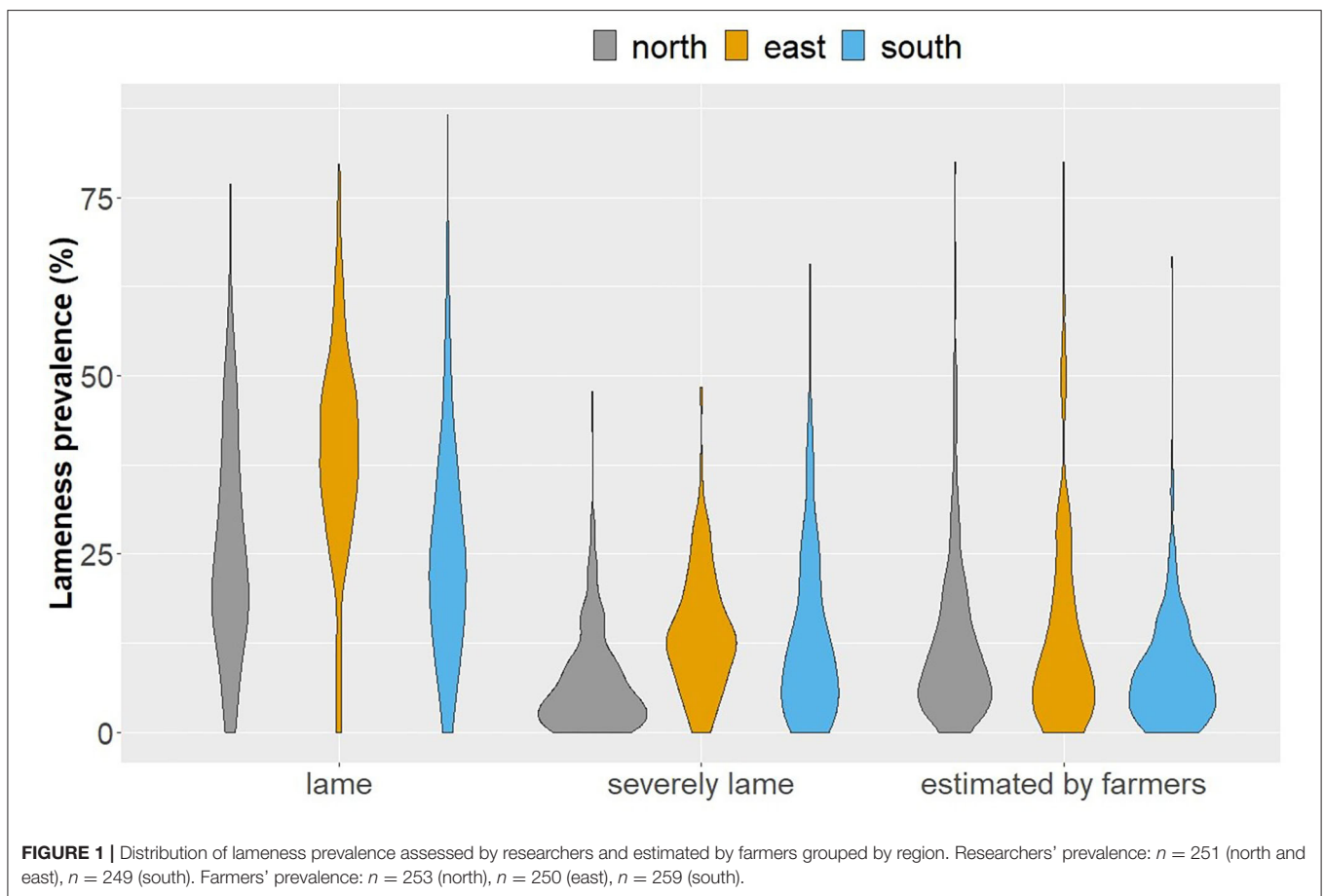
In the north and south, farmers with a university degree in agriculture had a higher FDI than farmers with another education (**Table 6**).

Farmers who stated that they were totally satisfied with the health of their herds had lower FDI than the other farmers (**Table 6**). This finding was consistent across all the three regions. In the north, farmers who stated that they were (totally) unsatisfied with the health of their herds had the highest FDI.



**TABLE 1** | Characteristics of farms.

| Region  | N   | Mean  | Min   | 25%-Q | Median | 75%-Q  | Max    | CV    | Missing |
|---|-----|-------|-------|-------|--------|--------|--------|-------|---------|
| <b>Mean milk yield per cow and year (kg)</b>        |     |       |       |       |        |        |        |       |         |
| North   | 240 | 9,062 | 3,597 | 8,080 | 9,330  | 10,068 | 12,069 | 15.3  | 13      |
| East  | 248 | 9,222 | 2,739 | 8,543 | 9,481  | 10,299 | 12,907 | 17.8  | 4       |
| South   | 231 | 7,606 | 3,712 | 6,987 | 7,706  | 8,456  | 10,598 | 16.1  | 29      |
| <b>Herd size (number of dry and lactating cows)</b> |     |       |       |       |        |        |        |       |         |
| North   | 253 | 104.6 | 12    | 59    | 87     | 127    | 1,011  | 84.5  | 0       |
| East  | 252 | 355.2 | 1     | 132.5 | 254.5  | 459.5  | 2,952  | 102.7 | 0       |
| South   | 260 | 45.0  | 4     | 25.5  | 40     | 59     | 247    | 67.9  | 0       |
| <b>Average age within the herd (years)</b>          |     |       |       |       |        |        |        |       |         |
| North   | 240 | 4.7   | 3.1   | 4.3   | 4.7    | 5.0    | 7.4    | 11.9  | 13      |
| East  | 247 | 4.4   | 2.9   | 4.1   | 4.3    | 4.7    | 7.7    | 14.2  | 5       |
| South   | 231 | 4.9   | 3.8   | 4.4   | 4.8    | 5.2    | 7.4    | 13.1  | 29      |



**FIGURE 1** | Distribution of lameness prevalence assessed by researchers and estimated by farmers grouped by region. Researchers' prevalence:  $n = 251$  (north and east),  $n = 249$  (south). Farmers' prevalence:  $n = 253$  (north),  $n = 250$  (east),  $n = 259$  (south).

