Impact of Veterinary Herd Health Management on German Dairy Farms: Effect of Participation on Farm Performance

Jenny Ries¹, Katharina Charlotte Jensen¹, Kerstin Elisabeth Müller², Christa Thöne-Reineke³† and Roswitha Merle¹*¹

¹ Institute for Veterinary Epidemiology and Biostatistics, Department of Veterinary Medicine, Freie Universität Berlin, Berlin, Germany, ² Ruminant and Swine Clinic, Department of Veterinary Medicine, Freie Universität Berlin, Berlin, Germany, ³ Institute of Animal Welfare, Animal Behavior and Laboratory Animal Science, Department of Veterinary Medicine, Freie Universität Berlin, Berlin, Germany

German dairy farming has intensified markedly in recent years, and the demand for Veterinary Herd Health Management (VHHM) is rising. To protect farms from epidemics, ensure food safety, and prevent developing of antibiotic resistance, VHHM has been anchored in EU law since April 2021. Via an online survey, distributed by different farmers’ organizations, dairy farmers were asked about the cooperation with their veterinarian. The aim was to evaluate farm performance as a function of participation in VHHM. From 216 analyzed questionnaires, 106 respondents participated in VHHM. Results showed that farmers who make use of VHHM and consult their veterinarian in decision-making frequently have the highest 305-day milk yield (305dMY), the lowest bulk tank somatic cell counts, and the lowest age at first calving (AFC). However, these farmers tended to have higher replacement rates and a higher mortality of cows in the period up to 60 days in milk (MORT60DIM). Furthermore, respondents who defined VHHM as “evaluation of herd data, strategic planning” had the highest 305dMY compared with those who defined VHHM through one of the different options given (“pregnancy checks and support in reproduction”/“problem solving”). In the multifactorial regression model, VHHM participating farms had a 660-kg higher 305dMY and 1 month less in AFC, compared with farms not participating in VHHM. However, within the VHHM participants, no association between VHHM practices and performance parameters was found. Further research is needed, to find out if tailored advice of the VHHM approach may show effect herein.

Keywords: survey, dairy herd health management, cooperation with veterinarian, integrated herd health management, future of dairy farming

INTRODUCTION

Dairy farming is of utmost economic importance in Germany. In 2020, Germany was the largest EU milk producer with an output of approximately 33 million tons of milk. Approximately half of the produced quantity was exported, representing a production value of more than 10 billion € (1). The increase in quantities is inherent in structural changes on dairy farms demanding
intensification with, as a result, an uneven decline in the number of farms and animals (2–4). Since the discontinuation of the milk quota in 2015, the dependency has made the milk price a pawn on the global market (5). In parallel to the economic pressure at the beginning of the production chain, legal and social requirements also set the expectations on dairy farms even higher (6–8). For this reason, farmers must improve animal health and welfare while optimizing their milk production to continue to withstand economic constraints and survive in the marketplace.

Over the years, breeding progress has made a considerable contribution to the development of today’s dairy industry. This development led to an increased milk yield but also to an increased incidence of production associated diseases, such as decreased fertility, milk fever, hyperketonemia, and so on (9–11). In addition, societal demands on dairy farming have become louder, and consumers prefer small-structured farms without exploitation of animals and the environment (12). Consequently, stakeholders of agriculture need to be aware that only transparency can counteract societal alienation from modern agriculture (13, 14).

Considering the developments mentioned above, an all-encompassing approach is needed not only to balance the extreme demands on our dairy cows with the production-associated diseases, but also to ensure animal welfare and food safety for the future of German dairy farming, not only to appease the consumer. Therefore, Veterinary Herd Health Management (VHHM) programs have been established since on-farm disease prevention, health management, and a focus on prophylaxis instead of therapy have played a main role. This paradigm shift is due to the use of epidemiological science in livestock diseases and thus evaluation of problems at herd rather than individual animal level (15). Therefore, the veterinarian has become an essential part of this herd management, and his/her role has evolved away from purely curative work toward advisory work (8, 16). VHHM, in its position of independence from interests and finances, offers the possibility of a regular farm audit, without immediate negative consequence for premium reduction or similar, as, for example, is the case with quality management milk (QM) or cross-compliance inspections (CC) (17, 18). Peer collaboration between farmer and veterinarian in the interest of the farmer to reach the set targets can have demonstrable impact on performance (19, 20), as well as on animal health and welfare (6, 21), especially as the former requires the latter. As a study proved, information for disease prevention and thus optimized farm management is generally provided by the veterinarian through a VHHM program, but eventually depends on the farmer to implement suggestions (22, 23). It was also shown that the extent of VHHM participation varies considerably. Some farmers understand this to mean pregnancy checks, whereas others make use of the greatest possible range of services offered by the veterinarian, such as udder or young stock health (24–26). Regardless of the participation rate, the literature is controversial on the economic benefit of such VHHM programs. Two studies reported better farm performance and thus financial benefits with participation (27, 28), and another study showed an effect, although that disappeared after termination of the VHHM program (29). However, other research could not show a significant effect during participation (30). Another consideration is the cost and time of a veterinary farm visit (21, 28, 31–33), whereby the goal should be that the progress pays off the (cost) effort.

