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Impact of Veterinary Herd Health Management on German Dairy Farms

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List of abbreviations

AFC:	Age at first calving
AMS:	automatic milking system
BTSCC:	bulk tank somatic cell count
CC:	Cross Compliance
DIM:	days in milk
EU:	European Union
FTE:	full-time equivalent
GOT:	German Scale of Veterinary Fees (“Gebührenordnung für Tierärzte“)
MLP:	German DHI testing (“Milchleistungsprüfung“)
MORT60DIM:	mortality of cows in the period up to 60 days in milk
QM:	German Quality Management Milk (“Qualitätsmanagement Milch“)
RR:	replacement rate
SWOT:	strengths, weakness, opportunities, threats
VHHM:	Veterinary Herd Health Management
305dMY:	305-day milk yield

Introduction

Veterinary Herd Health Management (VHHM) is becoming increasingly important in the field of veterinary dairy practice. Whereas a few decades ago veterinarians had mainly purely curative tasks, these are now complemented by advisory activities and thus regular collaboration between veterinarian and farmer is an important tool in the full support of a dairy farm. Keeping the animals healthy and optimizing farm performance while maintaining animal health, animal welfare and legal aspects are the focus of herd health programs, not only to ensure food safety. For this purpose, animal-related data are collected, both problem-oriented but especially preventive, which are discussed with the persons that care for the animals. The resulting operational objectives are addressed consecutively by measures within the framework of the program and reviewed by means of interval-based evaluation.

With the EU-wide "Animal Health Act" (VO 2016/429) which is in effect since April 2021, a VHHM is mandatory on dairy cow farms.

The topic of VHHM is of multi-faceted interest for the stakeholders involved. To the veterinary profession, a deeper insight can serve to better promote farm-specific approaches, but also to recruit farms not previously participating in VHHM in order to proactively market VHHM as a veterinary service. For the dairy farmers, a broader horizon of possibilities within the framework of VHHM can help them to position their individual situation and, if necessary, achieve progress or change with the farm veterinarian. Not least is public interest given through the change in law, but also from the consumer’s point of view, since the production of high-quality and safe food is demanded more and more with emphasis on animal welfare and animal health, on which the veterinarian could influence actively by means of VHHM.

Until now, little is known about the establishment of VHHM programs on dairy farms in Germany, so the aim of this study was to collect a status quo of the current VHHM practice. An online survey was used to address dairy farmers and to record whether VHHM was taking place and, if so, the extent to which it was being implemented. Dairy farmers were asked about satisfaction with the veterinarian as well as problems and desires within the VHHM program, with the intent of providing a reflection of the nationwide dissemination.

The hypothesis of the first part of the study was that farms that participated in a VHHM were more satisfied with the veterinarian and with the VHHM program itself. It was also to find out if the scope of support was related to the satisfaction of a corresponding program. The second part of the project analyzed whether closer and more regular collaboration was potentially associated with improved overall farm performance such as milk yield, age at first calving, bulk tank somatic cell count etc.

Literature

The structural change in agriculture is in full swing with the consequence that the number of German dairy farms has almost halved in the last ten years, with a disproportionately smaller decline in the number of animals (Federal Statistical Office 2021). In addition, the German dairy market has been exposed to international developments since the abolition of the milk quota in 2015, so that an already tight economic situation is further intensified (Banse et al. 2019).

With a sales share of about 20% in the last year, the dairy sector contributes enormously to the corresponding economic sector of the Federal German Republic and, in addition, Germany has been the most producing EU member state in recent years; half of the 33 million tons produced went for export (Federal Ministry of Food and Agriculture, Germany 2021).

Part of this development is that for many years the breeding focus has been on improving the various performance traits. With the help of advanced reproductive technologies, such as artificial insemination and embryo transfer, targeted mating has become possible, and thus changes in, for example, milk yield or milk composition (Vries 2017). The increase in individual animal milk yield is particularly remarkable: since the 1950s, the genetically possible yield has been constantly increasing and rose by more than 100 kg with each year of breeding progress (Hansen 2000; LeBlanc et al. 2006; Capper and Cady 2020). Nevertheless, there are also downsides of a higher performance, such as the increased incidence of so-called production diseases (Bauer et al. 2021) or demonstrably reduced reproductive performance due to this development (Dobson et al. 2007; Berglund 2008).

Nevertheless, this development is not fully coherent. While production is subject to an intensification process, extrinsic factors are working in an opposite direction. In particular, society's demands on the production of animal foods have grown enormously (Barkema et al. 2015; Flint et al. 2016; German Ethics Council 2020). For example, consumers demand small-structured, owner-operated farms with respect for animal welfare, animal health and sustainable environmental conditions (Boogaard et al. 2010; Román et al. 2017). At the same time, there is a threat of social alienation of modern agriculture and the current production conditions. Since ruthless coexistence is not a sustainable solution, societal requirements must come to a common denominator with the possibilities of production, so that the implementable measures create transparency for all parties involved (Croney and Botheras 2010; Weary and Keyserlingk 2017).

In the development of this system, the farm veterinarian has a significant role. While for a long time the veterinary task was the pure treatment of individual animal diseases, in the second half of the 20th century a new approach already began, which made the veterinarian a central farm advisor (LeBlanc et al. 2006; Douphrate et al. 2013). Since its beginnings, with the collection of metabolic profiles in the eighties of the last century, the VHHM has continuously evolved to include different areas of farm management. The term "preventive veterinary medicine" was born, which on the one hand meant the prophylaxis of herd diseases and on the other hand subclinical diseases gained attention for the first time (Radostitis et al. 1994). Since then, veterinary advice has evolved in parallel with curative practice and is now referred to, among other, as "Veterinary Herd Health Management". This is understood as an all-encompassing approach, i.e., an approach that takes care of all production stages of a dairy farm in its details and takes place through visits by a veterinarian at regular intervals with the aim of optimizing animal health and performance in dairy herds. For this purpose, animal-related indicators and key figures are recorded, interpreted, and discussed with the animal owner and other advisors. In a further step, measures are developed, goals are outlined, and deadlines are set in order to achieve these goals. This concept is intended to find and maintain a balance between the enormous demands on the animals, while maintaining health and welfare, the economically tight situation in agriculture, taking into account individual farm objectives, and the preservation of food safety.

According to previous studies, the veterinarian is one of the most important advisors of a farm (Derks et al. 2012), so a good collaboration can be promising. However, the concept is particularly fruitful if that collaboration is intrinsically motivated by the farmer. Besides the personality of the farm manager, which plays a decisive role in the success of measures (Kristensen and Enevoldsen 2008; Derks et al. 2013; Pothmann et al. 2014), the interpersonal level of the supervising veterinarian and the farmer is influential and mutual trust is a contributing factor (Jansen and Lam 2012; Derks et al. 2014b; Bard et al. 2019; Svensson et al. 2019). VHHM programs are ideally based on a heterarchical approach, where all stakeholders work on jointly defined operational goals. However, practicability, among other things, remains the top priority for possible change actions, which the veterinarian should be aware of, because otherwise, according to studies, only 50% of the proposals will be implemented (Svensson et al. 2019). Once a VHHM program is established on a good foundation, according to the literature, the harvest is promptly: for example, VHHM farms are more often free stall barns with higher levels of digitization, which can be associated with higher performance and financial benefits and most important greater animal welfare (Friewald 2010; Derks et al. 2012; Hagevoort et al. 2013; Derks et al. 2014b; Derks et al. 2014a; Barkema et al. 2015). Nevertheless, disadvantages are also reported by farmers. These range from the associated costs to the high level of time required for preparation and follow-up (Lievaart et al. 2008; Friewald 2010; Derks et al. 2014a; Derks et al. 2014b; Ifende et al. 2014).

Regardless of all possible upsides and downsides of such a program, the future will be directed due to the legislative change on European Union level (European Union 2016). This provides for mandatory participation of all dairy farms in herd management, so that a change will inevitably occur in the near future. While ten years ago only every twentieth farmer aimed at such a cooperation with the veterinarian (Friewald 2010), it can be assumed that the participation rate will steadily increase over time.

The present study was conducted close to the time of the EU-wide change in legislation and therefore provides insight into the prevalence of VHHM programs at that time. The aim was to evaluate the common understanding of the term “Veterinary Herd Health Management” among the farmers, the extent of implementation of and satisfaction with VHHM programs as well as a possible association between participation and performance. Thus, part one of this study presents the extent to which farmers claim advisory support by the veterinarian and how they continue to do so. For this purpose, they were asked about possible participation in a VHHM program, the general design of an implementation, their satisfaction with it, and possible outlooks for the future. In part two, the hypothesis of a possible association between VHHM participation and better performance parameters was addressed. Here, the question was whether establishments of a VHHM program and higher satisfaction with such were characterized by improved herd performance parameters.

The results of the study are especially intended to give the veterinary profession a cross-section of the current situation, with insights into the desires and criticisms of the target group, in order to enable targeted action on the way to the nationwide establishment of VHHM programs. Of course, farmers in particular, but also society and politics may benefit from the results by obtaining transparency on this topic.

Publication 1: “Benefits of Veterinary Herd Health Management on German Dairy Farms: Status Quo and Farmers’ Perspective”

Benefits of Veterinary Herd Health Management on German Dairy Farms: Status Quo and Farmers’ Perspective

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Benefits of Veterinary Herd Health Management on German Dairy Farms: Status Quo and Farmers' Perspective

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Veterinary Herd Health Management plays an important role in veterinary medicine on dairy farms and has also been mandatory at the European Union level since April 21, 2021. Despite the increasing importance of VHHM, little is known about the extent of utilization of VHHM by dairy farmers and their view on this type of collaboration. Therefore, this cross-sectional study aimed to determine the status quo of the currently practiced VHHM in Germany. For this purpose, an online survey was conducted among dairy farmers in November and December 2020. From 216 analyzed questionnaires, about half ($n = 106$) of the surveyed dairy farmers used VHHM at different scopes. However, regardless of the group, the term "veterinary herd health management" generally was given most relative importance by the participants as a veterinary service for herd fertility improvement, rather than the actual definition of a holistic approach. In contrast to this, the actual motivation of the VHHM participants, to take part in such a program was primarily based on the desire to safeguard animal health by employing preventive measures, that is, to avoid the occurrence of diseases *via* improved management and to improve farm performance (and profitability). Dairy farmers who opted for VHHM tended to manage larger higher yielding herds than those who did not. Additionally, the farmers in latter farms were more likely to make joint animal health decisions with their veterinarians. Using a latent class analysis, two groups of farmers among farms that were not currently using VHHM were identified, one of which expressed great interest in using VHHM while the other did not. Since the new legal basis makes the topic even more relevant than before, dairy farmers, animals, and veterinarians might benefit from the study to exploit hidden opportunities for VHHM collaboration.