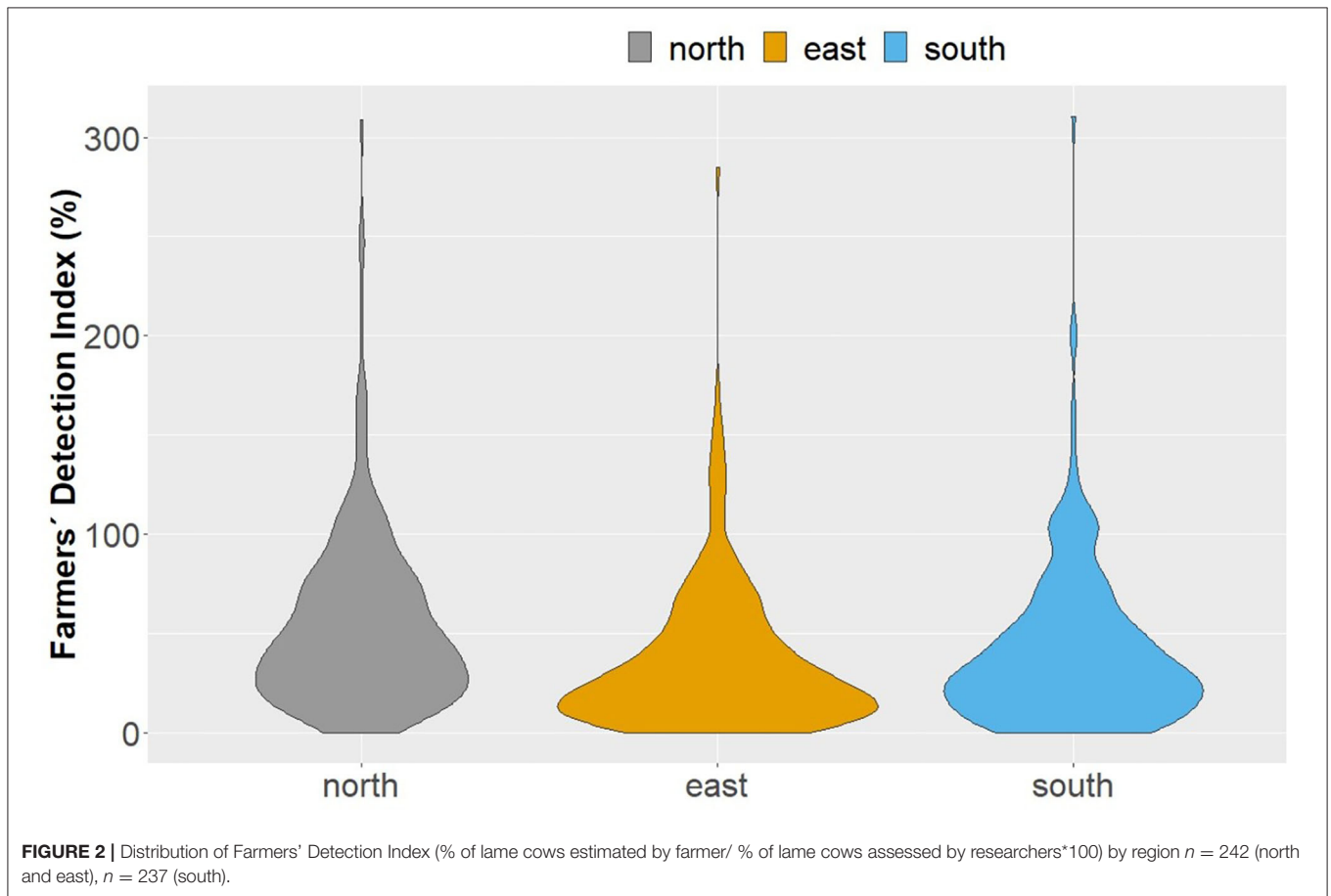
However, in the east and south, farmers who were neutral or agreed with the statement, "I am satisfied with the health of my herd," had the highest FDI (Table 6). Farmers who stated claw health to be a major breeding goal had higher FDI (east and south; Table 6).

No statistically significant associations were consistently apparent between emotionality, agreeableness, conscientiousness, and openness. However, in the south, more extraverted farmers had lower FDI (Table 7;  $p < 0.0001$ ).

**TABLE 2** | Agreement of the lameness prevalence estimated by the farmer (FP) and the prevalence of lame (VP) and severely lame (VP\_severe) cows assessed by the researchers.

|                               |               | North (n = 251) | East (n = 249) | South (n = 248) |
|-------------------------------|---------------|-----------------|----------------|-----------------|
| Agreement of FP and VP        | CCC (Lin)     | 0.34            | 0.16           | 0.14            |
|                               | CC (Spearman) | 0.52            | 0.41           | 0.31            |
| Agreement of FP and VP_severe | CCC (Lin)     | 0.33            | 0.34           | 0.24            |
|                               | CC (Spearman) | 0.45            | 0.45           | 0.31            |

CCC (Lin), Lin's Concordance Correlation Coefficient.  
 CC (Spearman), Spearman's Correlation Coefficient.



## DISCUSSION

This study shows that the majority of farmers underestimated the proportion of lame cows within their herds. Factors related to farmers' mindset tended to have a stronger association with FDI than factors from field claw health management or farm structure.

### Study Design

The study was conducted in three regions differing in herd size, performance, and management. Because of the sufficient sample size, it was possible to analyze these regions separately. In our view, it was mandatory to analyze the regions separately due to the aforementioned differences. The separate analyses

increased the validity of the results and showed similarities and differences concerning the prevalence, estimation of the farmers, and associations between FDI and different factors.

Participation in the study was voluntary. Therefore, the prevalence of lame cows might be biased compared to that of the underlying target population. Although selection was at random from a preformed list of farmers, farmers had to answer to the invitation by contacting the study team. Therefore, potentially more proactive and open farmers or those with better-managed dairy farms may have been enrolled and visited, which could have resulted in an underestimation of the true lameness prevalence. On the contrary, voluntary participation may have motivated farmers with problems concerning their herds' health to participate (38).

**TABLE 3** | Association (Kruskal-Wallis-test) and descriptive analyses of Farmers' Detection Index depending on farm characteristics (qualitative variables).

|                             | North |      |        |        | East |      |        |        | South |      |        |        |
|-----------------------------|-------|------|--------|--------|------|------|--------|--------|-------|------|--------|--------|
|                             | N     | 25%Q | Median | 75%Q   | N    | 25%Q | Median | 75%Q   | N     | 25%Q | Median | 75%Q   |
| <b>Main housing system*</b> |       |      |        |        |      |      |        |        |       |      |        |        |
| Tie stalls                  | 5     | 0.0  | 10.0   | 43.5   | 3    | 0.0  |        |        | 63    | 0.0  | 33.3   | 57.4   |
| Cubicles                    | 210   | 22.9 | 41.6   | 72.6   | 189  | 12.6 | 26.3   | 52.2   | 167   | 15.8 | 30.0   | 54.9   |
| Straw pens                  | 6     | 49.1 | 82.1   | 210.3  | 8    | 10.4 | 13.1   | 52.1   | 1     | 0.0  |        |        |
| Pasture                     | 5     | 50.0 | 52.2   | 100.0  | 3    | 0.0  |        |        | 0     |      |        |        |
| Mixed                       | 16    | 26.4 | 64.2   | 97.4   | 39   | 8.8  | 19.1   | 42.7   | 6     | 5.8  | 17.0   | 36.6   |
| P-value                     |       |      |        | 0.1092 |      |      |        | 0.7365 |       |      |        | 0.8071 |
| <b>Farming</b>              |       |      |        |        |      |      |        |        |       |      |        |        |
| Conventional                | 232   | 22.5 | 41.9   | 71.7   | 217  | 11.5 | 24.1   | 47.4   | 180   | 13.9 | 28.6   | 51.6   |
| Organic                     | 10    | 75.7 | 84.1   | 97.2   | 15   | 10.1 | 28.9   | 62.6   | 34    | 17.2 | 40.2   | 77.9   |
| P-value                     |       |      |        | 0.0152 |      |      |        | 0.8457 |       |      |        | 0.0461 |

Farms within categories with  $n < 5$  were not incorporated in Kruskal-Wallis-test.

\* $\geq 80\%$  of cows were kept in this system at the day of the farm visit; mixed implies that not 80% were kept in one system but different systems were used.

**TABLE 4** | Spearman's correlation analyses: Farmers' Detection Index and farm characteristics (quantitative variables).

|                              | North |       |         | East |      |         | South |       |         |
|------------------------------|-------|-------|---------|------|------|---------|-------|-------|---------|
|                              | N     | SCC   | P-value | N    | SCC  | P-value | N     | SCC   | P-value |
| Herd size                    | 242   | -0.07 | 0.3064  | 242  | 0.09 | 0.1577  | 242   | -0.13 | 0.0400  |
| Milk yield (kg)              | 233   | -0.06 | 0.3502  | 239  | 0.06 | 0.3536  | 215   | -0.06 | 0.3958  |
| Culling rate due to lameness | 238   | 0.06  | 0.3651  | 242  | 0.26 | <0.0001 | 236   | 0.04  | 0.5058  |

SCC, Spearman's Correlation Coefficient.