As study results showed before (26), the calculated overall satisfaction with VHHM was normally distributed and was rated, on average, as “good,” which was observed in other studies before (34, 35). The individual scope of VHHM was assessed by components with associated subquestions (e.g., VHHM component “udder health” included subquestions “evaluation of herd performance data,” “milk sampling,” “assessment of parlor routine”). The agreement to all VHHM components would have resulted in a scope of 100%. The average level of participation in our study was 36% and indicated that VHHM is still too focused on a few areas rather than taking a multidisciplinary approach. VHHM satisfaction correlated with scope of VHHM, and a possible reason for that is that a holistic herd management keeps several aspects overlooked.

The aim of the study was to describe the current practice of VHHM on German dairy farms. In the first part of the study, dairy farmers’ attitude toward and satisfaction with VHHM have been displayed to enable future veterinarians to offer more adequate tailored concepts (26). The aim of the present article was to explore the associations between farm performance and the participation in and the satisfaction with VHHM. It was expected that in the group of VHHM farms, higher satisfaction with the veterinarian and the VHHM program would result in optimized farm performance parameters.

**MATERIALS AND METHODS**

**Study Design**

This cross-sectional study was conducted from November 1 to December 31 of 2020 via the online survey tool LimeSurvey® (LimeSurvey GmbH, Hamburg, Germany).

**Questionnaire Design**

The questionnaire with a total of 123 questions was created based on a study from the Netherlands (36). Depending on answers given in the first few questions, the further questions differed in amount and content between VHHM participants and non-VHHM participants. Therefore, the time frame needed to answer the questionnaire was evaluated by a two-step pretest and took 20 min for VHHM participants and 12 min for non-VHHM participants.

The included questions were closed single-choice questions, questions with 5-point Likert scales, open-ended questions, and ranking questions. Page 1 contained details of goal and process of the survey and a privacy notice from the conducting Institute of
Freie Universität Berlin as well as a data processing consent form was added. While the first block included questions on general farm data, the second section covered available workforce on the farm. Further on, participants were asked about their subjective definition of VHHM, as participants were intentionally not given a definition of VHHM to prevent bias. Therefore, the classification for participation in a VHHM was left to the participants themselves. This question was followed by a key question on individual participation in a VHHM program, which decided about the further questions asked: Those who denied participation in a VHHM program at the time of the survey followed up with questions about possible potential on their farm and their willingness to pay for veterinary consultation while participants who stated to receive VHHM support on their farm were asked about the detailed design of the service. Eventually, questions regarding the demographics of the participants were asked.

A two-phase pretesting consisted of two phases: Phase I, where three dairy farmers were asked to sample the questionnaire in presence of the first author for understanding of questions and answer options. Subsequently, a few questions were adapted in terms of understanding. In phase II, three different dairy farmers were selected to complete the online format of the questionnaire without prior explanation, whereas the first author recorded the time required. Comprehension problems no longer existed in this phase, but a few questions were shortened, so the time limit of the survey was realistic.

Participants
The voluntary participation in the survey was only possible online, and no regional limitations were given. To disseminate the study among the target group, farmers' associations were asked to spread the link among their members (“Deutscher Bauernverband”: 18 associations led by the head association). Moreover, other farmers’ associations were contacted by mail and asked for assistance (“Bundesverband der Maschinenringe e.V.” (with all subassociations), “Bund Deutscher Milchviehhalt e.V.”, “Bund der deutschen Landjugend e.V.”). The six largest dairy associations as well as organic associations were likewise included. The willingness of support was given among the sought-after as most replied on first contact.

Statistical Analysis
The data were imported into IBM SPSS Statistics 27 (SPSS for Windows, IBM®, Armonk NY, USA) for descriptive data analysis and additionally transferred to R Studio [version 4.0.3. “Bunny-Wunniess Freak Out”; R Core Team, 2020 using the packages “dplyr” (37); “car” (38), “desctools” (39), “lmertest” (40), and “corrplot” (41)] for further analysis.

The amount that did not complete the survey and exited before the limit we set was due to analytical reasons: answered questionnaires to at least page 3, including questions of general farm data, available labor force and relative importance of VHHM definition, animal health decision-making, and satisfaction with veterinarian, were included in the analysis. The replies included were examined for duplication using the SPSS function and then subjected to further plausibility checks. No duplicates were identified, missing values were not filled in, and implausible values were removed but not replaced. Frequency tables were created for categorical variables. Continuous variables were checked for normal distribution using histograms and boxplots. To test the stochastic independence of the variables, the Wilcoxon rank test was performed in the part of the descriptive farm data.

The mean values of the variable blocks “advantages,” “disadvantages,” “fulfillment of expectations by vet,” “cooperation with vet,” and “improvements of VHHM” (matrix questions with Likert scale) were used to calculate a new variable (mean value of all equally weighted Likert scales), describing the overall satisfaction with the current VHHM.

Furthermore, to determine the scope of a farm’s VHHM program, each VHHM component was scored based on its subquestions (e.g., VHHM component “udder health” included the subquestions “evaluation of herd performance data,” “milk sampling,” “assessment of parlor routine”). Components were weighted equally, and according to the number, the weight of individual subquestions was adjusted. Agreement on all subquestions of all VHHM components would have resulted in a scope of 100%.

Correlation coefficients were used to determine undirected correlations, and in case of normally distributed, metrically scaled data, Bravais-Pearson method was used, whereas, if one variable was at least ordinaly scaled, Spearman rank correlation coefficient was calculated.