Keywords: survey, integrated herd health management, latent class analysis, satisfaction with veterinarian, decision-making

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INTRODUCTION

German dairy farming is undergoing tremendous structural changes. The constant intensification in this field over the last few years is reflected in the decrease in the number of dairy farms between 2010 and 2020 by almost 40% (2020: 54,300 farms) and the decrease in the number of animals by almost 6% (2020: ∼3.9 million dairy cows). As a result, the average number of dairy cows per farm increased from 46 to 72 (1). At the same time, there is an increasing call for sustainability in favor of animal welfare and the protection of natural and social resources (2). Ensuring sufficient food production under changing conditions and an intensified societal focus also plays a central role in the latest national development, with the collaboration of the German government's Commission on the Future of Agriculture (3). Therefore, it is even more understandable that, not only partly due to the ever-increasing societal pressure (2, 4, 5), but also due to legal and economic constraints, the focus of veterinary activity is shifting significantly from therapy to prevention. In 1994, researchers described the four phases of preventive veterinary medicine in animal husbandry, with phase three, which involves the application of proactive rather than reactive measures, established in the 1960s (6). Back then, prophylaxis focused particularly on fertility or udder health, and subclinical diseases were recognized for the first time as an obstacle to increased productivity. In this context, farmers began to pay for veterinary consulting services. Since then, veterinarians have become increasingly important as advisors on dairy farms (7, 8).

The highly topical nature of preventive herd management lies in the fact that VHHM has recently become legally binding. Until April 21, the 2016/429 Regulation (the so-called "EU Animal Health Law") had to be implemented in the European Union (EU) member states (9). Therefore, it is no longer a question of whether such models have a part in the future in Germany, but rather what their structure will look like (10, 11). More than 10 years ago, <6% of farmers participated in VHHM (12); in the future, all of these farmers are expected to participate in VHHM programs. In addition, VHHM is an integral part of animal food production in other countries such as the Netherlands (13, 14), Austria (15), Denmark (16), Sweden (17), the United Kingdom (18), and Canada (19).

Whether VHHM can be fully implemented is additionally influenced by an important factor: the increasingly severe shortage of livestock-focused veterinarians. The fact that the next generation of veterinarians is even more transient to this field of practice than it already is compared to veterinarians working on other animal species, does not favor the provision of high-quality veterinary herd care on farms (20, 21).

Abbreviations: AFC, age at first calving; AMS, automatic milking system; BTSCC, bulk tank somatic cell count; DIM, days in milk; EU, European Union; FTE, full-time equivalent; GOT, German Scale of Veterinary Fees; MLP, German DHI testing; QM, German Quality Management Milk; RR, replacement rate; SWOT, strengths, weaknesses, opportunities, and threats; VHHM, Veterinary Herd Health Management; SD, Standard Deviation.

Regardless of the extrinsic factors mentioned previously, a farmer's intrinsic motivation plays a major role in the decision to implement or not implement VHHM (22, 23). Compared to some audit systems in Germany, such as quality management milk (QM) standard or dairy internal programs (24, 25), that allow farms to develop a direct financial dependency with immediate negative consequences in case of non-compliance (e.g., milk revenue is influenced by farm individual sustainability and animal welfare measures), VHHM is not meant for achieving that kind of hierarchical control. Rather, it is intended to encourage equal cooperation between the farmers and the veterinarian and to guide the farmers, free of premiums, using a mature concept with the help of a veterinarian, with a focus toward improved animal health and animal welfare, which in turn positively improves profitability. Several studies have already proven that the attitude and character of farm managers have a major influence on the implementation and progress of a herd management program (15, 16, 23). In addition, success depends on a good veterinarian-livestock owner relationship and interpersonal communication (26–29). Although the veterinarian is considered one of the most important external advisors on the farm (30) and livestock owners value him or her for, for example, up-to-date expertise or information on industry-relevant events (26, 31, 32), this alone does not guarantee a successful collaboration. Researchers found that, according to farmers, the main criteria for implementing the veterinarian's suggestions are trust, practicability, and agreement with their own priorities (23, 33). The veterinarian must be aware of these criteria; otherwise, only 50% of the veterinarian-suggested changes will be applied (33). If the basic conditions for successful cooperation are in place, other positive effects have been proven on VHHM farms: studies showed a correlation between VHHM participation and loose housing as well as a higher degree of digitalization, which is potentially associated with higher levels of herd performance (26, 30, 34, 35) and possibly better animal welfare (4, 12).

Of course, VHHM not only has advantages; the additional costs (13, 26, 34) and time associated with a visit of the veterinarian, including a tour around the farm, should not be ignored (12, 36).

This study was divided into two separate parts: The here present aimed to give an insight from the farmers' perspective on the implementation and practices of VHHM on German dairy farms. The focus was to determine the extent to which the VHHM is implemented on German farms and how this is shaped. Dairy farmers in Germany were asked about their attitude toward and satisfaction with VHHM to enable veterinarians to develop better farm-specific, and thus successful, concepts. While this is more concerned with the "soft skills" of a potential VHHM program, the second publication deals with the "hard facts," meaning the association between farm performance and (non-) participation in a VHHM program. It was expected that in the group of VHHM farms, a higher satisfaction with the veterinarian and the VHHM program would be accompanied by a better overall farm performance.

MATERIALS AND METHODS

Study Design

The online survey tool Lime Survey® (LimeSurvey GmbH, Hamburg, Germany) was used to collect data for this cross-sectional study. The study was conducted from November 1 to December 31, 2020.

Questionnaire Design

A questionnaire comprising 123 questions was created based on a study conducted in the Netherlands (37). The underlying questionnaire contained a total of 10 subgroups of questions: All participants were asked 40 questions from different groups, as described below. Question group 3 divided participants into VHHM-participants and non-VHHM-participants. The non-VHHM participants were asked another 9 questions, while the VHHM-participants had another 74 questions. Since the answers given previously were used to decide which additional questions should be administered, neither of the participants had to answer all 123 questions. Estimated by pre-testing, it took the non-VHHM participants ∼12 min to complete the questionnaire and the VHHM participants 20 min.

The questionnaire consisted largely of closed questions with a single choice and contained questions that are rated on a 5-point Likert scale. Open-ended questions were used less frequently as well as ranking questions. The first page contained a detailed explanation of the goals and processes of the survey. At the end of the introduction, the participants were provided with a privacy notice from the Institute of Veterinary Epidemiology and Biostatistics, Freie Universität Berlin, and had to agree to a data processing consent form.

In the first block, general farm data were collected. The number of animals (whole herd including young stock vs. lactating and dry cows of the herd), 305-day milk yield, daily milk yield, milk fat and protein content, bulk tank somatic cell count (BTSCC) of the last two inspections during the DHI (Dairy Herd Improvement) testing (also known as MLP in Germany) or analysis of the dairy product, age at first calving (AFC), and replacement rate (RR) were included in the statistical analyses. Farm type, animal breed, management type, housing type, bed type, use of automatic milking systems (AMS), participation in "MLP" testing, and number of cows that died in <60 days in milk (DIM) were also asked.

The second section assessed in more detail the resources of the available labor force. Of importance to us were the number and expertise of the workforce, employment model, in-house communication, and employment of foreign language workers.

As regards VHHM, all participants were asked questions about their relative importance of subjective VHHM definition, their participation in VHHM, their participation in animal health decision-making, and overall satisfaction with their veterinarian. The answers given were used to decide which additional questions should be administered. Those who did not use VHHM at the time of the survey were asked about possible past participation in a VHHM program and whether they saw a potential need for it in their farm. They were also asked about their willingness to pay for veterinary consultation and their opinion on the offer provided by their cooperating veterinarians. The final set of questions for this group was related to the use of non-veterinary consultants on the farm.

Participants who indicated to receive VHHM support for their farm were asked questions about the detailed design of the service. First, two questions about motivation of participation in VHHM were asked, of which the first one was a free-text field. After this, the second question provided answers that had to be rated on a 5-point Likert Scale (1 = fully applicable; 5 = not applicable at all). Further collaboration was analyzed by asking the participants about perceived advantages and disadvantages of VHHM, and cooperation with the involved veterinarian, which was also assessed with a 5-point Likert Scale. Subsequently, a filter question about the VHHM components, as in which field support was received, was asked. Depending on these answers, the question about "fulfillment of expectations" was asked, with answers rated by school grades (German school grades: 1 = very good to 5 = insufficient). Additionally, the section "Future of the VHHM" with questions about the opportunities for improvement in the components covered in VHHM as well as the precise content of each VHHM component was assessed in detail. Moreover, the accounting for VHHM was examined by asking the participants to answer questions related to the current billing and desired billing method.

Questions regarding the demographics of the participants were indicated at the end of the questionnaire. According to their geographical location, the federal states were grouped into four major regions: North, East, South, and West of Germany. The northwestern part is characterized by family-run business. Dairy farms in the East are characterized by their corporate structure with numerous employees and bigger in size, due to having been the former German Democratic Republic. In southern Germany, the average herd size is smallest, and these family-run farms are still very traditional.

A two-phase pretest of the questionnaire was conducted prior; in phase I, three dairy farmers were asked to complete the questionnaire survey in the presence of the first author to determine whether the farmers understood the content of the questionnaire and the answer options provided. If necessary, questions were adapted, and more detailed explanations were added. In phase II, three additional dairy farmers were selected to complete the questionnaire in an online format without prior explanation, while the first author recorded and documented the time required. Comprehension problems were no longer observed in this phase, but a few questions were shortened so that the limit of the survey could be realized.

Participants

Participation in the survey was voluntary and only possible online *via* an online link. The survey was not limited to a certain region, and all farmers' associations ("Deutscher Bauernverband;" 1 head association with 18 regional associations) were asked to disseminate the link among their members. Furthermore, additional associations such as the "Bundesverband der Maschinenringe e.V." (with all 248 sub-associations), "Bund Deutscher Milchviehhalter e.V.," "Deutscher Raiffeisenverband e.V.," and "Bund der deutschen Landjugend e.V." were contacted

by mail and asked for assistance. The largest dairy and organic associations (each six in number) were also included. Most of the contacted replied with their willingness to forward the questionnaire. One dairy denied multiplication in a written response.

Statistical Analysis

The data were extracted from the survey tool and imported into the "IBM SPSS Statistics 27" program (SPSS for Windows, IBM®, Armonk, New York, USA) for further analysis.

Out of 434 questionnaires, 166 were fully completed, 268 were partially completed, and 216 were analyzed. All questionnaires that were completed at least up to page three, that included all questions of general farm data, available labor force and relative importance of subjective VHHM definition, a question on animal health decision making as well as satisfaction with veterinarian were included in the analysis. These questionnaires were examined for duplication using the SPSS function and then subjected to further plausibility checks. No duplications were identified, missing values were not filled, and implausible values were excluded but not replaced. Frequency tables were created for categorical variables. Continuous variables were assessed for the normality of distribution using histograms and boxplots. In order to test the stochastic independence of the variables, the Chi-Square test, the Fisher's Exact test and the Wilcoxon Rank test were performed in the part of descriptive farm data.

The mean values of the variables "advantages," "disadvantages," "fulfillment of expectations by a veterinarian," "cooperation with a veterinarian," and "improvements of VHHM" (matrix questions with Likert scale) were used to calculate the overall satisfaction with the current VHHM for each participant.