Historically, locomotion scoring approaches have been implemented to record the characteristics of dairy cow gait and to subsequently classify cows as lame and not lame. Among these approaches, Sprecher et al. (24) presented the most widely used locomotion scoring systems that are based on posture and gait (38, 39). Evidence has suggested that slight locomotive aberrations, such as an arched back (score 2; "mildly lame"), may lead to marked consequences for production level and animal welfare (24, 40). However, most studies relying on the Sprecher score classify cows as lame when they receive a score  $\geq 3$ . Therefore, we followed this categorization.

For tie stall systems, the SLS (25) was implemented and, in alignment with previous work (41, 42), a cow was classified as lame if two out of the four indices of the SLS were recorded. Lameness detection in tie-stall facilities is more challenging than in loose housing systems, as cows cannot be observed during locomotion. Furthermore, Leach et al. (25) observed a moderate sensitivity of the SLS (0.54–0.77) compared with the Sprecher score; on average, the prevalence of lameness was underestimated by 27% (11–37%) in their study when assessing cows in tie stalls. This needs to be taken into consideration when interpreting our results as well, and as a consequence, the prevalence of lame cows in tie stall operations might have been underestimated. In the regions north and east only a minor proportion of cows was scored using the SLS (north: 1.4%; east: 0.3%), but in the region south 16.6% of the cows were scored using the SLS.

Three observer training sessions were carried out during the study to reduce potential observer bias. Only moderate agreement was achieved when comparing the ordinal ratings of the observers. Aberrance of single observers, but no aberrance of the team of a region was observed. Therefore, a systematic bias leading to a higher or lower prevalence in one region compared to the other was unlikely. A comparison of the classification (severe) lame–not lame was not conducted. This would probably have resulted in a better agreement. However, the moderate agreement despite the use of SOPs and training shows that the classification of lameness is challenging. This might be one reason for the underestimation by the farmers and points additionally toward the need of widely applying more objective lameness detection techniques (e.g., automatic lameness detection systems).

Farmers might have stated a lower number of lame cows due to social desirability. Social desirability bias describes the tendency to state things that place the interviewee in a favorable light (43). The social desirability bias consists of two separate factors: "Other-deception" describes that a person purposely misrepresents the truth as a form of impression management motivated by a desire to avoid evaluation. "Self-deception" occurs when a respondent actually believes a statement to be true of himself or herself, even though it is inaccurate (43). As the FDI describes the difference between the situation systematically assessed by trained researchers and the perception of the farmers, it describes nothing other than the bias of social desirability; the

**TABLE 5** | Association (Kruskal-Wallis-test) and descriptive analyses of Farmer' Detection Index depending on claw health management.

|   | North  |      |        |      | East   |      |        |      | South  |      |        |      |
|---|--------|------|--------|------|--------|------|--------|------|--------|------|--------|------|
|   | N      | 25%Q | Median | 75%Q | N      | 25%Q | Median | 75%Q | N      | 25%Q | Median | 75%Q |
| <b>Participation in veterinary herd health management program (VHHMP)</b> |        |      |        |      |        |      |        |      |        |      |        |      |
| No participation  | 110    | 22.2 | 42.7   | 72.6 | 95     | 10.1 | 21.0   | 49.7 | 192    | 16.5 | 30.0   | 53.5 |
| Participation in general VHHMP  | 90     | 22.5 | 46.3   | 79.2 | 65     | 11.6 | 35.2   | 51.8 | 41     | 11.1 | 22.7   | 54.5 |
| Participation in VHHMP incl. claw health                                  | 42     | 23.6 | 39.7   | 67.6 | 81     | 12.5 | 37.5   | 45.4 | 3      |      | 29.0   |      |
| P-value   | 0.5662 |      |        |      | 0.6759 |      |        |      | 0.8970 |      |        |      |
| <b>Mean frequency of claw trimming per cow</b>                            |        |      |        |      |        |      |        |      |        |      |        |      |
| Once a year or less   | 59     | 20.6 | 39.9   | 71.4 | 20     | 6.3  | 16.1   | 30.9 | 90     | 12.0 | 31.9   | 53.9 |
| Twice a year  | 140    | 23.6 | 44.9   | 73.9 | 127    | 14.8 | 26.0   | 53.0 | 131    | 16.2 | 29.0   | 50.9 |
| Three times a year or more often  | 40     | 22.5 | 41.9   | 78.3 | 93     | 8.8  | 21.5   | 46.2 | 11     | 10.3 | 51.6   | 75.0 |
| P-value   | 0.6061 |      |        |      | 0.0430 |      |        |      | 0.8772 |      |        |      |
| <b>Person who mainly performs claw trimming</b>                           |        |      |        |      |        |      |        |      |        |      |        |      |
| Farmer  | 52     | 25.4 | 39.0   | 71.2 | 26     | 11.3 | 20.7   | 53.0 | 103    | 15.8 | 32.8   | 54.9 |
| Claw trimmer or veterinarian  | 190    | 22.2 | 43.7   | 74.4 | 216    | 11.4 | 24.3   | 49.0 | 132    | 14.5 | 28.6   | 54.2 |
| P-value   | 0.8977 |      |        |      | 0.8228 |      |        |      | 0.6619 |      |        |      |
| <b>Lameness detection (LD)</b>  |        |      |        |      |        |      |        |      |        |      |        |      |
| No LD   | 9      | 18.8 | 29.7   | 80.1 | 6      | 21.3 | 40.1   | 52.4 | 14     | 9.1  | 29.4   | 50.0 |
| LD during stable work   | 226    | 23.7 | 43.2   | 74.4 | 217    | 11.2 | 23.0   | 48.3 | 216    | 14.8 | 29.7   | 54.2 |
| LD as a separate work task  | 7      | 17.5 | 28.0   | 56.8 | 19     | 15.4 | 27.6   | 65.1 | 6      | 33.3 | 46.4   | 66.7 |
| P-value   | 0.4974 |      |        |      | 0.3302 |      |        |      | 0.6688 |      |        |      |

question is how strong the influence of self-deception and other-deception was. Concerning the influence of other-deception, on one hand, farmers might have consciously stated a lower percentage of lame cows as they were aware that they were talking to a veterinarian. Veterinarians are experts on the health of animals. Therefore, farmers might have felt controlled or might have been under pressure to state a lower number than they might have stated in another context. On the other hand, it can be hypothesized that farmers might also have stated a higher number of lame cows because of the professional background of the interviewers. Farmers may trust veterinarians more than the general population, as they expected them to know about the problems in dairy herds. Moreover, farmers were aware that locomotion scoring was performed. Therefore, they might have been motivated to provide a preferably correct estimation.

To speak from our experience within this study, most farmers reacted honestly concerned or shocked when they were handed a list of lame cows at the end of the farm visit. Therefore, we expect that the FDI was less influenced by other-deception than by the fact that farmers were actually not aware of the lameness situation (self-deception).

## Lameness Prevalence and Farmers' Awareness

The median within-farm prevalence of lame ( $\geq 3$ ) and severely lame ( $\geq 4$ ) cows, as determined by study veterinarians, was similar or even higher compared with most studies from different areas of the world addressing this issue in the past 5 years (Table 8). Farmers' estimations were high compared to those in recent studies (Table 8). In previous studies, farmers were aware

of an even lower proportion of lame cows [Table 8; (28, 37, 44)]. This finding may be related to the fact that farmers in the present study were explicitly asked to include those cows that were mildly lame in their estimations. This might also be the reason, that in total 62 farmers overestimated the proportion of lame cows. Half of these farmers had a good estimation of the lameness situation but nine farmers overestimated the prevalence by factor two or more. Most of these farmers had <40 cows, so that one or two had a great impact on the prevalence.

Some authors assume that farmers experience only severely lame cows as "lame" and overlook mildly lame cows (13, 18). In this study, no substantial or good agreement was detected between FP and VP\_severe. The agreement between FP and VP\_severe was only slightly higher than that between FP and VP in the east and south. Therefore, the hypothesis that farmers rate severely lame cows as "lame" and overlook moderately lame cows was not confirmed. As the consequences of lameness for animal well-being are a subject of discussion these days, improvement of claw health is of priority for the farmers. Nevertheless, a mean FDI between 36 and 56% cannot be regarded as satisfying. Keeping in mind the high prevalence of lameness in cows, the question is what has to be done to raise awareness.