Regression models were developed using R Studio. First, single-factorial linear regression models were calculated with the performance parameters (dependent variable) and participation in VHHM (influencing variable). For those models where the participation had a $p < 0.2$ and showed normal distribution of residuals, a multifactorial model including relevant confounders was calculated. Therefore, the impact of the participation in VHHM on performance parameter was assessed adjusting for the confounders herd size, region, breed, conventional or organic farming, husbandry system, and staffing ratio. Because of multiple testing, a Bonferroni correction was applied leading to a level of significance of $0.05/5 = 0.01$.

To assess if a higher satisfaction or higher scope with VHHM or more frequent visits were associated with a higher 305-day milk yield (305dMY) or a lower age at first calving (AFC), multifactorial linear regression models were calculated including the mentioned variables and confounders (herd size, conventional or organic farming, husbandry system).

The requirements regarding linearity, homoscedasticity, and multicollinearity were tested using the QQ plot of residuals for visual inspection of normal distribution, the Breusch-Pagan test, and Cramer V and variation inflation coefficients, respectively.

RESULTS
All Participants
With 57,322 registered German dairy farms at the time of evaluation and 216 evaluable questionnaires, the response rate
results in 0.38%. Two hundred sixteen of 434 questionnaires were either fully (166×) or partially (50×) completed and were included in the analysis, whereas the remaining 218 did not complete the survey and were excluded from evaluation. Approximately half of the study participants (n = 106) participate in VHHM (Table 1). The VHHM farms kept higher numbers of animals (total stock of milk production including young stock) (mean = 491) compared with non-VHHM farms (mean = 360) (p = 0.0793). The mean 305dMY on VHHM farms differed by 1,218 kg compared with non-VHHM farms (10,195 vs. 8,977 kg; p < 0.0001). Mean AFC on VHHM farms was 26 months, whereas AFC on non-VHHM farms was 27 months (p = 0.0020). The mortality of cows in the period up to 60 days in milk (MORT60DIM) was slightly higher on VHHM farms (mean = 5.47%) than on non-VHHM farms (mean = 4.89%) (p = 0.2527). VHHM farms had a mean staffing ratio of 94 animals/staff member, compared with non-VHHM farms with a mean of 84 animals/staff member (p = 0.3507).

More than three-quarters of the VHHM farms “always/often” discussed decisions with their veterinarian, whereas a little over half of the non-VHHM farms did so (Table 2). The comparison of means revealed that VHHM farms reporting taking important decisions “always” with their veterinarian had numerically the highest 305dMY compared with farmers taking decisions less frequently with their veterinarian. VHHM farms that “always” discussed decisions had numerically the lowest

| TABLE 1 | Descriptive data of farm characteristics. | VHHM participation |
| --- | --- | --- | --- |
| | Yes | No |
| Total no. of animals for milk production (including offspring) | | |
| n | 106 | 110 |
| 25% | 150 | 120 |
| Mean | 491 | 360 |
| Median | 243 | 200 |
| 75% | 479 | 400 |
| SD | 978 | 450 |
| p-value | 0.0793 |
| No. of animals: lactating/dry (productive part of herd—in lactation or in dry period) | | |
| n | 106 | 110 |
| 25% | 76 | 65 |
| Mean | 217 | 191 |
| Median | 130 | 105 |
| 75% | 270 | 238 |
| SD | 225 | 228 |
| p-value | 0.0869 |
| 305-day milk yield in kg | | |
| n | 106 | 110 |
| 25% | 9,500 | 8,000 |
| Mean | 10,195 | 8,977 |
| Median | 10,399 | 9,120 |
| 75% | 11,200 | 10,100 |
| SD | 1,524 | 1,793 |
| p-value | <0.0001 |
| Energy corrected milk in kg | | |
| n | 105 | 107 |
| 25% | 21.18 | 17.73 |
| Mean | 22.58 | 20.20 |
| Median | 23.09 | 21.05 |
| 75% | 24.56 | 23.13 |
| SD | 2.93 | 4.16 |
| p-value | <0.0001 |
| Bulk tank somatic cell count in thousands/mL (average of last 2 months) | | |
| n | 106 | 110 |
| 25% | 125.50 | 130.50 |
| Mean | 176.23 | 179.16 |
| Median | 165.50 | 178.25 |
| 75% | 226.00 | 224.00 |
| SD | 69.47 | 78.06 |
| p-value | 0.5434 |
| Age at first calving in months | | |
| n | 106 | 110 |
| 25% | 25 | 25 |
| Mean | 26 | 27 |
| Median | 26 | 26 |
| 75% | 27 | 28 |
| SD | 2 | 3 |
| p-value | 0.0020 |
| Replacement rate in% | | |
| n | 82 | 76 |
| 25% | 23 | 20 |
| Mean | 28 | 27 |
| Median | 28 | 28 |
| 75% | 32 | 34 |
| SD | 6 | 9 |
| p-value | 0.9763 |

(Continued)
TABLE 2 | Descriptive data of decision-making with veterinarian.