Furthermore, to determine the scope of a farm's VHHM program, each VHHM component was scored based on its sub-questions (e.g., VHHM component "Udder health" included the sub-questions "evaluation of herd performance data," "milk sampling," "assessment of parlor routine"). Each component was weighted equally, and the weight of the individual sub-questions was adjusted according to the number of sub-questions. Agreement on all sub-questions in all VHHM components would have resulted in a scope of 100%.

The correlation coefficient was used to determine the undirected correlations between two continuous variables. Thus, the rank correlation coefficient according to Spearman makes it clear in which direction and in which intensity a certain correlation exists. For this, the variables must be at least ordinally scaled (38, 39). To determine the Bravais/Pearson's correlation coefficient, the variables under consideration must be metrically scaled and normally distributed (38, 39). If both variables were normally distributed, the Pearson's correlation coefficient was calculated; otherwise, the Spearman's correlation coefficient was calculated.

Within the non-VHHM farms, we investigated whether the participants could be grouped according to their personal views. For this purpose, a latent class analysis (LCA) was used, which was calculated using the program "SAS Version 9.4" (SAS Institute Inc., Cary, NC, USA). An LCA serves as a statistical model for the exploratory analysis of a dataset. The observed, that is, manifest, variables are checked for unobserved (i.e., latent) correlations to determine the so-called traits. This allows observations to be categorized into two or more groups based on latent classes. The responses of non-VHHM farms were assessed using several possible classes. The subjectively perceived need for VHHM, satisfaction with the veterinarian, herd size, willingness to pay for VHHM, and the presence of other non-veterinary consultants were taken into consideration in the formation of classes. Models with two, three, and four classes were calculated for the four and five variables mentioned, respectively, and compared in terms of interpretability and fit statistics like Akaike information criterion (AIC) (40). Both item-response probabilities and class prevalence were used to assess the interpretability and characterize the classes. The model with two classes and four variables had the lowest AIC and was found to be useful. The variable "presence of non-veterinary consultants" was originally taken into consideration, due to the assumption of a disproportionate presence of the said on the non-VHHM farms and in order to assess the replacement of possible veterinary tasks by the aforementioned.

The free text field on "Motivation for VHHM participation" was analyzed based on Mayring's qualitative content analysis using the independent six-eye principle (41). This analysis technique is used to evaluate the response material by abstracting the individual content to manageable supergroups. The message of the original material is preserved in this process. The advantage of this open approach is the unbiased analysis of individual responses with a simultaneous reduction in scope. The individual steps suggested by Mayring were carried out analogously, and the material was the free text response in the present survey with the above origin and motivation. The answers were analyzed inductively and structured. A coding system was then created, which was then used to review the response material in several sections. After the first author had applied this procedure, two other persons, independent of the project and partly independent of the subject, were assigned this task. Intermediate results were not exchanged at any time, so that the first author only compared all three analyses results at the end of the survey. This independent six-eye principle helps ensure objectivity in the interpretation of free-text responses (41).

For satisfaction with accounting, we determined the proportion of participants who provided the same response on the questions "current billing method" and "desired billing method." When answers given on the two questions were equal, we concluded that the person is satisfied with the current method of accounting.

RESULTS

Participants vs. Non-participants in VHHM

As shown in the descriptive statistics in **Table 1**, half of the respondents ($n = 106$) responded that they participated in VHHM, while 110 participants responded that they did not participate in VHHM. In both groups, half of the participants belonged to the 30–49-year age group. Three-quarters of the respondents were the respective farm manager, while

TABLE 1 | Farm demographics and animal husbandry.

(Total: 216)		**Participation in VHHM**			
		Yes		**No**	
	p-value (p_F = Fisher's exact; p_C = Chi Square)	*n*	%	*n*	%
		106	49.1%	110	50.9%
Age	p_F *0.0914*	*n = 72*		*n = 100*	
<30 years		12	16.7%	25	25.0%
30–49 years		35	48.6%	54	54.0%
50–65 years		23	31.9%	21	21.0%
>65 years		2	2.8%	0	0.0%
Region	p_F *0.0226*	*n = 72*		*n = 101*	
North		28	38.9%	27	26.7%
East		6	8.3%	19	18.8%
South		8	11.1%	23	22.8%
West		30	41.7%	32	31.7%
Position	p_F *0.8776*	*n = 72*		*n = 101*	
Farm manager		56	77.8%	75	74.3%
Successor		8	11.1%	15	14.9%
Herdsman		6	8.3%	9	8.9%
Other		2	2.8%	2	2.0%
Form of cultivation	p_C *0.0250*	*n = 106*		*n = 110*	
Conventional		99	93.4%	92	83.6%
Organic		7	6.6%	18	16.4%
Form of husbandry	p_F *0.0323*	*n = 106*		*n = 110*	
Free stall—without access to exercise area		42	39.6%	49	44.5%
Free stall—with access to exercise area		28	26.4%	12	10.9%
Free stall—with access to pasture		33	31.1%	43	39.1%
Tie stall—without access to exercise area		0	0.0%	1	0.9%
Tie stall—access to pasture		3	2.8%	5	4.5%
Form of stalls	p_F *0.1558*	*n = 104*		*n = 104*	
Raised stall—with mattress		44	42.3%	48	46.2%
Raised stall—without mattress		4	3.8%	11	10.6%
Deep bedded cubicle		53	51.0%	42	40.4%
Bedded pack		3	2.9%	3	2.9%
Usage of AMS	p_C *0.3521*	*n = 106*		*n = 110*	
yes		32	30.2%	27	24.5%
no		74	69.8%	83	75.5%
Future plan in 10 years	p_F *0.2692*	*n = 72*		*n = 101*	
Continue farm as usual		26	36.1%	32	31.7%
Expand number of milking cows		16	22.2%	19	18.8%

(Continued)

TABLE 1 | Continued

(Total: 216)		Participation in VHHM Yes		No	
Reduce number of milking cows		2	2.8%	2	2.0%
Hand over the farm to a successor		16	22.2%	15	14.9%
Give up the dairy farm		1	1.4%	5	5.0%
Restructure the farm differently		3	4.2%	13	12.9%
I do not know		8	11.1%	12	11.9%
Others		0	0.0%	3	3.0%
Open house day	p_C 0.6026	*n* = 72		*n* = 101	
Yes		45	62.5%	67	66.3%
No		27	37.5%	34	33.7%
Highest qualification of staff		*n* = 105		*n* = 107	
Without experience		5	4.8%	4	3.7%
>5 years of relevant experience		11	10.5%	10	9.3%
Apprentice		7	6.7%	10	9.3%
Dairy herdsman		1	1.0%	0	0.0%
Trained farmer (degree)		81	77.1%	83	77.6%

the remaining respondents were family members or leading employees. The North, East, South, and West regions of Germany were represented by a quarter of each of the non-VHHM farms; among the VHHM farms, those in the East (8.3%) and South (11.1%) regions had low participation rates. Less than 7% of VHHM farms reported farming organically, while 16.4% of non-VHHM farms reported farming organically (**Table 1**).

A slight difference was observed between the two subgroups in terms of the type of housing and bed type: animals were kept in free stall barns, while the animals were tethered in only 2.8% of VHHM farms and 5.4% of non-VHHM farms. 51.0% of VHHM farms and 40.4% of non-VHHM farms kept animals in a free stall with deep-bedded stalls, while 46.1% of VHHM farms and 56.8% of non-VHHM farms used a free stall with high stalls (**Table 1**). 30.2% of VHHM farms reported using an AMS, while only 24.4% of non-VHHM farms used an AMS.

When asked about the plans in the next 10 years, 36.1% of the VHHM farm owners responded that they planned to continue the operation, while only 31.7% of the non-VHHM farm owners wanted to continue the operation. Moreover, 12.9% of the non-VHHM farm owners responded that they wanted to restructure the farm (e.g., start organic milk production), while only 4.2% of VHHM farm owners responded that they wanted to do so.

There was no difference when asked about their willingness to host an open house day where interested citizens could visit the farm: two-thirds in both groups agreed that they would be willing to offer an open house to the public. In both groups, the highest vocational qualification on more than three-quarters of the farms was a trained farmer (degree). The percentage of employees without subject-related experience was <5% in each case (**Table 1**).

As regards farm data, differences were observed in the two groups (**Table 2**). The VHHM farms had a mean total number of animals (total stock kept for milk production, including young stock) of 491 with an average milk yield of 22.58 kg ECM (energy corrected milk) per day, while the non-VHHM farms had a mean herd size of 360 animals with 20.20 kg ECM per day on average. The average AFC values were 26 months for VHHM farms and 1 month more for non-VHHM farms. By contrast, the differences in other key performance indicators were less pronounced; for example, the BTSCCs of two MLP-measurements in the last 2 months were 176,000 cells/ml of milk in VHHM farms and 179,000 cells/ml of milk in non-VHHM farms. The RR values were 28% for the VHHM farms and 27% for the non-VHHM farms. On average, 94 animals (total stock for milk production, including young stock) were cared for by each staff member in VHHM farms, while 84 animals were cared by each staff member in non-VHHM farms.

Table 3 shows that more than three-quarters of VHHM farms "always" or "often" discussed animal health-related decisions with their veterinarian beforehand, while this was only the case in 57.2% of non-VHHM farms. 3.8% of the VHHM dairies "rarely" or "never" made use of advice from their veterinarians, while this was the case of <15% of non-VHHM farms. When asked about general satisfaction with the work of the farm veterinarian, 37.7% of VHHM farms and 28.2% of non-VHHM farms replied "very good." Combined answers of "very good" and "good" resulted in a value of 80.2% for VHHM farms and a value of 77.3% for non-VHHM farms. "Poor" and "insufficient" satisfaction ratings were awarded by 6.6% of VHHM farms and 8.1% of non-VHHM farms.

A ranking question was used, to assess the participants' subjective definition of the term "Veterinary Herd Health

TABLE 2 | Farm characteristics.

		VHHM participation	
		Yes	**No**
Total number of animals for milk production (incl. offspring)	*n*	106	110
	25%	150	120
	Mean	491	360
	Median	243	200
	75%	479	400
	SD	978	450
	p-value		0.0793
Number of animals: lactating/dry	*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 | Continued

		VHHM participation	
		Yes	**No**
Mortality < 60 days in milk	*n*	59	56
	25%	1.00	0
	Mean	5.47	4.89
	Median	2.00	2.50
	75%	8.00	5.00
	SD	6.82	6.57
	p-value		0.2527
Staffing ratio: total stock (# animals/staff)	*n*	106	110
	25%	54.59	48.00
	Mean	93.65	84.19
	Median	80.24	72.86
	75%	100.00	105.00
	SD	82.24	67.05
	p-value		0.3507
Staffing ratio: lactating/dry (# animals/staff)	*n*	106	110
	25%	30.00	26.00
	Mean	48.05	45.13
	Median	43.07	38.13
	75%	54.67	55.96
	SD	35.80	36.42
	p-value		0.3401

TABLE 3 | Decision-making and satisfaction with veterinarian.