Recently, research in veterinary consultation and communication has revealed that motivational interviewing is a promising approach to help farmers change their behavior and improve their herd health status (45, 46). Motivational interviewing is linked to the transtheoretical model of behavior change (47). The transtheoretical model describes the stages and processes of change to explain health behavior changes (48). In the first stage, precontemplation, people are not likely



**TABLE 6 |** Association (Kruskal-Wallis-test) and descriptive analyses of Farmers' Detection Index depending on farmer's attitude and education.

|   | North |      |        |        | East |      |        |        | South |      |        |        |
|---|-------|------|--------|--------|------|------|--------|--------|-------|------|--------|--------|
|   | N     | 25%Q | Median | 75%Q   | N    | 25%Q | Median | 75%Q   | N     | 25%Q | Median | 75%Q   |
| <b>Highest degree of professional education</b>       |       |      |        |        |      |      |        |        |       |      |        |        |
| No professional education as a farmer                 | 23    | 20.9 | 50.0   | 91.0   | 15   | 0.0  | 8.7    | 30.2   | 30    | 8.1  | 29.9   | 50.0   |
| Agricultural apprenticeship                           | 45    | 18.8 | 39.4   | 72.0   | 40   | 12.9 | 24.2   | 45.4   | 93    | 13.0 | 28.6   | 53.9   |
| Further agricultural education <sup>a</sup>           | 151   | 22.7 | 42.2   | 71.1   | 41   | 11.6 | 27.6   | 53.8   | 88    | 17.3 | 29.0   | 50.80  |
| University degree in agricultural science             | 23    | 23.7 | 55.8   | 100.0  | 146  | 12.1 | 24.8   | 55.3   | 10    | 20.7 | 50.4   | 64.4   |
| P-value   |       |      |        | 0.7018 |      |      |        | 0.0297 |       |      |        | 0.6123 |
| <b>"I regularly attend technical seminars."</b>       |       |      |        |        |      |      |        |        |       |      |        |        |
| I (totally) disagree                                  | 28    | 18.7 | 35.9   | 76.5   | 15   | 6.9  | 12.1   | 55.1   | 22    | 9.1  | 23.7   | 50.0   |
| Neutral   | 24    | 29.3 | 56.8   | 80.4   | 24   | 6.5  | 20.6   | 31.9   | 31    | 14.8 | 33.3   | 77.9   |
| I agree   | 107   | 25.5 | 46.4   | 74.4   | 73   | 10.5 | 20.3   | 42.7   | 88    | 20.3 | 29.9   | 54.4   |
| I totally agree                                       | 80    | 18.6 | 39.7   | 71.7   | 60   | 11.3 | 22.7   | 42.8   | 96    | 12.5 | 25.9   | 53.0   |
| P-value   |       |      |        | 0.3328 |      |      |        | 0.6682 |       |      |        | 0.4846 |
| <b>"I am satisfied with the health of my herd."</b>   |       |      |        |        |      |      |        |        |       |      |        |        |
| I (totally) disagree                                  | 46    | 36.4 | 51.8   | 80.0   | 43   | 10.5 | 20.3   | 53.8   | 30    | 14.8 | 29.5   | 52.7   |
| Neutral   | 47    | 21.5 | 38.6   | 79.2   | 35   | 17.8 | 32.7   | 49.9   | 42    | 23.1 | 38.3   | 67.8   |
| I agree   | 125   | 22.5 | 46.4   | 74.9   | 84   | 9.1  | 20.1   | 35.0   | 138   | 15.7 | 32.2   | 54.5   |
| I totally agree                                       | 20    | 16.7 | 24.5   | 43.3   | 10   | 0.0  | 5.0    | 15.4   | 27    | 0.0  | 16.2   | 50.0   |
| P-value   |       |      |        | 0.0175 |      |      |        | 0.0027 |       |      |        | 0.0191 |
| <b>"I have an emotional relationship to my cows."</b> |       |      |        |        |      |      |        |        |       |      |        |        |
| I (totally) disagree                                  | 23    | 18.5 | 46.6   | 91.0   | 22   | 6.1  | 22.7   | 41.8   | 27    | 9.8  | 36.4   | 75.2   |
| Neutral   | 29    | 25.4 | 47.5   | 56.8   | 25   | 11.2 | 18.6   | 44.2   | 22    | 8.5  | 28.0   | 47.5   |
| I agree   | 91    | 22.5 | 41.5   | 67.7   | 53   | 10.3 | 20.4   | 34.6   | 66    | 20.0 | 30.0   | 50.0   |
| I totally agree                                       | 96    | 22.0 | 44.6   | 78.6   | 71   | 9.4  | 22.6   | 53.8   | 121   | 14.4 | 32.3   | 56.5   |
| P-value   |       |      |        | 0.6896 |      |      |        | 0.7581 |       |      |        | 0.8067 |
| <b>"It affects me to see a cow in pain."</b>          |       |      |        |        |      |      |        |        |       |      |        |        |
| I disagree/neutral                                    | 17    | 45.5 | 82.7   | 100    | 5    | 10.1 | 28.6   | 87.7   | 7     | 10.4 | 36.4   | 75.2   |
| I agree   | 90    | 25.5 | 43.1   | 74.4   | 58   | 12.6 | 20.9   | 34.6   | 60    | 15.2 | 28.3   | 48.4   |
| I agree totally                                       | 132   | 19.7 | 41.1   | 70.1   | 108  | 9.8  | 20.7   | 48.0   | 169   | 14.4 | 30.2   | 56.5   |
| P-value   |       |      |        | 0.0073 |      |      |        | 0.8418 |       |      |        | 0.6331 |
| <b>"My job as a farmer puts weight on me."</b>        |       |      |        |        |      |      |        |        |       |      |        |        |
| I totally disagree                                    | 34    | 17.6 | 37.2   | 77.9   | 24   | 7.6  | 14.1   | 23.6   | 67    | 10.4 | 24.0   | 50.0   |
| I disagree  | 98    | 26.6 | 49.6   | 77.9   | 52   | 11.4 | 21.6   | 46.8   | 59    | 16.7 | 34.1   | 60.0   |
| Neutral   | 52    | 16.7 | 32.7   | 62.1   | 34   | 12.6 | 22.7   | 49.7   | 53    | 14.6 | 29.9   | 50.0   |
| I agree   | 42    | 20.0 | 43.9   | 70.5   | 47   | 10.1 | 21.5   | 43.4   | 50    | 19.4 | 33.3   | 64.9   |
| I totally agree                                       | 11    | 36.2 | 45.5   | 67.2   | 15   | 7.1  | 22.4   | 51.8   | 8     | 14.3 | 19.2   | 57.1   |
| P-value   |       |      |        | 0.0741 |      |      |        | 0.5854 |       |      |        | 0.3681 |
| <b>Claw health as a breeding goal</b>                 |       |      |        |        |      |      |        |        |       |      |        |        |
| No  | 70    | 18.3 | 44.5   | 86.7   | 58   | 6.9  | 15.6   | 37.9   | 120   | 15.0 | 32.5   | 66.3   |
| Yes   | 171   | 24.5 | 42.9   | 70.8   | 183  | 13.2 | 28.3   | 53.0   | 116   | 14.7 | 28.7   | 46.9   |
| P-value   |       |      |        | 0.8015 |      |      |        | 0.0028 |       |      |        | 0.1633 |

<sup>a</sup>Two year education at an agricultural college or "Meister"-degree.