| VHMM | 305dMY (kg) | ECM (%) | BTSCC (×1,000/mL) | MORT60DIM (%) | RR (%) | AFC (months) |
|------|-------------|---------|-------------------|----------------|--------|-------------|
| Always | Yes | n = 21 | n = 20 | n = 21 | n = 11 | n = 17 | n = 21 |
|        | 10,639 | 23.69 | 155 | 7.55 | 28.12 | 25.0 |
| No     | n = 15 | n = 15 | n = 15 | n = 9 | n = 9 | n = 15 |
|         | 8,916 | 20.38 | 201 | 5.11 | 27.33 | 26.7 |
| Often  | Yes | n = 63 | n = 63 | n = 63 | n = 36 | n = 51 | n = 63 |
|        | 10,297 | 22.63 | 183 | 5.36 | 27.76 | 26.1 |
| No     | n = 47 | n = 47 | n = 48 | n = 21 | n = 28 | n = 48 |
|         | 8,732 | 19.94 | 171 | 5.14 | 27.14 | 27.4 |
| Occasionally | Yes | n = 18 | n = 18 | n = 18 | n = 9 | n = 11 | n = 18 |
|        | 9,844 | 21.93 | 171 | 4.22 | 29.00 | 26.1 |
| No     | n = 30 | n = 30 | n = 31 | n = 16 | n = 24 | n = 31 |
|         | 9,022 | 20.02 | 179 | 5.50 | 29.71 | 27.5 |
| Rare   | Yes | n = 2 | n = 2 | n = 2 | n = 1 | n = 2 | n = 2 |
|        | 7,464 | 19.66 | 161 | 1.00 | 20.00 | 26.5 |
| No     | n = 14 | n = 14 | n = 15 | n = 10 | n = 14 | n = 15 |
|         | 9,943 | 21.58 | 184 | 3.20 | 24.43 | 26.1 |
| Never  | Yes | n = 2 | n = 2 | n = 2 | n = 1 | n = 2 | n = 2 |
|        | 8,200 | 18.68 | 233 | 4.00 | 24.00 | 28.5 |
| No     | n = 1 | n = 1 | n = 1 | n = 0 | n = 1 | n = 1 |
|         | 6,500 | 15.65 | 178 | — | 20.00 | 26.0 |

Table 3 shows that, in the single regression analysis of the variables (VHMM scope, VHMM satisfaction, visit frequency) with the performance data (305dMY, AFC, BTSCC), only a significant correlation between 305dMY and VHMM scope could be found (p = 0.039). With each percent more VHMM scope the 305dMY raised by 18 kg. However, multifactorial modeling of the variables visit frequency, VHMM satisfaction, VHMM scope, herd size, farm management, and housing type showed no significant impact on the 305dMY and the AFC.

DISCUSSION

The hypothesis tested was the presence of an association between farm performance and participation in VHMM. The results indicate a statistically significant association between participation and milk yield as well as AFC. However, no significant associations were detected between the different services of VHMM and performance.

According to the Federal Statistical Office of Germany, 57,322 dairy farms were registered in the entire country in 2020. Thus, the participating 216 farms represented 0.38% of dairy farms in Germany (2). As a low percentage of the target population could be reached, results may be biased, and this issue can be found in previous studies (36). Validity of results is influenced by the sample size and several other factors, as also analyzed in
TABLE 3 | Descriptive data of satisfaction with veterinarian.

| VHHM                | 305dMY (kg) | ECM (%) | BTSCC (× 1,000/mL) | MORT60DIM (%) | RR (%) | AFC (months) |
|---------------------|-------------|---------|-------------------|----------------|--------|--------------|
| Very good           | Yes         | n = 40  | n = 40            | n = 40         | n = 31  | n = 40       |
|                     |             | 10,406  | 23.11             | 173            | 5.08   | 26.06        |
|                     | No          | n = 30  | n = 31            | n = 31         | n = 20  | n = 31       |
|                     |             | 8,433   | 19.40             | 168            | 4.88   | 25.20        |
| Good                | Yes         | n = 45  | n = 44            | n = 45         | n = 34  | n = 45       |
|                     |             | 10,149  | 22.39             | 183            | 6.50   | 28.56        |
|                     | No          | n = 52  | n = 52            | n = 45         | n = 39  | n = 54       |
|                     |             | 9,297   | 20.78             | 172            | 5.54   | 28.15        |
| Satisfactory        | Yes         | n = 14  | n = 14            | n = 10         | n = 11  | n = 14       |
|                     |             | 9,762   | 21.58             | 169            | 4.10   | 28.82        |
|                     | No          | n = 16  | n = 16            | n = 4          | n = 10  | n = 16       |
|                     |             | 9,464   | 20.77             | 195            | 6.00   | 29.70        |
| Sufficient          | Yes         | n = 4   | n = 4             | n = 4          | n = 4   | n = 4        |
|                     |             | 8,950   | 20.10             | 157            | 10.00  | 35.00        |
|                     | No          | n = 5   | n = 5             | n = 4          | n = 3   | n = 5        |
|                     |             | 8,070   | 18.01             | 240            | 3.25   | 19.67        |
| Unsatisfactory      | Yes         | n = 3   | n = 3             | n = 1          | n = 2   | n = 3        |
|                     |             | 11,767  | 26.30             | 175            | 2.00   | 20.50        |
|                     | No          | n = 4   | n = 4             | n = 3          | n = 4   | n = 4        |
|                     |             | 8,063   | 19.37             | 218            | 1.33   | 30.75        |

Survey among German dairy farmers on VHHM participation (n = 216).