VHHM participation	**Yes**		**No**	
Decision-making with veterinarian	*n* = 106		*n* = 110	
Always	21	19.8%	15	13.6 %
Often	63	59.4%	48	43.6%
Occasionally	18	17.0%	31	28.2%
Rare	2	1.9%	15	13.6%
Never	2	1.9%	1	0.9%
Satisfaction with veterinarian	*n* = 106		*n* = 110	
Very good	40	37.7%	31	28.2%
Good	45	42.5%	54	49.1%
Satisfactory	14	13.2%	16	14.5%
Sufficient	4	3.8%	5	4.5%
Poor	3	2.8%	4	3.6%

Management," through which the participants were asked about their relative importance. Most of the participants ranked the answer "pregnancy checks/advice on reproduction" as number one (**Table 4**). For VHHM farms and non-VHHM farms, 50 and 40% of the participants provided the same ranking, respectively. Moreover, both groups assigned the answer "improvement of farm management/cost-benefit analyses" the lowest rank.

Participants in VHHM

As shown in **Table 5**, Mayring's content analysis indicated that the main motivation for participation was to ensure animal health on the farm, since "animal health/animal welfare (prophylaxis)" found most approval. This also crystallized in the ranking question, in which "remedying herd health problems" was assigned a high importance. Increasing milk yield played a subordinate role, and participation due to external regulations, such as obligations by the dairy farm, was provided the lowest priority.

Potential advantages of VHHM were rated similar on the Likert scale (1 = fully applicable, 5 = not applicable at all), with "More timely problem detection" (mean: 2.04) and "better herd health" (mean: 2.08) having had the lowest mean values. The

TABLE 4 | Subjective definition of VHHM. Relative importance of subjective VHHM definition. *(VHHM: 106; non-VHHM: 110)*.

		Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
"Pregnancy checks/consultation on reproduction"	VHHM	50.0%	24.6%	10.1%	7.6%	7.6%
	Non-VHHM	40.0%	25.5%	9.9%	10.9%	13.6%
"Discussion of herd production data"	VHHM	0.9%	16.0%	27.4%	36.8%	18.9%
	Non-VHHM	3.6%	14.5%	26.4%	33.6%	21.8%
"Tour through all stages of production/strategy discussion"	VHHM	14.2%	13.2%	26.4%	29.2%	17.0%
	Non-VHHM	13.6%	12.7%	33.6%	24.5%	15.5%
"Identifying and addressing current herd health problems"	VHHM	31.1%	39.6%	18.9%	8.5%	1.9%
	Non-VHHM	40.9%	40.9%	11.8%	3.6%	2.7%
"Improving farm management/cost-benefit analyses"	VHHM	3.8%	6.6%	17.0%	17.9%	54.7%
	Non-VHHM	1.8%	6.4%	18.2%	27.3%	46.3%

TABLE 5 | VHHM: Motivation of participation.

Motivation to participate in VHHM (free definition) ***(n = 94)***	***n***	**%**
"Animal health/animal welfare (prophylaxis)"	40	42.55
"Optimizing performance/efficiency"	21	22.34
"Reproduction"	16	17.02
"General help/management/problem identification/broadening of horizon"	35	37.23
"Protocols (e.g., through dairy/slaughter plant)"	8	8.51
Motivation to participate in VHHM (ranking) *(n = 97)* [1 = fully applicable −5 = not applicable at all]		Mean
Remedy herd health problems		1.97
Prevention of operational blindness		2.00
Avoid conflicts of law		2.10
Profit optimization		2.38
Control of production data		2.44
Recommended by veterinarian		2.71
Work structuring/sharing administration work with veterinarian		2.78
Required by higher authority		3.92

disadvantages met with less approval. Here, "High costs" (mean: 3.04) and "very time-consuming" (mean: 3.15) had the lowest mean values (**Table 6**).

The area of herd fertility management was the most frequently assessed part in VHHM; from the participants' point of view, the veterinarian fulfilled the expectations placed on him or her, particularly in this field. Farm economics, on the other hand, was only very rarely (8%) part of the VHHM, and the role of the veterinarian in this regard was rated as comparatively less satisfactory (mean = 2.71) (**Table 6**).

Also evident from **Table 6** are results of why veterinary recommendations did not always lead to the desired outcome. 46.7% of the participants responded that they implemented the veterinarian's advice, and the cause was also correctly addressed, but the problem could not still be resolved for other reasons. Meanwhile, 7.8% of the participants did not follow the advice because they considered it impractical.

As **Table 7** shows, the calculated satisfaction rate with the current VHHM was normally distributed and had a mean value of 2.18 ("good"). This satisfaction rate correlated significantly negatively with the VHHM scope, that is, the utilized proportion of all areas that the VHHM could possibly cover ($r_P = -0.477$, $p < 0.001$); as shown in **Figure 1**, the higher the scope of VHHM, the better the average satisfaction rate. Decision-making with the veterinarian was similarly correlated with VHHM satisfaction ($r = -0.402$, $p < 0.001$). The more satisfied participants were, the more often they made health-related decisions together with their veterinarians. VHHM satisfaction was positively and significantly correlated with the general satisfaction with the veterinarian ($r = 0.576$, $p < 0.001$). When VHHM appointments were scheduled independently of the veterinarian's curative visits, this increased the animal owners' satisfaction with the VHHM ($r_S = 0.367$, $p < 0.001$). Animal owners who were satisfied with the VHHM also perceived greater financial value ($r_S = 0.563$, $p < 0.001$). These participants would continue VHHM even if the fee for this service increased by 10% ($r_S = 0.266$, $p = 0.021$).

The average scope of VHHM was 36.41% and was normally distributed (**Table 7**). The most intensively attended areas were fertility (59.8%) and animal welfare (57.7%), while farm economics (10.3%) was the least intensively attended area (**Figure 2**).

Table 7 shows additionally, that the more intensively a farm was attended, the more satisfied its farm manager was with the veterinarian as a person ($r_S = -0.320$, $p = 0.006$). Moreover,

TABLE 6 | VHHM: Perceived advantages/disadvantages and fulfillment of expectations.

Advantages of VHHM and ranking *(n = 98)* [1 = fully applicable −5 = not applicable at all]		**Mean**	**SD**
More timely problem identification		2.04	0.849
Better herd health		2.08	0.833
Prevention of operational blindness		2.21	0.853
Better farm management		2.22	0.844
More structured problem-solving		2.32	0.892
Better herd performance		2.45	0.863
Organization has improved		2.46	0.943
Information on subject-related development		2.46	0.954
Control of production data		2.64	0.997
Disadvantages of VHHM and ranking *(n = 98)* [1 = fully applicable −5 = not applicable at all]			
High costs		3.04	0.962
Very time-consuming		3.15	0.956
Difficulties with data collection		3.64	0.977
Non-tailored advice		3.85	0.945
Inappropriate visiting hours		3.95	0.988
Little experience of veterinarian/not enough good advice		3.95	1.170
Advice not useful		3.97	0.779
Veterinarian interferes too much in management		4.07	0.750
Fulfillment of the expectation in VHHM *(n = 90)* [1 =very good −5 = insufficient]	***n***	**Mean**	**SD**
Fertility	84	1.67	0.781
Animal welfare	43	1.79	0.742
Claw health	46	1.98	0.856
Young stock health	45	1.98	0.917
Udder health	75	1.99	0.893
Biosecurity	22	2.00	0.873
Facilities/animal husbandry	15	2.40	1.121
Staff management/education	8	2.13	0.991
Performance/herd data	35	2.14	0.879
Nutrition	36	2.28	1.059
Farm economics	7	2.71	0.488
If some advice does not have a desired outcome, what might be the reason? *(n = 90)*		*n*	%
I followed the advice, but it failed because…	…the advice did not correctly address the cause of the problem.	30	33.3
	… the correct cause was addressed and implemented but still no effect occurred.	42	46.7
I did *not* follow the advice because…	… the advice was not practicable in everyday life.	11	12.2
	… the advice did not seem useful to me.	7	7.8

TABLE 7 | VHHM: Satisfaction with VHHM/scope of VHHM and importance of VHHM subjects.

Satisfaction with VHHM [1 = very good −5 = insufficient]							
n	**25%**	**Mean**	**Median**	**75%**	**SD**	**Shapiro wilk**	
						Statistics	**Sig.**
98	1.80	2.18	2.13	2.42	0.48	0.97	0.013

Correlation	*n*	r ($r_{P=Pearson;}$ $r_{S=Spearman-Rho}$)	*p*-value
Scope of VHHM [0–100%]	73	r_P −0.477	<0.001
Satisfaction with veterinarian [1 = very good −5 = insufficient]	98	r_S 0.576	<0.001
Decision making with veterinarian [1 = never −5 = always]	98	r_S −0.402	<0.001
Herd visit (in-)dependent of curative visit [1 = yes/2 = no]	98	r_S 0.367	<0.001
Financial added value [1 = fully applicable −5 = not applicable at all]	85	r_S 0.563	<0.001
Participation if VHHM fee is increased by 10% [1 = yes; 2 = yes, but reduced hours; 3 = no]	75	r_S 0.266	0.021

Scope of VHHM [0–100%]							
n	**25%**	**Mean**	**Median**	**75%**	**SD**	**Shapiro wilk**	
						Statistics	**Sig.**
68	21.02%	36.41%	33.33%	51.02%	19.76%	0.953	0.008

Correlation	n	r ($r_{P=Pearson;}$ $r_{S=Spearman-Rho}$)	*p*-value
Satisfaction with veterinarian [1 = very good −5 = insufficient]	73	r_S −0.320	0.006
Decision-making with veterinarian [1 = never −5 = always]	73	r_S 0.366	0.002
Herd visit (in-)dependent of curative visit [1 = yes/2 = no]	73	r_S −0.363	0.002
Recording of the current state and setting goals [1 = yes/2 = no]	73	r_S −0.583	<0.001
Setting written goals [1 = yes/2 = no]	73	r_S −0.369	0.001
Establishing a cost-benefit analyses [1 = yes/2 = no]	73	r_S 0.494	<0.001
Financial added value [1 = fully applicable −5 = not applicable at all]	73	r_S −0.416	<0.001
Participation if VHHM fee is increased by 10% [1 = yes; 2 = yes, but reduced hours; 3 = no]	73	r_S −0.232	0.049
Farm size (number of animals lactating/dry)	73	r_P 0.051	0.671
Ranking: Importance of VHHM subjects (*n* = 73)		**Rank**	**Mean**
Fertility		1	1.40
Udder health		2	1.81
Claw health		3	2.79
Young stock health		4	2.97
Animal welfare		5	3.03
Nutrition		6	3.07
Herd data		7	3.33
Biosecurity		8	3.56
Farm economics		9	3.78
Facilities		10	3.90
Staff management/training		11	4.05

the more intense dairy farms were supported, the higher the probability of making decisions together with the veterinarian ($r_S = 0.366$, $p = 0.001$). Support was equally more intensive when the visit was independent of curative veterinary visits ($r_S = -0.363$, $p = 0.002$). Moreover, the scope of support correlated with the recording of current status ($r_S = -0.583$, $p < 0.001$), writing down goals ($r_S = -0.369$, $p = 0.001$), and use of cost-benefit analyses ($r_S = -0.494$, $p < 0.001$). The more intensive the support, the more likely the previously mentioned aspects were. Likewise, there was a significant correlation between financial added value and support scope ($r = -0.416$, $p < 0.001$).