to change their behavior in the near future. They are often not well-informed about the problem or tried to improve the situation unsuccessfully and became demoralized. Those persons tend to avoid engaging with this problem and may be perceived as "unmotivated" or "resistant." One of the factors motivating a person to change is the perceived severity of the disease (49). As lameness was strongly underestimated, it can be assumed that most farmers were not likely to take any measures in the

near future and were in the stage of precontemplation. In the transtheoretical model, three cognitive processes of change are described that can initiate the stage of contemplation and the intention to take measures. These processes of change are consciousness raising (for example, feedback, new information, confrontation, or media campaigns), dramatic relief (for example, traumatic experiences such as the loss of a valued cow), and self-re-evaluation (by becoming aware that a certain

**TABLE 7** | Spearman's correlation analyses: Farmers' Detection Index and farmers' personality traits (HEXACO).

|                   | North |       |         | East |       |         | South |       |         |
|-------------------|-------|-------|---------|------|-------|---------|-------|-------|---------|
|                   | N     | SCC   | P-value | N    | SCC   | P-value | N     | SCC   | P-value |
| Emotionality      | 191   | 0.03  | 0.6672  | 175  | 0.02  | 0.7931  | 231   | 0.04  | 0.5088  |
| eXtraversion      | 191   | -0.03 | 0.6995  | 175  | -0.13 | 0.0752  | 231   | -0.26 | <0.0001 |
| Agreeableness     | 191   | -0.13 | 0.0813  | 175  | 0.04  | 0.5627  | 231   | 0.05  | 0.4865  |
| Conscientiousness | 191   | 0.02  | 0.7713  | 175  | 0.02  | 0.7885  | 231   | 0.04  | 0.5869  |
| Openness          | 191   | 0.03  | 0.6707  | 175  | 0.12  | 0.1090  | 231   | -0.11 | 0.0877  |

SCC, Spearman's Correlation Coefficient.

**TABLE 8** | Studies published during the last 5 years reporting the prevalence of lame cows.

| Authors                        | Average within herd prevalence of... |   |                                   |                 |                |           |                     |
|--------------------------------|--------------------------------------|---|-----------------------------------|-----------------|----------------|-----------|---------------------|
|                                | ...lame cows assessed by researchers | ...severely lame cows assessed by researchers | ...lame cows estimated by farmers | Number of farms | Number of cows | Country   | Main housing system |
| Jensen et al. current data set | 29.7%                                | 11.4%   | 11.6%                             | 751             | 84,998         | Germany   | misc.               |
| Denis-Robichaud et al. (33)    | 36.9%                                | n/a   | 25.3%                             | 93              | n/a            | Canada    | tie stalls          |
| Beggs et al. (34)              | 3.2%                                 | n/a   | 0.8%                              | 50              | 19,154         | Australia | pasture             |
| Jewell et al. (35)             | 20.7%                                | n/a   | n/a                               | 40              | 2,719          | Canada    | freestalls          |
| Jewell et al. (35)             | 15.3%                                | n/a   | n/a                               | 33              | 1,346          | Canada    | tie stalls          |
| Bran et al. (17)               | n/a                                  | 14.4%   | 6.5%                              | 44              | 1,633          | Brazil    | pasture             |
| Griffiths et al. (9)           | 31.6%                                | 3.7%  | n/a                               | 61              | 14,700         | UK        | freestall           |
| Cutler et al. (11)             | 22.2%                                | n/a   | 9.0%                              | 237             | n/a            | Canada    | misc.               |
| Adams et al. (36)              | 9.8%                                 | 2.6%  | n/a                               | 184             | 22,042         | USA       | misc.               |
| Ranjbar et al. (37)            | 19.1%                                | n/a   | 5%                                | 63              | 18,960         | Australia | pasture             |

n/a, not available (not assessed or not reported); misc., miscellaneous.

problem may be caused by oneself). Santman-Berends et al. (50) showed that the phase of awareness plays a crucial role in herd health problems. Keeping in mind that most farmers underestimate the prevalence of lameness in dairy cows, client-centered interventions, including the transtheoretical model and motivational interviewing, might be helpful in controlling lameness in dairy cows. Therefore, further research exploring the effects of the transtheoretical model and motivational interviewing on lameness awareness and the implementation of on-farm control is required.

## FDI and Farm Characteristics

Concerning the housing system, we expected farmers housing their cows in tie stalls to have a lower FDI, as observed by Cutler et al. (11). In tie stalls, lameness detection might be impaired, as cows can only be seen in movement when they have access to pastures. Only in the south did an adequate number of farmers kept their cows tied most of the time. The FDI was similar between farmers keeping the cows in barns with cubicles and those keeping their cows tied. This can be due to the fact that in tie stalls, the method of lameness detection is not as sensitive as in free stalls. Another reason could be that lameness is usually a longlasting condition and most cows kept in tie stalls in Germany also have grazing periods. During these, farmers can observe the cows' locomotion daily when collecting them for milking.

In the north, farmers who kept their cows in alternative housing systems, such as straw pens, full-time pasture, or mixed systems, had higher FDI than those who kept their cows in free stall barns. However, this finding was not statistically significant. Farmers who operated according to organic principles had a higher FDI than farmers who operated their farms conventionally in the regions north and south. In organically managed farms, lower lameness prevalence was observed (8, 51). Farmers who decide to manage their farms according to organic principles might develop more activities to meet animal welfare needs (52). Our findings suggest that as the awareness of animal health and welfare may be generally higher in organic farming, this might also include higher awareness of claw health.

Concerning herd size, one may expect a lower FDI in larger herds, as the single lame cow may be overlooked (13). Only in south, a weak association between FDI and herd size was observed. Comparing the three regions, FDI was lower in the region east, where herds were larger. However, the highest FDI was observed in the north and not in the south. Fabian et al. (16) observed no association between the FDI and herd size.

Fabian et al. (16) observed higher estimated lameness incidences in dairy herds with a higher average milk yield per cow. In our study, no association was detected between the average milk yield and FDI. On the one hand, the risk for lameness is higher in high producing herds. On the other hand,

farmers of high producing herds may have a higher awareness toward herd health problems.

In the east, farmers who admitted to culling a higher percentage of cows due to lameness had a higher FDI. This finding implies a better awareness of the lameness status when the farmer is aware of the reasons for culling or, rather, a higher overall awareness of lameness and its consequences. However, this finding was not significant in the other regions. In the east, the documentation of culling reasons might be better than in the other regions due to a more professional organization and the use of software for surveillance of herd health.

## FDI and Claw Health Management

There were no associations between claw health management and farmers' awareness of lameness (Table 5), even though one might expect that farmers who experience lameness as a problem might take measures to control it.

Only 17% (north), 34% (east), and 1% (south) of the farms participated in a VHHMP that included claw health. In the region with the highest lameness prevalence (east), more farmers participated in the VHHMP than in the other two regions. Moreover, FDI was not higher on farms participating in these programs or in any other VHHMP (Table 5). We expected that awareness might be higher when a consultant provided regular feedback. Leach et al. (28) observed an increasing awareness of claw health in farmers who took part in a project with expert feedback on claw health issues on a regular basis. As a consequence, lameness prevalence decreased in farms with an initial lameness prevalence of up to 35%. These contrasting results show that further research is needed on the effect of regular feedback on the development of awareness and lameness prevalence as well as on the type of feedback that could initiate change.

The majority of farms performed claw trimming, on average, twice a year per cow (Table 5). There was no association between the frequency of claw trimming and FDI. We expected to have a higher FDI in farms with a higher frequency of claw trimming for two reasons: first, lame cows (and their claw lesions) might be detected during claw trimming, and second, farmers with a higher awareness might perform claw trimming more often to fight this problem. Even if farmers accurately estimate lameness prevalence, that alone does not equate to action being taken (53). Moreover, no association was found between the person trimming the claws and FDI. On the one hand, many professional claw trimmers give feedback to the farmers concerning the prevalence of certain diagnoses and might be more aware of lameness due to their professional training. On the other hand, one might expect a higher FDI if the farmers performed the claw trimming themselves, as they might be paying more attention to the claws and the lame cows.