TABLE 4 | Descriptive data of relative importance of subjective definition of VHHM.

| VHHM                | 305dMY (kg) | ECM (%) | BTSCC (× 1,000/mL) | MORT60DIM (%) | RR (%) | AFC (months) |
|---------------------|-------------|---------|-------------------|----------------|--------|--------------|
| Pregnancy checks and support in reproduction | Yes         | n = 53  | n = 52            | n = 53         | n = 28  | n = 39       |
|                     |             | 10,166  | 22.60             | 170            | 4.61   | 27.74        |
|                     | No          | n = 43  | n = 43            | n = 44         | n = 25  | n = 29       |
|                     |             | 9,325   | 20.96             | 171            | 3.88   | 27.00        |
| Problem solving     | Yes         | n = 33  | n = 33            | n = 33         | n = 22  | n = 27       |
|                     |             | 10,213  | 22.46             | 194            | 6.59   | 27.44        |
|                     | No          | n = 45  | n = 43            | n = 45         | n = 21  | n = 32       |
|                     |             | 8,417   | 19.29             | 179            | 4.76   | 28.03        |
| Herd data/strategy planning/farm economy | Yes         | n = 20  | n = 20            | n = 20         | n = 9   | n = 16       |
|                     |             | 10,241  | 22.73             | 163            | 5.44   | 28.38        |
|                     | No          | n = 19  | n = 21            | n = 21         | n = 10  | n = 15       |
|                     |             | 9,513   | 20.47             | 197            | 7.70   | 26.73        |

Survey among German dairy farmers on VHHM participation (n = 216).

part 1 of the study (26). As the survey was exclusively accessible online, selection bias was possibly present as it significantly contributes to a reduced range and thus smaller number of possible participants. Online recruitment only targeted dairy farms with email addresses and membership in association mailing lists or access to social media. An equally important factor was the participants’ personal affinity for online media and their motivation on the relevant topic (42). A former study showed a shift of participants toward larger farms (24), which is also evident from the discrepancy of the mean number of cows per farm in our study and the 2020 nationwide average of dairy cows (2, 3). However, the aim of this part of the study was not to assess a representative status but to assess a possible relationship between the participation in VHHM and farm performance.

A weakness of the study is undoubtedly the fact that participation was explicitly voluntary and anonymous, so we deliberately omitted to ask about health-related factors of the animals to prevent gross misrepresentation. Despite that participation was explicitly voluntary and anonymous, survey participants generally tend to give a distorted picture of
TABLE 5 | All participants: multiple regression models.

Multiple regression model: 305dMY (Analysis of dependent variable “305dMY” with influencing variables)

305dMY ~ participation in VHHM + herd size: lactating/dry + region + breed + conventional/organic + husbandry system + staffing ratio: lactating/dry

|     | Minimum | 25% | Median | 75% | Maximum | Standard error |
|-----|---------|-----|--------|-----|---------|----------------|
| Residuals | -1992.5 | -768.2 | -51.0  | 671.0 | 2953.2  | 1,102          |

Degrees of freedom = 159
Multiple R² = 0.6552
Adjusted R² = 0.6335

| Estimate | Standard error | t-value | p-value |
|----------|----------------|---------|---------|
| 305dMY (VHHM + region north + Holstein + conventional + free stall + staffing ratio) | 10,305.91 | 267.15 | 38.58 | <0.001 |
| No VHHM | -659.91 | 182.68 | -3.61 | <0.001 |
| Herd size: lactating/dry | 1.99 | 0.51 | 3.95 | <0.001 |
| Region east | -542.89 | 331.70 | -1.64 | 0.104 |
| Region south | 937.53 | 341.88 | 2.74 | 0.007 |
| Region west | -11.19 | 210.89 | -0.05 | 0.958 |
| No Holstein | -1,938.52 | 293.02 | -6.62 | <0.001 |
| Organic | -1,760.57 | 310.51 | -5.67 | <0.001 |
| Free stall + pasture | -709.12 | 211.84 | -3.35 | 0.001 |
| Tie stall (+/− pasture) | -1,171.60 | 449.39 | -2.61 | 0.010 |
| Staffing ratio: lactating/dry | 1.03 | 2.40 | 0.43 | 0.668 |

Multiple regression model: AFC (Analysis of depending variable “AFC” with influencing variables)

AFC ~ participation in VHHM + herd size: lactating/dry animals + region + breed + conventional/organic + staffing ratio: lactating/dry animals

|     | Minimum | 25% | Median | 75% | Maximum | Standard error |
|-----|---------|-----|--------|-----|---------|----------------|
| Residuals | -5.03 | -1.36 | -0.06  | 1.17 | 17.87  | 2.43           |

Degrees of freedom = 164
Multiple R² = 0.3476
Adjusted R² = 0.3158

| Estimate | Standard error | t-value | p-value |
|----------|----------------|---------|---------|
| AFC (VHHM + herd size + region north + Holstein + conventional + staffing ratio) | 25.97 | 0.54 | 48.55 | <0.001 |
| No VHHM | 0.80 | 0.40 | 2.02 | 0.045 |
| Herd size: lactating/dry | -0.002 | 0.001 | -1.74 | 0.084 |
| Region east | -0.07 | 0.73 | -0.10 | 0.922 |
| Region south | -1.00 | 0.74 | -1.35 | 0.179 |
| Region west | 0.83 | 0.46 | 1.80 | 0.073 |
| No Holstein | 2.38 | 0.63 | 3.76 | <0.001 |
| Organic | 2.21 | 0.63 | 3.53 | <0.001 |
| Staffing ratio: lactating/dry | -0.01 | 0.01 | -1.56 | 0.120 |

Survey among German dairy farmers on VHHM participation (n = 216).