The personal ranking of importance in the fields worked on during VHHM visits was led by reproduction (mean = 1.40) and closely followed by udder health (mean = 1.81). Staff management/training was evaluated as an area of low relevance (mean = 4.05) (**Table 7**).

Table 8 clarifies that nearly two-thirds (59.0%) of the veterinarians were satisfied with their current method of accounting for services provided as part of the VHHM program.

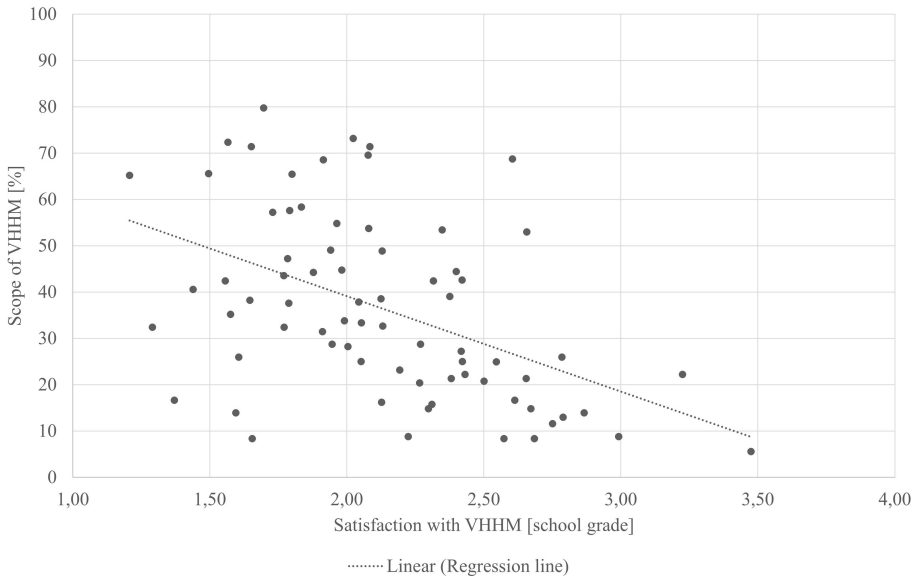

FIGURE 1 | Scatterplot: Scope/satisfaction with VHHM.

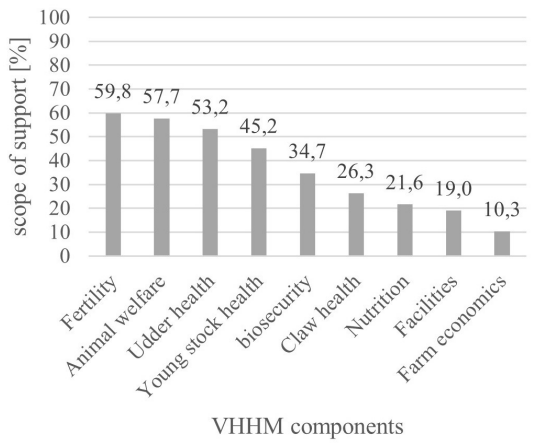

FIGURE 2 | Bar chart: Scope of VHHM subjects.

Charging by the hourly rate for services provided as part of the veterinarians' consultation and practical work was preferred (42.9%). Only 6.7% of the farmers would terminate VHHM services if the associated costs increased by 10% or more. Almost two-thirds of the participants would continue in the usual way under the previously mentioned conditions. The remainder would continue to use the VHHM service but reduce the number of hours. More than half of the participants indicated that their veterinarians' pre- and post-procedure hours were not billed. Only 21.2% of the respondents accounted for this time. When asked if VHHM generated added financial value on the farm, there was an average of agreement ("agree;" mean = 2.14).

Figure 3 shows that the participants in the survey placed a high value on the fact that explanations were given in an understandable language, as well as had the ability to listen actively and to spend enough time to answer questions. The fact that progress pays off in terms of effort and cost was provided an average rating of 2.14.

In order to outline the current VHHM quality on the farms (**Figure 4**), the participants were asked about the potential for improvement of the following aspects: topics, content and structure of a herd visit, consideration of farm-tailored goals, frequency of visits, use of cost-benefit analyses, consultation with other advisors, and comprehensibility of advice. The lowest mean value of these school grade ratings, and thus the highest consent, was "frequency of visits" (mean: 1.92) and the highest mean value, equaling lowest consent, was assigned to the use of cost-benefit-analyses for decision-making (mean: 2.68).

Non-participants in VHHM

Only four participants had used VHHM in the past but later abandoned it because they were either dissatisfied with the outcome, found the tariff too high, or considered the high time commitment unreasonable. The fourth participant cited a "change of veterinarian" as the reason for quitting VHHM.

Only 12.7% of non-VHHM farms were convinced that they do not need VHHM on their farms (**Table 9**). Just over half were unsure, and one-third said they had a need but were not currently receiving herd health management services. The areas in which participants saw the greatest or highest need were hoof health, fertility, and udder health.

Two-thirds of the participating farms were not willing to pay the minimum hourly rate of $89.32 for veterinary consultation required by the German Scale of Veterinary Fees (GOT).

TABLE 8 | VHHM: Accounting method.

Satisfaction with current accounting method *(n = 83)*		***n***	**%**
Overall satisfied		49	59.0%
Hourly rate (including all advisory and practical services performed)		47	56.6%
Hourly rate (practical services are charged extra)		16	19.3%
Fixed rate per animal and year		7	8.4%
Module form		5	6.0%
Total pack/flat rate for farm		7	8.4%
Success fee		1	1.2%
Desired accounting method *(n = 84)*		n	%
Hourly rate (including all advisory and practical services performed)		36	42.9%
Hourly rate (practical services are charged extra)		15	17.9%
Fixed rate per animal and year		6	7.1%
Module form		3	3.6%
Total pack/flat rate for farm		14	16.7%
Success fee		10	11.9%
Further participation if VHHM fee is increase by 10% *(n = 75)*		n	%
No		5	6.7
Yes	With reduced number of hours	22	29.3
	With same number of hours	48	64.0
Accounting for veterinarian's preparation and follow-up time *(n = 85)*		n	%
No, not accounted for		48	56.5
Yes, accounted for:	Separately	12	14.1
	Not separately	6	7.1
Unknown		19	22.4
Financial added value through VHHM	*(n = 48)*		Mean = 2.14

The majority (89.6%) of the farms were only served by one veterinary practice. Other veterinarians served the remaining farms mainly for support in herd fertility management (8 out of 11) and medication purchases (9 out of 11).

Non-veterinary consultants were present in 71.7% of the farms surveyed and were consulted mainly for feeding advice (88.2%) or were active as inseminators for the Cattle Breeders Association (61.8%).

With regard to the reasons for not using VHHM, two different "farm types" were identified using latent class analysis (**Table 10**). The Gamma estimate of belonging to class one was 0.7863, while that of belonging to class two was 0.2137. In class two farms, the associated farmers tended to manage larger farms and at the same time were more likely to be dissatisfied with their current veterinarians. At the same time, it was striking that almost all these farms saw a need for veterinary care and had a significantly higher willingness to pay the GOT minimum hourly rate for this. By contrast, type one farms were smaller farms that did not see the need for VHHM and were also not willing to pay the GOT minimum hourly rate. The main model selection criteria are shown in **Table 11**.

A comparison of VHHM-participants with the two LCA classes of non-VHHM participants, is outlined in **Table 12**. Farmers that do not participate in a VHHM but are interested (LCA class 2) have larger farms than those that do not participate and are not interested (LCA class 1). At the same time, those that do not participate but are interested in a participation (LCA class 2) are more dissatisfied with the current farm veterinarian, than the ones participating in VHHM and the ones without interest in participation (LCA class 1).

DISCUSSION

This study aimed to gain insight into the status quo of the currently practiced VHHM in Germany since the related study situation in this nation is scarce. Half of the study participants took part in the VHHM.

According to the Federal Statistical Office of Germany, 57,322 dairy farms in the entire country have already been registered in 2020 (42). Thus, the participation of 216 farms represented 0.38% of the population of dairy farms. Questionnaire dropouts were reviewed and showed slightly more VHHM participants who did not complete the questionnaire. The reason for this could be the more time-consuming questionnaire for this group of participants. The amount of fully completed questionnaires were divided about half each into VHHM-participants and non-VHHM-participants.

The fact that the survey was exclusively accessible online provides a reason to believe that selection bias was present. To avoid further bias, the survey was intentionally not advertised during veterinary visits to avoid weighting the specific practices