Most farmers stated that they control the presence of lame cows when fulfilling their routine tasks in the stable. Only a few farmers performed lameness detection as a separate task (Table 5). This finding is in accordance with a study by Cutler et al. (11). Horseman et al. (18) showed that farmers feel that existing methods are adequate to detect lameness and that locomotion scoring would add nothing more to their detection

process. Moreover, visual locomotion scoring systems are time-consuming and require knowledge and experience (54). The data need to be processed to provide maximal benefit. None of the farmers made use of an automated lameness detection system to support the early detection of lameness (3, 55). Farmers who do not experience lameness as a major problem in their herds may not be motivated to invest money in an automated lameness detection system. This might be one reason why these systems are not widely used in Germany.

## FDI and the Attitude and Education of the Farmers

The only significant association in all three regions was the association between herd health satisfaction and FDI. Farmers who stated that they were totally satisfied with the health of their herds had a lower FDI than the other farmers (Table 6). These farmers seemed to be unaware of problems or might not be willing to admit that they had problems with their herd's health. In the north, farmers who stated that they were (totally) unsatisfied with the health of their herds had the highest FDI. This finding appears logical, as these farmers seemed to be aware of and able to admit the deficiencies concerning their herd's health. Surprisingly, in the east and south, farmers who were neutral or agreed with the statement, "I am satisfied with the health of my herd" had the highest FDI (Table 6). Despite better awareness of the lameness situation, these farmers were generally okay or satisfied with their herd's health. These farmers might be focusing on acute diseases such as severe cases of mastitis or hypocalcemia and not on chronic or progressive diseases such as lameness when thinking of herd health. Moreover, a high FDI does not imply a high prevalence of lameness.

Education and attendance at technical seminars were not as strongly associated with FDI, as one might expect. Farmers with a university degree in agriculture had higher FDI in the north and south. In the east, farmers with no agricultural education had lower FDI than other farmers. However, these findings were not statistically significant (Table 6). Further research is needed concerning the association of education and lameness detection.

To assess empathy towards cows, the farmers had to state their agreement with two sentences ("I have an emotional relationship with my cows." and "It affects me to see a cow in pain."). Surprisingly, those farmers who stated not to agree or those who felt neutral toward the second statement had the highest median FDI in all three regions compared with those who agreed or those who agreed completely (Table 6). We can only speculate that these farmers might have been the most honest ones and were less biased by social desirability, or they had a more rational and analytic mindset toward their cows. Also, some farmers who know that lameness is an animal welfare issue might not be able to admit that their herd also has many lame cows because it poses a significant burden for them for that no quick and easy solution exists. In contrast, the study of Bruijnijis et al. (56), farmers who rated foot disorders as important for animal welfare were more motivated to take actions for foot health improvement.

## FDI and Farmers' Personality

To our knowledge, this is the first study examining awareness of lameness in dairy cows and traits of the farmer's personality,

even though farmer's personality is known to influence dairy cattle health and welfare (21). More extraverted farmers tended to have lower FDI. The reason for this finding can only be assumed. Extraverted persons have a higher self-acceptance and are happier in life (57). Therefore, they may be carefree and tend to experience lameness not as much of a problem. Also, extraverted farmers are more likely to have positive relationships with others (57). Thus, the correlation between extraversion and the FDI may be due to other-deception.

Regrettably, Honesty–Humility was not assessed in the shortened version of the HEXACO-questionnaire due to reasons of acceptance. The study was designed to assess cattle health, housing, and management. Indeed, some farmers reacted perplexed to the questionnaire handed out at the end of the interview containing statements such as “I enjoy contemplating paintings.” However, the assessment of Honesty–Humility would possibly have provided interesting insights.

Conscientiousness is a strong predictor concerning desirable health behavior (58). O’Kane et al. (59) reported that sheep farmers with a high score in conscientiousness reported to have fewer lame sheep. In this study, no associations between conscientiousness and the awareness of lameness were detectable (Table 7).

## Conclusions

Our study revealed that lameness remains a major problem in many dairy herds in Germany. However, the large variance showed that some farmers succeeded in lameness control and prevention. The prevalence estimated by farmers was substantially lower than that assessed by veterinarians. The poor agreement between farmers' estimated lameness prevalence and observers' results clearly demonstrate the need to support farmers in raising awareness of lameness.

The analyses concerning the associations with the FDI gave new insights into the mindset of farmers concerning the awareness of lameness; farmers managing their farm according to organic principles or using housing systems with improved cow comfort had a better awareness of lameness. Contrary to other studies, the hypothesis that in larger herds, individual cows receive less attention could not be confirmed. Moreover, there were no statistically significant associations between claw health management and FDI, leaving the question of how the awareness and implementation of actions are linked. A weak association between education and FDI could be detected, indicating that information is helpful in raising awareness of lameness. The results indicate that poor awareness of lameness was linked to the farmers' attitude and personality. Therefore, new approaches concerning the consultation regarding lameness control, such

as the use of Motivational Interviewing, may well be useful in the future.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study. Ethical review and approval was not required for the animal study because no painful interventions have been made. This was in accordance with the local legislation and institutional requirements. Written informed consent was obtained from the owners for the participation of their animals in this study.

## AUTHOR CONTRIBUTIONS

KJ, AS, SW, and AO visited the farms and collected the data. KJ and RM analyzed the data and discussed it with AO, MF, KM, and AS. AC developed the assessment of the farmers' personality and attitudes. KJ wrote the first draft of this work. All authors were involved in the planning of the study, revised the article critically, and contributed substantial ideas. All authors contributed to the article and approved the submitted version.

## FUNDING

Funding of this project was provided by the Federal Ministry of Food and Agriculture and Federal Office for Agriculture and Food, grant numbers 2814HS006 (University of Veterinary Medicine Hannover), 2814HS007 (Freie Universität Berlin), and 2814HS008 (Ludwig-Maximilians-Universität Munich).

## ACKNOWLEDGMENTS

We thank all participating farmers and their veterinarians for their cooperation. Moreover, we thank all persons involved in realizing the PraeRi project: F. Adler, H. Arndt, A. Bartel, J. Bäumer, K. Birnstiel, A.-K. Bodenstern, A. Böker, A. Choucair, L. Dachrodt, P. Do Duc, C. Freigang, N. Gundling, M. Hielscher, B. Hinzmann, L. Kellermann, M. Klawitter, M. Metzner, G. Knubben-Schweizer, C. Lausch, I. Litjens, P. Paul, F. Reichmann, A. Rösler, D. Sartison, K. Scheele, B. Schneider, A. Stoll, M. Volkmann, M. Volland, and P. Zuz.