Survey among German dairy farmers on VHHM participation (n = 216). Especially the results of performance parameters could deviate from reality. To prevent this aspect, we asked in the introduction to take data straight from the current MLP (provided participants with the exact page and field reference in this document to find the data). Because of this indication and the guaranteed anonymity, we assume that the information provided was mostly valid. Furthermore, the division into VHHM participants and non-VHHM participants was based solely on the participants’ self-assessment, as no definition of VHHM was deliberately given, in order to prevent inhibited participation or misperceptions. This may have resulted to farmers having been assigned to the wrong group. Also, this is a
### Single regression models

|                | BTSCC | AFC  | 305dMY |
|----------------|-------|------|--------|
| VHHM scope     | 0.717 | 0.066| 0.039  |
| VHHM satisfaction| 0.52  | 0.378| 0.13   |
| Visit frequency| 0.943 | 0.321| 0.538  |

### Single regression model: 305dMY

305dMY ∼ VHHM scope (Analysis of depending variable “305dMY” with influencing variable “scope”)

|               | Estimate | Standard error | t-value | p-value |
|---------------|----------|----------------|---------|---------|
| Residuals     | −161.74  | −47.74         | −9.24   | 31.26   | 186.76  | 70.98   |

### Multiple regression model: 305dMY

305dMY ∼ visit frequency + VHHM satisfaction + VHHM scope + herd size + conventional/organic + husbandry system (Analysis of depending variable “305dMY” with influencing variables)

|               | Estimate | Standard error | t-value | p-value |
|---------------|----------|----------------|---------|---------|
| Residuals     | −2,413.63| −790.83        | −70.86  | 839.75  | 2,055.16| 1,163   |

### Multiple regression model: AFC

AFC ∼ visit frequency + VHHM satisfaction + VHHM scope + herd size + conventional/organic + husbandry system (Analysis of depending variable “AFC” with influencing variables)

|               | Estimate | Standard error | t-value | p-value |
|---------------|----------|----------------|---------|---------|
| Residuals     | −3.11    | −1.07          | −0.19   | 0.97    | 2.75    | 1.56    |

(Continued)
The fact that VHHM farms were significantly larger in animal numbers is congruent with a previous study (24). However, it is conceivable that farms with more animals are more interested in current issues and more likely to participate in surveys (45). Another consideration may be that either farms with greater animal numbers are more likely to participate in VHHM, or the structure gained through VHHM participation allows an expansion, but that remains unclear in the final extent.

Moreover, in multiple regression, VHHM farms had a statistically significantly higher 305dMY of more than 600 kg adjusted for region, breed, farm management, housing type, and staffing ratio. Previous studies showed that VHHM-supported farms have significantly higher milk yields than non-VHHM farms (8, 24, 28, 33). The reasons for that can be manifold, as described herein, such as the appreciation of benefits of prophylaxis and a strategic approach.

In addition, a 0.8-month lower AFC on the VHHM farms also suggests better farm management: The AFC has been shown to be influenced by young stock rearing practices, for example, the amount and kind (no waste milk) of milk fed preweaning (46). Several studies show that heifer growth is essentially influenced by the feeding management at calf age, and rearing conditions have an immense effect on the potential of the future dairy cow (47, 48). It would be conceivable that this reflects the merit of VHHM on those farms.

Given the results of the performance parameters, the approach described in a previous study (15) fits: The main characteristic of VHHM is the integrated farm assessment based on valid, collected data and in consideration of economic interests. This approach, they argue, serves to prevent disease and to increase performance. The effect of increased overall performance with VHHM participation has additionally been demonstrated in other studies (28). Nevertheless, this key finding offers potential for further research to determine whether increased performance is a cause or effect of VHHM participation.

For the higher MORT60DIM on VHHM farms, no significant correlation could be shown further on. Still, it could be a consequence of higher milk yields and the purported occurrence of production diseases (11, 49–51) during the critical transition period and subsequently increased involuntary cull of animals (52, 53). Data from Israel explain the occurrence of these diseases through a deficient management and a reduction of said after an intensified VHHM program (50). For intensified dairy farming, it is even more important to put animal welfare at the forefront. Intensification that ignores animal welfare is not a promising or sustainable approach to future farming. The veterinarian is obliged to emphasize this in the interest of the animals within the framework of a VHHM program, which in turn will pay off (54).

The staffing ratio, relating to the total number of animals, might reflect a more intensive form of farming. With 94 animals per staff member on VHHM farms and 84 animals per staff member on non-VHHM farms, the results of this study are in the range of the staffing ratio of US farms, where values between 80 and 100 animals per employee have been described (55–57). Regardless of participation in VHHM, our study found that with each additional animal per staff member, BTSCC increased by 300 cells/mL of milk. Relatively less staff may lead to a less optimized parlor routine and/or routine of bedding maintenance, which implies advantages of a closer ratio.

The more intensive collaboration between veterinarian and farmer in decision-making on VHHM farms is also reflected in the results of previous studies (58). Indirectly, the scope of collaboration appears to be related to farm performance, as farms that consult more frequently with their veterinarian and farms that are more satisfied with their veterinarian both performed better in the mean comparison. As the veterinarian counts as one of the most important advisors to the farm (24, 59), the relationship with the veterinarian is an important contributor to success (28).

Furthermore, survey participants who understood that VHHM was “herd data/strategy planning/economy,” that is, the most encompassing management approach among the definitions given, had the highest farm performance parameters, regardless of their participation in VHHM. This contrasted with the non-VHHM participants, who defined VHHM primarily as problem-solving and had the lowest milk performance of all. The
once exclusively therapeutic task of a veterinarian over the years has been increasingly replaced by a disease prophylactic task, so that the commonly known “firefighting veterinarian” is replaced (8, 21).