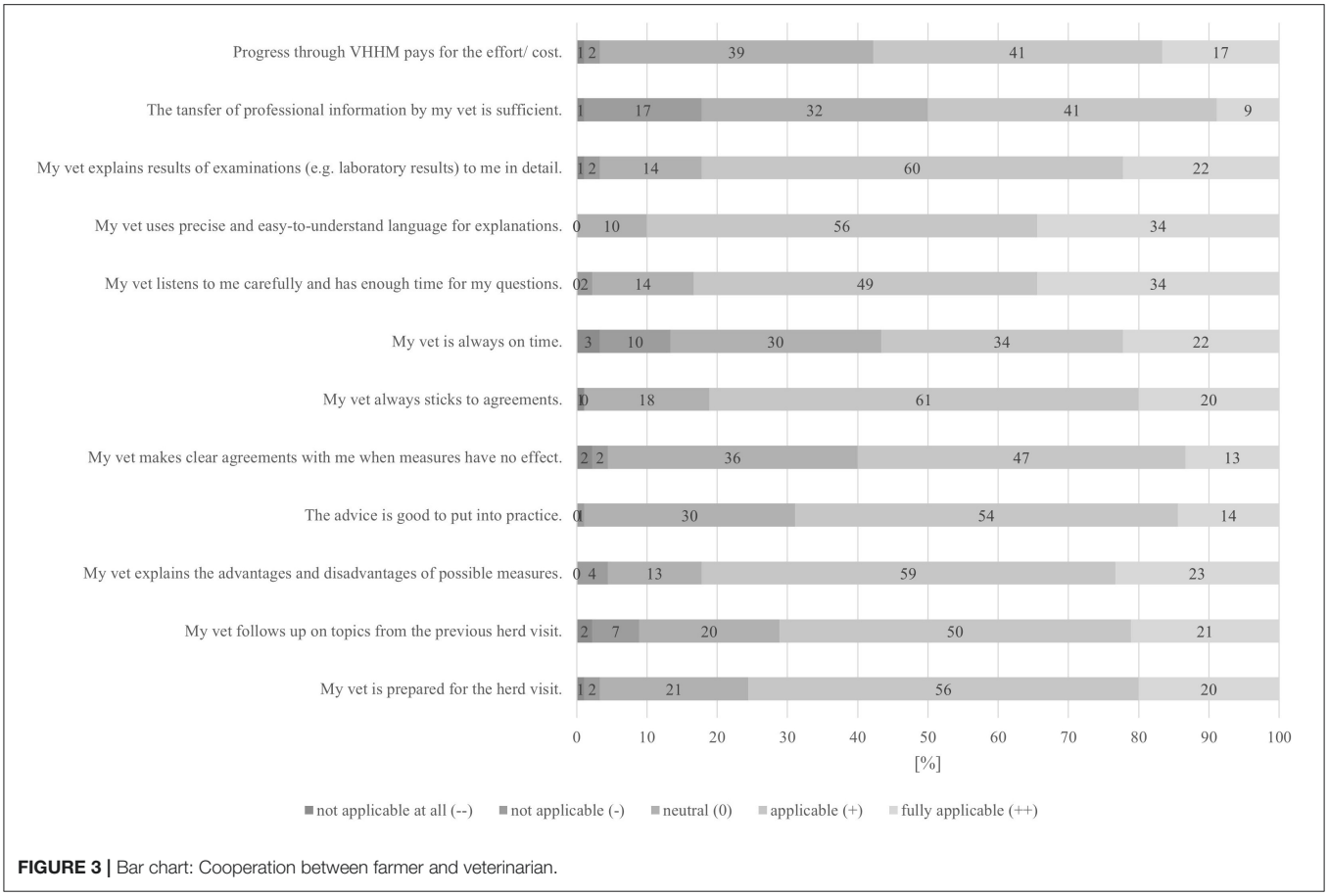

FIGURE 3 | Bar chart: Cooperation between farmer and veterinarian.

of VHHM. However, online recruitment only targeted dairy farms with email addresses and membership in association mailing lists or access to social media. An equally large factor was the participant's personal affinity for online media and their own motivation for the relevant topic (43). There was also a discrepancy between the mean number of lactating and dry cows per farm in our study and the 2020 nationwide average of dairy and dry cows (42, 44). This is not unexpected, as a previous study also showed a change in study participants, from smaller farms to larger farms (30). This can be explained by the fact that larger farms tend to be more proactive and, thus, more likely to show interest in current topics and to conduct surveys related to these topics (45). Consequently, this fact could lead to an overestimation of the proportion of VHHM program participants. In order to make a representative statement about the target group, a larger-scale follow-up study would be one way to get to the bottom of this research question. The study undoubtedly contains a certain bias, also due to the relatively extensive questionnaire. Therefore, the representativeness for Germany must be evaluated especially against this background. The transferability to other countries probably behaves in such a way that the type of dairy farming should be similar, and this depends on the respective farm structure. Nevertheless, Germany, as one of the leading dairy farming nations worldwide, offers a good cross-section in this field, as the country is very diverse in terms of farm structure. With this in mind, it can be assumed that the results of this study provide a good point of reference, especially for northern and western European countries, where similar studies were conducted before (13–18, 46). With regard to the legal basis, all EU member states are now facing the immediate implementation of the animal health law. Regarding the development over time, it is more of an outlook than a retrospective, as the latest change in the law is likely to be structurally significant.

Participation in the survey was explicitly voluntary and anonymous, but the results must nevertheless be interpreted against the background that participants tend to give a distorted picture of themselves (47). Specially in the case of the queried performance parameters, there could be a deviation from reality, as the farm might have been portrayed better than it is. To prevent this, we indicated in the introduction to prepare the current MLP in advance and provided participants with the exact page and field reference in this document where they would find the required data for the upcoming questions. Owing to this indication and the guaranteed anonymity, we assumed that the information provided was mostly valid.

Participants vs. Non-participants in VHHM

The participants were deliberately not given a definition of VHHM in the introduction to prevent inhibited participation

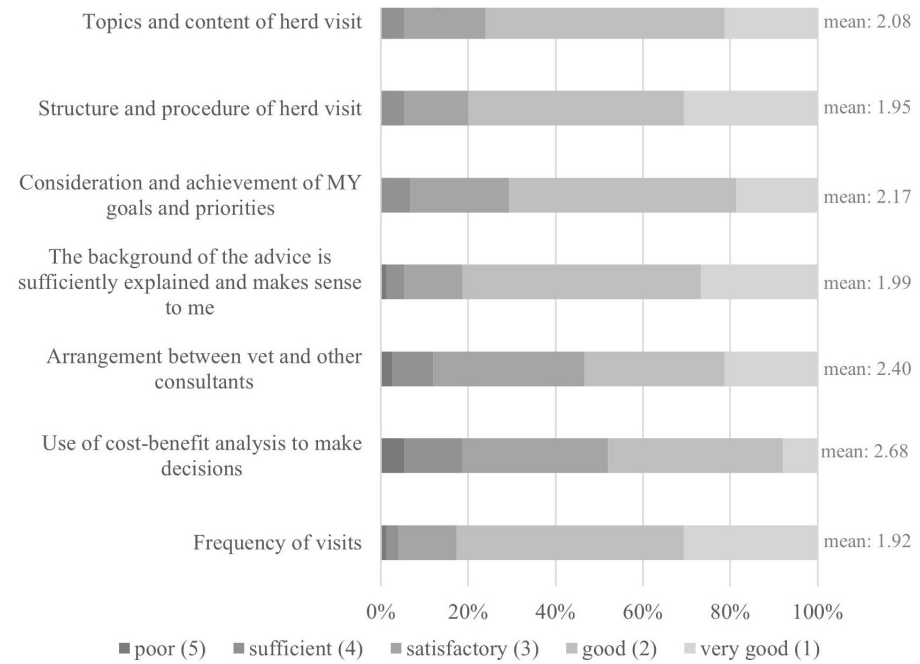

FIGURE 4 | Bar chart: Quality of current VHHM.

or supposed misperceptions. However, due to the resulting freedom of interpretation, the participants may have felt that they belonged to the wrong group. This could also explain the high proportion of VHHM farmers whose relative importance was mostly weighted toward regular pregnancy examinations and advice on reproduction, which does not justify the actual idea of a holistic approach to herd management (48). Of the non-VHHM respondents, 40% also interpreted VHHM as a purely reproduction-related service, although an equally large proportion understood it as a means to solve herd problems. Veterinarians should therefore provide targeted and proactive education in order to show the entire spectrum of opportunities that VHHM can offer.

Farms that participated in the program may be positive prospects in the future. VHHM farms were more likely to be willing to expand, while non-VHHM farms were more likely to stop dairy farming. Performance data confirmed this impression, as VHHM farms were larger on average with, for example, higher milk yields and lower AFC, implying a better overall production. This has already been shown in a previous study (26). However, it remains difficult to discern in our study whether VHHM is the cause or effect of this difference.

It is also necessary to differentiate the personnel structure in studied farms: in the literature, the specification of cows per full-time equivalent (FTE) (total number of hours worked by a full-time employee) is common to quantify the efficiency of labor. The cows/FTE ratio has been increasing over the years, possibly because of this labor-intensive enterprise and shortage of workers (49). A study in Michigan, USA, reported a range of 25–105 cows per FTE (50), while a study in California, USA reported a ratio of 82 cows per employee, for smaller farms below 250 head, to 151 cows per employee, for farms with more than 700 cows (51). In our sample, the data were within this range. The staffing ratio, based on the total number of animals in the herd, differed by 10% for VHHM and non-VHHM farms. However, the number of lactating and dry cows per employee was very similar between the two groups. Therefore, in contrast to the study mentioned above, the farm size factor, which would result from the tendency of larger farms to participate in VHHM, seemed to play a minor role in our sample. The variation between the staffing ratio for the total number of animals and that for lactating and dry cows could nevertheless be due to a stronger focus on dairy cows and/or a higher degree of digitization on the VHHM farms. A wider staffing ratio implies better labor efficiency; however, it remains unclear how a larger ratio affects animal welfare and/or performance.

Participants in VHHM

The result of the two motivation questions for participation in VHHM was congruent: the highest priority for the dairy farmers was the health status of their performing herd. Thus, the pure increase in performance or profit maximization was not given a priority, which is an important signal, especially in view of the critical consumer voices with recurring public discussions as a reflection of the farmers' mindset. The study participants felt primarily committed to maintain the health of their animals; in the long run, this approach also comes to the right conclusion: only a healthy herd and a healthy animal can

TABLE 9 | No VHHM participation: Descriptive data.

Previous participation in VHHM ($n = 106$)			***n***	**%**
Yes			4	3.8%
No			102	96.2%
Need for VHHM? ($n = 102$)			*n*	%
Yes			36	35.3%
Unsure			53	52.0%
No			13	12.7%
… if "yes"/"unsure": conceivable need in …? ($n = 8$	**Yes**		**No**	
	n	%	*n*	%
fertility	46	51.7%	43	48.3%
Udder health	45	50.6%	44	49.4%
Performance/evaluation of herd data/digitalization	25	28.1%	64	71.9%
Claw health	51	57.3%	38	42.7%
Young stock health	18	20.2%	71	79.8%
Nutrition	29	32.6%	60	67.4%
Facilities/animal husbandry	15	16.9%	74	83.1%
Biosecurity	18	20.2%	71	79.8%
Farm economics	17	19.1%	72	80.9%
Animal welfare	19	21.3%	70	78.7%
Staff management/training	13	14.6%	76	85.4%
Willingness to pay minimum hourly rate according to GOT ($n = 106$)	*n*	%		
Yes	35	33.0%		
No	71	67.0%		
Number of consulting veterinary practices ($n = 106$)	*n*	%		
1	95	89.6%		
2	11	10.4%		
Performance of above-mentioned additional practices ($n = 11$)			**Yes**	**No**
	n	%	*n*	%
Fertility	8	72.7%	3	27.3%
Drug purchase	9	81.8%	2	18.2%
Nutritional advice	1	9.1%	10	90.9%
Non-veterinary advisors ($n = 106$)	**Yes**		**No**	
	n	%	*n*	%
	76	71.7%	30	28.3%
Nature of the abovementioned non-veterinary advice ($n = 76$)				
Nutritional advice	67	88.2%	9	11.8%
AI technician/cattle breeder association	47	61.8%	29	38.2%
Agricultural advisor	16	21.1%	60	78.9%
Animal health service	11	14.5%	65	85.5%
Dairy/department of quality management	25	32.9%	51	67.1%
Regional advisory board	25	32.9%	51	67.1%

unfold its potential and perform accordingly. Since the genetic selection for performance may be viewed critically from the perspective of animal welfare (52), maintaining the health of individual animals is a basic element of dairy cow husbandry and is the key aspect of animal welfare (53). Other studies are in agreement with the latter observations, as one study stated that the most important attribute of their survey was the statement of a livestock farmer: "To feel happy knowing that my dairy cows are well-kept" (54). Another study also found, that animal welfare was valued most, compared to pure increase in milk production (16). The results of the ranking question on relative importance of subjective VHHM definition and motivation to participate in a VHHM program contrast with each other to a certain extent: All participants rated "pregnancy checks/consultation on reproduction" highest, while "identifying and addressing current herd health problems" was rated lower, whereas the question about motivation of participation reveals it the other way around. It is possible that then farmers' actual understanding (reflected in the ranking question) is the current practice they experience, while the answer to the question about

TABLE 10 | No VHHM: Latent class analysis.