## REFERENCES

1. Whay HR, Main DCJ, Green LE, Webster AJF. Assessment of the welfare of dairy cattle using animal-based measurements: direct observations and investigation of farm records. *Vet Rec.* (2003) 153:197–202. doi: 10.1136/vr.153.7.197
2. Whay HR, Shearer JK. The impact of lameness on welfare of the dairy cow. *Vet Clin North Am Food Anim Pract.* (2017) 33:153–64. doi: 10.1016/j.cvfa.2017.02.008
3. Taneja M, Byabazaire J, Jalodia N, Davy A, Olariu C, Malone P. Machine learning based fog computing assisted data-driven approach for early lameness detection in dairy cattle. *Comput*



- Electron Agric.* (2020) 171:105286. doi: 10.1016/j.compag.2020.105286
4. Dippel S, Dolezal M, Brenninkmeyer C, Brinkmann J, March S, Knierim U, et al. Risk factors for lameness in freestall-housed dairy cows across two breeds, farming systems, and countries. *J Dairy Sci.* (2009) 92:5476–86. doi: 10.3168/jds.2009-2288
  5. Solano L, Barkema HW, Pajor EA, Mason S, LeBlanc SJ, Zaffino Heyerhoff JC, et al. Prevalence of lameness and associated risk factors in Canadian Holstein-Friesian cows housed in freestall barns. *J Dairy Sci.* (2015) 98:6978–91. doi: 10.3168/jds.2015-9652
  6. Oehm AW, Knubben-Schweizer G, Rieger A, Stoll A, Hartnack S. A systematic review and meta-analysis of risk factors associated with lameness in dairy cows. *BMC Vet Res.* (2019) 15:346. doi: 10.1186/s12917-019-2095-2
  7. Clarkson MJ, Downham DJ, Faulk WB, Hughes JW, Manson FJ, Merritt JB, et al. Incidence and prevalence of lameness in dairy cattle. *Vet Rec.* (1996) 138:563–67. doi: 10.1136/vr.138.23.563
  8. Barker ZE, Leach KA, Whay HR, Bell NJ, Main DCJ. Assessment of lameness prevalence and associated risk factors in dairy herds in England and Wales. *J Dairy Sci.* (2010) 93:932–41. doi: 10.3168/jds.2009-2309
  9. Griffiths BE, Dai White G, Oikonomou G. A cross-sectional study into the prevalence of dairy cattle lameness and associated herd-level risk factors in England and Wales. *Front Vet Sci.* (2018) 5:65. doi: 10.3389/fvets.2018.00065
  10. Chapinal N, Barrientos AK, Keyserlingk MAG von, Galo E, Weary DM. Herd-level risk factors for lameness in freestall farms in the northeastern United States and California. *J Dairy Sci.* (2013) 96:318–28. doi: 10.3168/jds.2012-5940
  11. Cutler JHH, Rushen J, Passillé AM de, Gibbons J, Orsel K, Pajor E, et al. Producer estimates of prevalence and perceived importance of lameness in dairy herds with tiestalls, freestalls, and automated milking systems. *J Dairy Sci.* (2017) 100:9871–80. doi: 10.3168/jds.2017-13008
  12. van Huyssteen M, Barkema HW, Mason S, Orsel K. Association between lameness risk assessment and lameness and foot lesion prevalence on dairy farms in Alberta, Canada. *J Dairy Sci.* (2020) 103:11750–61. doi: 10.3168/jds.2019-17819
  13. Leach KA, Whay HR, Maggs CM, Barker ZE, Paul ES, Bell AK, et al. Working towards a reduction in cattle lameness: 1. understanding barriers to lameness control on dairy farms. *Res Vet Sci.* (2010) 89:311–17. doi: 10.1016/j.rvsc.2010.02.014
  14. Šárová R, Stěhulová I, Kratinová P, Firla P, Špinka M. Farm managers underestimate lameness prevalence in Czech dairy herds. *Anim Welf.* (2011) 20:201–4. Available online at: [https://www.researchgate.net/profile/Marek-Spinka/publication/236944492\\_Farm\\_managers\\_underestimate\\_lameness\\_prevalence\\_in\\_Czech\\_dairy\\_herds/links/00b7d51a4d3f7a5207000000/Farm-managers-underestimate-lameness-prevalence-in-Czech-dairy-herds.pdf](https://www.researchgate.net/profile/Marek-Spinka/publication/236944492_Farm_managers_underestimate_lameness_prevalence_in_Czech_dairy_herds/links/00b7d51a4d3f7a5207000000/Farm-managers-underestimate-lameness-prevalence-in-Czech-dairy-herds.pdf)
  15. Richert RM, Cicconi KM, Gamroth MJ, Schukken YH, Stiglbauer KE, Ruegg PL. Perceptions and risk factors for lameness on organic and small conventional dairy farms. *J Dairy Sci.* (2013) 96:5018–26. doi: 10.3168/jds.2012-6257
  16. Fabian J, Laven RA, Whay HR. The prevalence of lameness on New Zealand dairy farms: a comparison of farmer estimate and locomotion scoring. *Vet J.* (2014) 201:31–8. doi: 10.1016/j.tvjl.2014.05.011
  17. Bran JA, Daros RR, Keyserlingk MAG von, Hötzel MJ. Lameness on Brazilian pasture based dairies-part 1: farmers' awareness and actions. *Prev Vet Med.* (2018) 157:134–41. doi: 10.1016/j.prevetmed.2018.06.007
  18. Horseman SV, Roe EJ, Huxley JN, Bell NJ, Mason CS, Whay HR. The use of in-depth interviews to understand the process of treating lame dairy cows from the farmers' perspective. *Anim Welf.* (2014) 23:157–65. doi: 10.7120/09627286.23.2.157
  19. Sadiq MB, Ramanoo SZ, Shaik Mossadeq WM, Mansor R, Syed Hussain SS. Dairy farmers' perceptions of and actions in relation to lameness management. *Animals.* (2019) 9:270. doi: 10.3390/ani9050270
  20. Willock J, Deary IJ, McGregor MM, Sutherland A, Edwards-Jones G, Morgan O, et al. Farmers' attitudes, objectives, behaviors, and personality traits: the Edinburgh study of decision making on farms. *J Vocat Behav.* (1999) 54:5–36. doi: 10.1006/jvbe.1998.1642
  21. Adler E, Christley R, Campe A. Invited review: examining farmers' personalities and attitudes as possible risk factors for dairy cattle health, welfare, productivity, and farm management: a systematic scoping review. *J Dairy Sci.* (2019) 102:3805–24. doi: 10.3168/jds.2018-15037
  22. Dachrodt L, Arndt H, Bartel A, Kellermann LM, Tautenhahn A, Volkmann M, et al. Prevalence of disorders in preweaned dairy calves from 731 dairies in Germany: a cross-sectional study. *J Dairy Sci.* (2021) 104:9037–51. doi: 10.3168/jds.2021-20283
  23. Thünen-Institut für Betriebswirtschaft. *Steckbriefe zur Tierhaltung. Deutschland: Milchkühe* (2020). Available online at: [https://www.thuenen.de/media/ti-themenfelder/Nutztierhaltung\\_und\\_Aquakultur/Haltungsverfahren\\_in\\_Deutschland/Milchviehhaltung/Steckbrief\\_Milchkuehe\\_2020.pdf](https://www.thuenen.de/media/ti-themenfelder/Nutztierhaltung_und_Aquakultur/Haltungsverfahren_in_Deutschland/Milchviehhaltung/Steckbrief_Milchkuehe_2020.pdf) (accessed May 11, 2021)
  24. Sprecher DJ, Hostetle DE, Kaneen JB. Locomotion scoring of dairy cattle. *Theriogenology.* (1997) 47:1178–87. doi: 10.1016/S0093-691X(97)00098-8
  25. Leach KA, Dippel S, Huber J, March S, Winckler C, Whay HR. Assessing lameness in cows kept in tie-stalls. *J Dairy Sci.* (2009) 92:1567–74. doi: 10.3168/jds.2008-1648
  26. de Vries RE. The 24-item Brief HEXACO Inventory (BHI). *J Res Personality.* (2013) 47:871–80. doi: 10.1016/j.jrp.2013.09.003
  27. Lin LK. Assay validation using the concordance correlation coefficient. *Biometrics.* (1992) 48:599. doi: 10.2307/2532314
  28. Leach KA, Paul ES, Whay HR, Barker ZE, Maggs CM, Sedgwick AK, et al. Reducing lameness in dairy herds—overcoming some barriers. *Res Vet Sci.* (2013) 94:820–25. doi: 10.1016/j.rvsc.2012.10.005
  29. Bland JM, Altman DG. Multiple significance tests: the Bonferroni method. *BMJ.* (1995) 310:170. doi: 10.1136/bmj.310.6973.170
  30. Wickham H. *ggplot2: Elegant Graphics for Data Analysis*. New York, NY: Springer-Verlag (2016). doi: 10.1007/978-3-319-24277-4\_9
  31. Wickham H, François R, Henry L, Müller K. *dplyr: A Grammar of Data Manipulation. R package version 1.0.7.* (2021). Available online at: <https://CRAN.R-project.org/package=dplyr> (accessed February 2, 2021). doi: 10.1007/978-1-4842-6876-6\_1
  32. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics.* (1977) 33:159. doi: 10.2307/2529310
  33. Denis-Robichaud J, Kelton D, Fauteux V, Villettaz-Robichaud M, Dubuc J. Short communication: accuracy of estimation of lameness, injury, and cleanliness prevalence by dairy farmers and veterinarians. *J Dairy Sci.* (2020) 103:10696–702. doi: 10.3168/jds.2020-18651
  34. Beggs DS, Jongman EC, Hemsworth PH, Fisher AD. Lameness in Australian dairy farms: a comparison of farmer-identified lameness and formal lameness scoring, and the position of lame cows within the milking order. *J Dairy Sci.* (2019) 102:1522–29. doi: 10.3168/jds.2018-14847
  35. Jewell MT, Cameron M, Spears J, McCanna SL, Cockram MS, Sanchez J, et al. Prevalence of lameness and associated risk factors on dairy farms in the Maritime Provinces of Canada. *J Dairy Sci.* (2019) 102:3392–405. doi: 10.3168/jds.2018-15349
  36. Adams AE, Lombard JE, Fossler CP, Román-Muñoz IN, Kopral CA. Associations between housing and management practices and the prevalence of lameness, hock lesions, and thin cows on US dairy operations. *J Dairy Sci.* (2017) 100:2119–36. doi: 10.3168/jds.2016-11517
  37. Ranjbar S, Rabiee AR, Gunn A, House JK. Identifying risk factors associated with lameness in pasture-based dairy herds. *J Dairy Sci.* (2016) 99:7495–505. doi: 10.3168/jds.2016-11142
  38. Oehm AW, Jensen KC, Tautenhahn A, Mueller KE, Feist M, Merle R. Factors associated with lameness in tie stall housed dairy cows in South Germany. *Front Vet Sci.* (2020) 7:1086. doi: 10.3389/fvets.2020.601640
  39. Schlageter-Tello A, Bokkers EAM, Koerkamp PWGG, van Hertem T, Viaggi S, Romanini CEB, et al. Manual and automatic locomotion scoring systems in dairy cows: a review. *Prev Vet Med.* (2014) 116:12–25. doi: 10.1016/j.prevetmed.2014.06.006
  40. Schulz T, Gundelach Y, Feldmann M, Hoedemaker M. Early detection and treatment of lame cows: effect on duration and prevalence of lesion-specific lameness. *Tierarztl Prax Ausg G Grosstiere Nutztiere.* (2016) 44:5–11. doi: 10.15653/TPG-150534
  41. Palacio S, Peignier L, Pachoud C, Nash C, Adam S, Bergeron R, et al. Technical note: assessing lameness in tie-stalls using live stall lameness scoring. *J Dairy Sci.* (2017) 100:6577–82. doi: 10.3168/jds.2016-12171
  42. Gibbons J, Haley DB, Higginson Cutler J, Nash C, Zaffino Heyerhoff J, Pellerin D, et al. Technical note: a comparison of 2 methods of