**Participants in VHHM**

Certain associations, such as the presence of an effect of VHHM scope, VHHM satisfaction, and frequency of visits or support in a specific area (like udder health) combined with performance parameters, could not be verified in our study. The reason for this could be that the sample size was too small, at least for certain combinations of risk factors. This result may give reason to believe that the extent and design of a VHHM appear to be secondary to farm performance data and are well-worthy subject to further research.

**CONCLUSION**

The study outlined that participation in a VHHM program showed significant differences in the performance benchmarks 305dMY and AFC. Consequently, it is important for a farm to have VHHM participation theoretically. Within the VHHM participants, however, the detailed extent of herd management did not play a role in this present study. Thus, it can be assumed from this research that a participation in VHHM may lead to a better performance of the dairy herd. Regardless of the new legal situation, the results of the present study may contribute to higher intrinsic motivation among dairy producers to participate in a VHHM program.

**DATA AVAILABILITY STATEMENT**

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

**REFERENCES**

1. Federal Ministry of Food and Agriculture, Germany. Developments on the German dairy market - an overview (2021). Available online at: https://www.bmel.de/DE/themen/landwirtschaft/agrarmaerkte/entwicklungen- milchmarkt-de.html (accessed July 12, 2021)
2. Federal Statistical Office G. General and representative survey of livestock: number of farms: cattle 2 years and older, dairy cows (2021). Available online at: https://www-genesis.destatis.de/genesis//online?operation=table&code=41311-0003&bypass=true&levelindex=51&levelid=1635608671491#abreadcumb (accessed July 02, 2021)
3. Federal Statistical Office G. General and representative survey of livestock: number of animals: cattle 2 years and older, dairy cows (2021). Available online at: https://www-genesis.destatis.de/genesis//online?operation=table&code=41311-0001&bypass=true&levelindex=1&levelid=1635608671491#abreadcumb (accessed July 02, 2021)
4. Federal Statistical Office G. Press release: livestock production in the last decade: fewer but larger farms (2021). Available online at: https://www.destatis.de/DE/Presse/Pressemeldungen/2021/07/PD21_N043_41.html doi: 10.4000/books.pus.30182 (accessed July 24, 2021)
5. Banse M, Knuck J, Weber S. Thünen Working Paper 118: Stable and high milk prices?!: Options for influencing milk prices (2019). Thünen-Institute for market analysis. Available online at: https://www.thuenen.de/media/publikationen/thuenen-workingpaper/ThuenenWorkingPaper_118.pdf
6. Barkema HW, Keyserlingk MA. von. Kastelic JP, Lam TJ, Luby C, Roy JP, et al. Invited review: changes in the dairy industry affecting dairy cattle health and welfare. J Dairy Sci. (2015) 98:7426–45. doi: 10.3168/jds.2015-9377
7. Flint L, Kuhner H, Laggnzer B, Lassen B, Nieberg H, Strohm R. Sustainable milk production: development of a monitoring-tool for measuring and validating the sustainability of dairy farms: Thünen Working Paper 54 (2016).
8. Douphrate DI, Hagevoort GR, Nonnenmann MW, Lunner Kolstrup C, Reynolds SJ, Jakob M, et al. The dairy industry: a brief description of production practices, trends, and farm characteristics around the world. J Agromedicine. (2013) 18:187–97. doi: 10.1080/1059924X.2013.796901
9. Dobson H, Smith R, Royal M, Knight C. Im Sheldon. The high-producing dairy cow and its reproductive performance. Reprod Domest Anim. (2007) 42(Suppl 2):17–23. doi: 10.1111/j.1439-0531.2007.00906.x
10. Berglund B. Genetic improvement of dairy cow reproductive performance. Reprod Domest Anim. (2008) 43(Suppl 2):89–95. doi: 10.1111/j.1439-0531.2008.01147.x
11. Bauer A, Martens H, Thöne-Reinke C. Breeding problems relevant to animal welfare in dairy cattle - interaction between the breeding goal “milk yield” and the increased occurrence of production disease. Berliner und Münchener Tierärztliche Wochenschrift. (2021) 102:1–9. doi: 10.2376/1439-0299-2021-5
12. Cardoso CS, Hötzel MJ, Weary DM, Robbins JA, Keyserlingk MA. von. Imagining the ideal dairy farm. J Dairy Sci. (2016) 99:1663–71. doi: 10.3168/jds.2015-9925

**ETHICS STATEMENT**

In this study, no personal or sensitive data was collected. Participation was voluntary and anonymous. Before starting the questionnaire, participants perceived detailed information about the aims of the study and how the data were evaluated. Consent needed to be actively given by each participant. For no personal rights or any German and European data protection laws could be violated, we refrained from receiving approval from an Ethics Committee.

**AUTHOR CONTRIBUTIONS**

JR conceived and designed the study, developed the theoretical framework, and implemented it in a preliminary model and questionnaire. Statistical preliminary considerations and statistical analyses were performed in close cooperation with RM and KJ. JR drafted and revised the manuscript. RM, KM, and CT-R supervised and supported the project at each point of the development, conduction, statistical evaluation, and during the paper-writing process. All authors contributed to the article and approved the submitted version.

**ACKNOWLEDGMENTS**

We thank all participating farmers for their time and interest in this study and Marjolein Derks for her helpful support with the questionnaire.

**SUPPLEMENTARY MATERIAL**

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2022.841405/full#supplementary-material
13. Coney CC, Botharas NA. Animal Welfare, Ethics and the U.S. Dairy industry: maintaining a social license to operate: veterinary preventive medicine the Ohio State University. In: Tri-State Dairy Nutrition Conference (Fort Wayne, IN) (2010).