LCA model: 4 variables −2 classes (AIC: 125.02; BIC: 180.14; Adjusted BIC: 113.81; Entropy: 0.73)		
Class membership probabilities: Gamma estimates (standard errors)		
Class	1	2
	0.7861 (0.0739)	0.2139 (0.0739)
Item response probabilities: Rho estimates (standard errors)		
Herd Size		
Small (<70 cows)	0.3025 (0.0550)	0.2186 (0.1152)
Rather small (70–120 cows)	0.2849 (0.0529)	0.1916 (0.1024)
Rather big (121–251 cows)	0.2198 (0.0489)	0.3365 (0.1201)
Big (>251 cows)	0.1928 (0.0479)	0.2533 (0.1137)
Satisfaction with vet		
Very good	0.2807 (0.0550)	0.2069 (0.1205)
Good	0.5908 (0.0598)	0.2169 (0.1543)
Satisfactory	0.1137 (0.0389)	0.2678 (0.1155)
Sufficient	0.0145 (0.0154)	0.1737 (0.0934)
Poor	0.0003 (0.0022)	0.1348 (0.0817)
Possible need of VHHM		
Yes	0.1864 (0.0718)	0.9549 (0.0792)
Unsure	0.6525 (0.0702)	0.0390 (0.0756)
No	0.1610 (0.0429)	0.0061 (0.0242)
Willingness to pay the minimum GOT hourly rate		
Yes	0.2635 (0.0543)	0.6310 (0.1400)
No	0.7365 (0.0543)	0.3690 (0.1400)

TABLE 11 | No VHHM: LCA-Model selection based on AIC.

	4 variables **- herd size, - satisfaction with vet, - possible need of VHHM, - willingness to pay**	***5 variables*** **- herd size, - satisfaction with vet, - possible need of VHHM, - willingness to pay, - presence of non-veterinary consultants**
2 classes	125	196
3 classes	131	197
4 classes	144	207

motivation to participation reflects their theoretical conception or desires of this type of support. Furthermore, it is possible that the motivation of participation for veterinary support puts more focus on (herd) health, because the "health aspect" gives a medical professional a certain monopoly in the minds of farmers, while pregnancy checks or similar could also be performed by other professionals such as AI technicians.

Animal health was also reflected in the subjectively perceived benefits: all participants provided similar ratings to the benefits of VHHM. Early problem detection was identified as the greatest benefit, closely followed by improved herd health. As previously confirmed, farms regarded the threat of operational blindness without external input as an important factor (36). This goes hand in hand with the motivation mentioned above, as VHHM can be valuable because of the external view of the veterinarian. Similar to our results of the motivation and advantage question, a study in the UK found, that the main advantage for participating in VHHM was "Improving health and welfare of the animals" (46). Finally, the veterinarian is one of the most important advisors in a farm (30). In contrast to other studies (36), the perceived disadvantages did not seem to matter much: these were all rated as "neutral" to "does not apply." As discovered before (17), high costs were still the most important issue, although in our study this cannot be judged as such, due to the weak or neutral ratings. Similar to a previous study (46) the time needed for a VHHM program was also a highly ranked disadvantage. Nevertheless, veterinarians should always address the problems related to the invested costs and, more importantly, show the benefits of making the advantages of VHHM transparent.

As mentioned above, most participants understood that VHHM equals support in "herd reproduction." This is also reflected in the fulfilled expectations of veterinarians because the area of "fertility" is treated as a priority in the vast majority of farms. For example, the hidden costs of up to 230$/cow/cow/year in the case of poor fertility management confirm the importance of the topic (55); nevertheless, future studies may not only focus on VHHM as a single topic. The goal is to approach all production areas of the entire farm. In a publication by a veterinarian from Israel, one of the world's leading countries in dairy farming, the development of production diseases was also described as a consequence of mismanagement due to a ruthless desire to increase performance. VHHM is designed to buffer mismanagement and thus enhance production under optimal regimens (56). In terms of economic impact, hoof health, young stock rearing, and cow comfort (23, 57–59) are areas with high economic impact but are less considered in VHHM. It can be debated whether employee management or farm economics falls within the scope of practice of a veterinarian; nevertheless, it was covered by some practices. In the future, such an offer or cooperation, including experts in this field, could be conceivable.

As mentioned before, the relationship between animal owners and veterinarians is a working relationship of a special kind. Intensive collaboration with a high degree of professionalism under tight economic conditions and sometimes emotionally charged situations, due to the unpredictability of working with living creatures and the high daily workload, characterize this trusting relationship (60). Therefore, it is immensely important that the basis between individuals is correct;

TABLE 12 | Comparison: VHHM-participants and non-VHHM participants with interest in participation.

		Participants in VHHM ($n = 106$)	Non-participants in VHHM	
			LCA class 1 ($n = 86$)	LCA class 2 ($n = 24$)
Herd size [# lactating/dry cows]	Mean	217.5	187.3	202.6
	Median	130.0	100.0	178.5
General satisfaction with herd veterinarian [school grade]	Mean	1.92	1.83	2.92
	Median	2.00	2.00	3.00

otherwise, the construct is not very promising. Researchers from the Netherlands validated this in their study: "Because VHHM is based on preventive advice, the strength of the relationship is an important contributor to the success of VHHM" (26).

The tendency of medical professionals to use medical language when talking to non-medical people does not seem to apply to veterinarians in VHHM. After all, the participants rated their veterinarians best at this point. It is likely, that the participants' agricultural education background and the close relationship and thus, resulting loyalty, constituted a basic satisfaction with the farm veterinarian of the participants in our study.

In their own perceptions, the study's animal owners considered themselves reliable. After all, 80% of the participants said that they followed the advice of the veterinarian. This contrasts with the results of other studies; for example, only 50% of the participants implemented the recommended veterinary measures (12, 19, 33). The answers of our survey and thus, resulting difference with the studies mentioned above may be due to the phenomenon of "socially desirable responding" by participants of a survey (47).

Veterinarians have the potential to influence the quality of the current VHHM. For example, including cost-benefit analyses in their advice, such calculations are useful for any type of new investment in an economically tight field such as dairy farming. Also, not to be neglected is the survey participants' dissatisfaction in the cooperation between veterinarians and other consultants. A collaboration between dairy farmers and all advisors involved is more likely to succeed, than without said communication.

Overall, dairy farmers showed good satisfaction with VHHM, which also coincided with the results of other studies (16, 61). It can be assumed that intensive and long-term collaboration between veterinarians and animal owners has been maintained for years. Consequently, VHHM satisfaction also correlates with VHHM scope. Intensive herd management can keep many aspects overlooked at the same time, and thus a farm is more likely to reach its potential. Furthermore, it is not surprising that decision-making correlated with satisfaction, because a trusting relationship with the veterinarian strengthens regular exchange and thus indirectly regular consultation (29). If decisions must be made, the farmer is happy to consult the veterinarian.

Only the costs of VHHM were viewed critically. As mentioned above, the participants saw the costs as the greatest disadvantage of the VHHM, and their dissatisfaction with the accounting system was correspondingly high. Only <60% of the participants were satisfied with the current form of accounting. This could again be due to the financial difficulties of dairy farming. More than half were accounted for *via* a fixed hourly rate, including all services, the fewest *via* a performance-independent payment. However, the latter would be more desired, possibly to have financial security as a farm and at the same time calculable fixed costs. Here, it would be interesting to determine how high the veterinary costs of individual participants are and whether conclusions can be drawn from it on the (desired) accounting form. In principle, the cost shares of total production for veterinary measures are well-described (62, 63); hence, the conduct of cost-benefit analyses is strongly recommended to show farms the benefits of the invested VHHM costs.

Nevertheless, the participating farms appreciated the added value of VHHM. This was clearly demonstrated by the fact that not even 7% would stop participating despite the increase in the in the VHHM service fee. In 20% of the participants, the time invested by the veterinarian outside of the time for the management on-farm for VHHM was accounted for; this would be a possible approach that can be used in the future in the field of veterinary practice. At least there is recognition from the dairy farms, as they feel it is true that the VHHM offers them added financial value. However, it remains difficult to evaluate the different veterinary consulting activities included in monetary terms, since the indirect economic impact and positive financial impact of disease prevention and improvement in animal welfare is highly complex to monetarize and is additionally of great lag, since it can only be observed at a later time.

The calculated scope of VHHM showed once again that the claim of a holistic approach has not been implemented to a sufficient extent so far and that veterinarians can exploit the existing potential based on the quality they offer. Even if the indicated activities of a VHHM veterinarian do not necessarily involve providing a quality VHHM service, the most important message is that only one-third of the possible VHHM components were included. None of the respondents achieved 100% of the components; however, as mentioned, the bar was also set high. The cause could be insufficient supply on the part of the veterinary profession, but it could be a lack of adoption by farmers given the existing supply. However, further research is needed to examine the specific

cause. The scope is strongly correlated with the recording of current status and goal setting. It is recommended to perform a SWOT analysis, agree on goals, write them down, and work toward them (64). Since the scope did not correlate with the size of the farm, these measures are not an attribute of a larger and therefore supposedly well-organized farm; however, a farm of any size can carry out a VHHM of any degree. Notably, the more intensively a farm was managed, the more likely it was to perceive the financial added value of stock management.

Non-participants in VHHM

The respondents who have not participated in VHHM so far are an interesting target group for offering VHHM service in the future. Thus, one-third of the farmers said that there was a need, and only <10% denied this. More than half of the farmers were interested in support, especially in the areas of fertility and udder health. One-third of the dairy farmers would also be willing to pay the GOT hourly rate for consulting. With this in mind, veterinarians should realize that they can more actively promote VHHM, and farms that are not currently receiving support may just be doing so out of unawareness. On the contrary, the widespread growing shortage of veterinarians could also contribute to the problem, and willing farms cannot be adequately served. All others may not have had any contact with veterinary herd advice and therefore do not know the value of this service. Based on these values, the two groups crystallized in the latent class analysis. In group 2, one out of five dairy farmers provided a receptive target for VHHM. They tend to be larger in number and dissatisfied with their current veterinarian (**Table 12**) but are also willing to pay for consultative services. The root of this initially contradictive mindset is hard to assess but might be caused by either their own experience with previous veterinarians and through experience exchange with colleagues or the nationwide lack of large animal veterinarians with an offer of VHHM programs. Furthermore, a comparison of these farms with VHHM-participating farms shows, they are more similar in size than those, that are not interested in participating in VHHM (**Table 12**). Veterinarians should identify these farms and actively invest energy in marketing VHHM (24). As proven before, veterinarians lack of active promotion of their VHHM services (17).