- assessing lameness prevalence in tiestall herds. *J Dairy Sci.* (2014) 97:350–53. doi: 10.3168/jds.2013-6783
43. Nederhof AJ. Methods of coping with social desirability bias: a review. *Eur J Soc Psychol.* (1985) 15:263–80. doi: 10.1002/ejsp.2420150303
  44. Espejo LA, Endres MI, Salfner JA. Prevalence of lameness in high-producing holstein cows housed in freestall barns in Minnesota. *J Dairy Sci.* (2006) 89:3052–58. doi: 10.3168/jds.S0022-0302(06)72579-6
  45. Bard AM, Main DCJ, Haase AM, Whay HR, Roe EJ, Reyher, et al. The future of veterinary communication: partnership or persuasion? A qualitative investigation of veterinary communication in the pursuit of client behaviour change. *PLoS ONE.* (2017) 12:e0171380. doi: 10.1371/journal.pone.0171380
  46. Svensson C, Wickström H, Emanuelson U, Bard AM, Reyher KK, Forsberg L. Training in motivational interviewing improves cattle veterinarians' communication skills for herd health management. *Vet Rec.* (2020) 187:191. doi: 10.1136/vr.105646
  47. Noordman J, de Vet E, van der Weijden T, van Dulmen S. Motivational interviewing within the different stages of change: an analysis of practice nurse-patient consultations aimed at promoting a healthier lifestyle. *Soc Sci Med.* (2013) 87:60–7. doi: 10.1016/j.socscimed.2013.03.019
  48. Velicer WF, Prochaska JO, Fava JL, Norman GJ, Redding CA. Detailed overview of the transtheoretical model. *Homeostasis.* (1998) 38:216–33.
  49. Baum A, Newman S, Weinman J, West R, McManus C. *Cambridge Handbook of Psychology, Health and Medicine.* Cambridge: Cambridge University Press (1997).
  50. Santman-Berends IMGA, Buddiger M, Smolenaars AJG, Steuten CDM, Roos CAJ, van Erp AJM, et al. A multidisciplinary approach to determine factors associated with calf rearing practices and calf mortality in dairy herds. *Prev Vet Med.* (2014) 117:375–87. doi: 10.1016/j.prevetmed.2014.07.011
  51. Rutherford KMD, Langford FM, Jack MC, Sherwood L, Lawrence AB, Haskell MJ. Lameness prevalence and risk factors in organic and non-organic dairy herds in the United Kingdom. *The Vet J.* (2009) 180:95–105. doi: 10.1016/j.tvjl.2008.03.015
  52. Spoolder H. Animal welfare in organic farming systems. *J Sci Food Agric.* (2007) 87:2741–46. doi: 10.1002/jsfa.2999
  53. Tunstall J, Mueller K, White DG, Oultram JWH, Higgins HM. Lameness in beef cattle: UK farmers' perceptions, knowledge, barriers and approaches to treatment and control. *Front Vet Sci.* (2019) 6:94. doi: 10.3389/fvets.2019.00094
  54. Brennkemeyer C, Dippel S, March S, Brinkmann J, Winckler C, Knierim U. Reliability of a subjective lameness scoring system for dairy cows. *Anim Welf.* (2007) 16:127–29.
  55. Alsaod M, Fadul M, Steiner A. Automatic lameness detection in cattle. *Vet J.* (2019) 246:35–44. doi: 10.1016/j.tvjl.2019.01.005
  56. Bruijnijns M, Hogeveen H, Garforth C, Stassen E. Dairy farmers' attitudes and intentions towards improving dairy cow foot health. *Livest Sci.* (2013) 155:103–13. doi: 10.1016/j.livsci.2013.04.005
  57. Aghababaei N, Arji A. Well-being and the HEXACO model of personality. *Pers Individ Dif.* (2014) 56:139–42. doi: 10.1016/j.paid.2013.08.037
  58. Molloy GJ, O'Carroll RE, Ferguson E. Conscientiousness and medication adherence: a meta-analysis. *Ann Behav Med.* (2014) 47:92–101. doi: 10.1007/s12160-013-9524-4
  59. O'Kane H, Ferguson E, Kaler J, Green L. Associations between sheep farmer attitudes, beliefs, emotions and personality, and their barriers to uptake of best practice: the example of footrot. *Prev Vet Med.* (2017) 139:123–33. doi: 10.1016/j.prevetmed.2016.05.009

**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Publisher's Note:** All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Copyright © 2022 Jensen, Oehm, Campe, Stock, Woudstra, Feist, Müller, Hoedemaker and Merle. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.