14. Weary DM, Keyserlingk MA. von. Public concerns about dairy-cow welfare: how should the industry respond? Anim Prod Sci. (2017) 57:1201. doi: 10.1071/AN16680

15. LeBlanc SJ, Lissimore KD, Kelton DF, Duffield TF, Leslie KE. Major advances in disease prevention in dairy cattle. J Dairy Sci. (2006) 89:1267–79. doi: 10.3168/jds.S0022-0302(06)72195-6

16. Cannas da Silva J, Noordhuizen JP, Vagneur M, Bexiga R, Gelfert CC, Baumgartner W. Veterinary dairy herd health management in Europe: constraints and perspectives. Vet Q. (2006) 28:23–32. doi: 10.1080/01652176.2006.9695203

17. Meyer C, Matsdorf B, Müller K, Schleyer C. Cross compliance as payment for public goods? Understanding EU and US agricultural policies. Ecol Econ. (2014) 107:185–94. doi: 10.1016/j.ecolecon.2014.08.010

18. Knuth U, Amjah-Babu TS, Kniefer A. Adoption of farm management systems for cross compliance - an empirical case in Germany. J Environ Manag. (2018) 220:109–17. doi: 10.1016/j.jenvman.2018.04.087

19. Noordhuizen JP, Wentink GH. Developments in veterinary herd health systems on dairy farms: a review. Vet Q. (2001) 23:162–9. doi: 10.1080/01652176.2001.9695106

20. Noordhuizen JPTM. Changes in the Veterinary Management of Dairy Cattle: Threats or Opportunities? Veterinary Sciences Tomorrow Issue 2 (2001). Available online at: https://dspace.library.uu.nl/handle/1874/28895

21. Friewald RM. Significance and Development of the Dairy Herd Controlling System: A Statistical Survey of a Written Interview Among Bavarian Farmers. (2010), p. 131.

22. Jansen J, Steuten CD, Renes RJ, Aarts N, Lam TJ. Debunking the myth of the hard-to-reach farmer: effective communication on udder health. J Dairy Sci. (2010) 93:1296–306. doi: 10.3168/jds.2009-2794

23. Derks M, van de Ven LM, van Werven T, Kremer WD, Hogeven H. The perception of veterinary herd health management by Dutch dairy farmers and its current status in the Netherlands: a survey. Prev Vet Med. (2012) 104:207–15. doi: 10.1016/jprevmed.2011.12.019

24. Derks M, van Werven T, Hogeven H, Kremer WD. Veterinary herd health management programs on dairy farms in the Netherlands: use, execution, and relations to farmer characteristics. J Dairy Sci. (2013) 96:1623–37. doi: 10.3168/jds.2012-6106

25. Ries J, Jensen KC, Müller KE, Thöne-Reineke C, Merle R, Noordhuizen JPTM. What should the industry respond? Anim Prod Sci. (2017) 57:1201. doi: 10.1071/AN16680

26. Höss M, Kemper-Gisler D, Liesegang A, Braun U. Comparison of productivity and veterinary expenses in Swiss dairy farms with and without integrated veterinary herd health service. Schweizer Archiv für Tierheilkunde. (2010) 152:470–6. doi: 10.1024/0036-7281/ao0107

27. Lieveart J, Noordhuizen J, Buckley D, van Winden S. The marketing of herd health and production management services on Dutch dairy farms: perceptions of dairy farmers and their veterinary surgeons. J Vet Med. (2008) 61:668–76. doi: 10.1159/00018481-61-10-668

28. Van der Merwe W, Soukupova A, van der Merwe W. The impact of veterinary herd health management programs. Vet Rec. (2014) 175:224. doi: 10.1136/vr.102183

29. Derks M, Hogeven H, Kooistra SR, van Werven T, Tauer LW. Efficiency of dairy farms participating and not participating in veterinary herd health management programs. Prev Vet Med. (2014) 117:478–86. doi: 10.1016/j.prevetmed.2014.10.008

30. Kristensen E, Enevoldsen C, A. mixed methods inquiry: How dairy farmers perceive the value(s) of their involvement in an intensive dairy herd health management program. Acta Vet Scand. (2008) 50:50. doi: 10.1186/1751-0147-50-50

31. Friewald RM. Significance and Development of the Dairy Herd Controlling System: A Statistical Survey of a Written Interview Among Bavarian Farmers. (2010), p. 131.

32. Ifende VI, Derks M, Hooijer GA, Hogeven H. Financial aspects of veterinary herd health management programmes. Vet Rec. (2014) 175:224. doi: 10.1136/vr.102183
57. Durst P. Dairy farm labor efficiency: Is your farm as efficient as it could be? (2020). https://www.canr.msu.edu/news/dairy-farm-labor-efficiency

58. Bard AM, Main D, Roe E, Haase A, Whay HR, Reyher KK. To change or not to change? Veterinarian and farmer perceptions of relational factors influencing the enactment of veterinary advice on dairy farms in the United Kingdom. J Dairy Sci. (2019) 102:10379–94. doi: 10.3168/jds.2019-16364

59. Pothmann H, Nechanitsky K, Sturmlechner F, Drillich M. Consultancy to dairy farmers relating to animal health and herd health management on small- and medium-sized farms. J Dairy Sci. (2014) 97:851–60. doi: 10.3168/jds.2013-7364

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 Ries, Jensen, Müller, Thöne-Reineke 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.