CONCLUSION

In summary, the prevalence of VHHM in Germany in this small-scale study was 50%, whereas the overall reason for participating in VHHM was the dairy farmers' interest in the health of their animals. Many of the VHHM participants, mostly running larger herds with higher milk yields, joined this program to achieve herd fertility improvement, while non-participants were divided into those who would consider making use of a service and those who had no interest in participation. The most mentioned critical point was the costs related to the VHHM.

The overall satisfaction of German dairy farmers with their veterinarians was good, while the overall satisfaction rate of VHHM farms was better than that of non-VHHM farms; therefore, this rating provides a suitable basis for further cooperation.

Proactive farm support becomes unavoidable simply because of the recent changes in law. Ideally, the topics covered would extend further than herd fertility and udder health and would increasingly include claw health, young stock rearing, and animal welfare. If the veterinary profession will take advantage of this potential, for example, by cost-benefit analyses and written, farm-specific objectives, the associated benefits could be clearly presented. The VHHM could be expanded according to its intention to provide holistic support to the farm. In addition, this could facilitate future accounting for time invested away from the farm and demonstrate that the VHHM can add value to all sizes of farms. If veterinarians identify the highly receptive portion among non-VHHM farms, this provides a grateful target audience for a VHHM offering.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

In this study, no personal or sensible 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 was actively given by each participant. We refrained from seeking approval from an Ethics Committee as this was in line with German and European data protection laws.

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, K-EM, 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.

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- **Jenny Ries** *(first author)*
  - conception and design of the research task and hypothesis
  - developing of theoretical framework and preliminary model
  - developing of questionnaire
  - collection and evaluation of data
  - creation of the publications and manuscript
- **Katharina Charlotte Jensen** *(second author)*
  - close cooperation in data evaluation with statistical software
  - continuous support in developing of the publications
  - regular proofreading during creation of the manuscript
- **Kerstin Elisabeth Müller** *(co-author)*
  - advisor in designing of research task and questionnaire through practice-oriented advice
  - supervision during conduction and paper-writing process (e.g., proofreading of drafts)
- **Christa Thöne-Reineke** *(co-author)*
  - advisor in designing of research task and questionnaire through practice-oriented advice
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- **Roswitha Merle** *(last author; mentor of dissertation)*
  - leading supportive task in development of study design
  - support in preliminary statistical analyses and framework of questionnaire design
  - continuous supervision of collection and evaluation/ statistical analyses of data
  - regular proofreading of drafts before submission of manuscripts

Publication 2: “Impact of Veterinary Herd Health Management on German Dairy Farms: Effect of Participation on Farm Performance”

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

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

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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

Abbreviations: AFC, age at first calving; AMS, automatic milking system; BTSCC, bulk tank somatic cell count; CC, cross compliance; DIM, days in milk; EU, European Union; MLP, German DHI testing; MORT60DIM, mortality of cows in the period up to 60 days in milk; QM, German Quality Management Milk; RR, replacement rate; VHHM, Veterinary Herd Health Management; 305dMY, 305-day milk yield.

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 Milchviehhalter e.V.," "Deutscher Raiffeisenverband 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-Wunnies 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 ordinally 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

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
Mortality <60 days in milk	*n*	59	56
	25%	1.00	0
	Mean	5.47	4.89
	Median	2.00	2.50
	75%	8.00	5.00
	SD	6.82	6.57
	p-value		0.2527
Staffing ratio: total stock (no. of animals/staff)	*n*	106	110
	25%	54.59	48.00
	Mean	93.65	84.19
	Median	80.24	72.86
	75%	100.00	105.00
	SD	82.24	67.05
	p-value		0.3507
Staffing ratio: lactating/dry (no. of animals/staff) (no. of animals of productive part of herd—in lactation or in dry period—per staff)	*n*	106	110
	25%	30.00	26.00
	Mean	48.05	45.13
	Median	43.07	38.13
	75%	54.67	55.96
	SD	35.80	36.42
	p-value		0.3401

Survey among German dairy farmers on VHHM participation (n = 216). p-values were calculated using the Wilcoxon rank test.

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 2 | Descriptive data of decision-making with veterinarian.

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

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

bulk tank somatic cell count (BTSCC). The replacement rate (RR) reached the numerical maximum value within those who "occasionally" made decisions with the veterinarian, regardless of VHHM participation. The AFC was numerically lowest within the VHHM farms that answered "always" with 25 months.

Results in **Table 3** demonstrate that more than one-third of the VHHM farms and approximately one-quarter of the non-VHHM farms rated the question about satisfaction with their veterinarian with "very good." Numerically lowest 305dMY had non-VHHM farms that selected "sufficient" or "unsatisfactory. Analysis showed that non-VHHM farms that indicated "very good" had the numerically lowest BTSCC values. Non-VHHM farms reporting "sufficient" or "unsatisfactory" had the numerically highest BTSCC values, respectively. Regardless of the level of satisfaction with the veterinarian, the numerical values for AFC were between 25 and 26 months for VHHM farms and between 26 to 28 months for non-VHHM farms.

The mean comparison of the ranking question about their relative importance of the term "Veterinary Herd Health Management" (**Table 4**) showed that the numerically highest 305dMY was reached by the subgroup that ranked "herd data/strategy planning/economy" first. VHHM farms, which considered "problem-solving" in their definition of VHHM, had numerically lowest 305dMY.

In single regression models, only 305dMY and AFC showed significant associations ($p \leq 0.001$), and thus, multiple regressions were created for these variables. In multifactorial modeling for 305dMY, adjusted for herd size, region, breed, farm management, housing type, and staffing ratio, VHHM farms had a 660-kg higher 305dMY than non-VHHM farms (adjusted $R^2 = 0.6335$) (**Table 5**). Moreover, AFC on VHHM farms was 0.8 months lower than on non-VHHM farms when adjusted for the confounders written above ($p = 0.045$).

Participants in VHHM

Table 6 shows that, in the single regression analysis of the variables (VHHM scope, VHHM satisfaction, visit frequency) with the performance data (305dMY, AFC, BTSCC), only a significant correlation between 305dMY and VHHM scope could be found ($p = 0.039$). With each percent more VHHM scope the 305dMY raised by 18 kg. However, multifactorial modeling of the variables visit frequency, VHHM satisfaction, VHHM 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 VHHM. 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 VHHM 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.

Comparison of means: satisfaction with vet							
	VHHM	**305dMY (kg)**	**ECM (%)**	**BTSCC (×1,000/mL)**	**MORT60DIM (%)**	**RR (%)**	**AFC (months)**
Very good	Yes	*n* = 40 10,405	*n* = 40 23.11	*n* = 40 173	*n* = 25 5.08	*n* = 31 26.06	*n* = 40 25.8
	No	*n* = 30 8,433	*n* = 31 19.40	*n* = 31 168	*n* = 19 4.68	*n* = 20 25.20	*n* = 31 27.1
Good	Yes	*n* = 45 10,149	*n* = 44 22.39	*n* = 45 183	*n* = 22 6.50	*n* = 34 28.56	*n* = 45 26.1
	No	*n* = 52 9,297	*n* = 52 20.78	*n* = 45 172	*n* = 26 5.54	*n* = 39 28.15	*n* = 54 26.8
Satisfactory	Yes	*n* = 14 9,762	*n* = 14 21.58	*n* = 14 169	*n* = 10 4.10	*n* = 11 28.82	*n* = 14 25.6
	No	*n* = 16 9,464	*n* = 15 20.77	*n* = 16 195	*n* = 4 6.00	*n* = 10 29.70	*n* = 16 28.4
Sufficient	Yes	*n* = 4 8,950	*n* = 4 20.10	*n* = 4 157	*n* = 1 10.00	*n* = 4 35.00	*n* = 4 25.5
	No	*n* = 5 8,070	*n* = 5 18.01	*n* = 5 240	*n* = 4 3.25	*n* = 3 19.67	*n* = 5 26.6
Unsatisfactory	Yes	*n* = 3 11,767	*n* = 3 26.30	*n* = 3 175	*n* = 1 2.00	*n* = 2 20.50	*n* = 3 26.7
	No	*n* = 4 8,063	*n* = 4 19.37	*n* = 4 218	*n* = 3 1.33	*n* = 4 30.75	*n* = 4 28.0

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

Comparison of means: definition of VHHM—rank 1							
	VHHM	**305dMY (kg)**	**ECM (%)**	**BTSCC (×1,000/mL)**	**MORT60DIM (%)**	**RR (%)**	**AFC (months)**
Pregnancy checks and support in reproduction	Yes	*n* = 53 10,166	*n* = 52 22.60	n = 53 170	*n* = 28 4.61	*n* = 39 27.74	*n* = 53 25.9
	No	*n* = 43 9,325	*n* = 43 20.96	*n* = 44 171	*n* = 25 3.88	*n* = 29 27.00	*n* = 44 27.4
Problem solving	Yes	*n* = 33 10,213	*n* = 33 22.46	*n* = 33 194	*n* = 22 6.59	*n* = 27 27.44	*n* = 33 25.7
	No	*n* = 45 8,417	*n* = 43 19.29	*n* = 45 179	*n* = 21 4.76	*n* = 32 28.03	*n* = 45 27.2
Herd data/strategy planning/farm economy	Yes	*n* = 20 10,241	*n* = 20 22.73	n = 20 163	*n* = 9 5.44	n = 16 28.38	*n* = 20 26.3
	No	*n* = 19 9,513	*n* = 21 20.47	*n* = 21 197	*n* = 10 7.70	*n* = 15 26.73	*n* = 21 26.4

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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 the data were collected by questionnaire. There were no farm visits, 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: 305*d*MY (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						
Degrees of freedom = 159				$p = 0.001$		
Multiple $R^2 = 0.6552$				Adjusted $R^2 = 0.6335$		
	Minimum	**25%**	**Median**	**75%**	**Maximum**	**Standard error**
Residuals	−1992.5	−768.2	−51.0	671.0	2953.2	1,102
			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: *A*FC (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						
Degrees of freedom = 164				$p = 0.001$		
Multiple $R^2 = 0.3476$				Adjusted $R^2 = 0.3158$		
	Minimum	**25%**	**Median**	**75%**	**Maximum**	**Standard error**
Residuals	−5.03	−1.36	−0.06	1.17	17.87	2.43
			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

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themselves (43). 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

TABLE 6 | VHHM participants: single/multiple regression models survey among German dairy farmers on VHHM participation ($n = 216$).

Single regression models						
***p* Value**	**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: 305*d*MY						
305dMY ~ VHHM scope (Analysis of depending variable "305dMY" with influencing variable "scope")						
Degrees of freedom = 71 Multiple $R^2 = 0.05855$				$p = 0.03916$ Adjusted $R^2 = 0.04529$		
	Minimum	**25%**	**Median**	**75%**	**Maximum**	**Standard error**
Residuals	−161.74	−47.74	−9.24	31.26	186.76	70.98
			Estimate	**Standard error**	***t*-value**	***p*-value**
305dMY (VHHM scope)			9,597.90	361.08	26.58	<0.001
VHHM scope			18.34	8.73	2.10	0.0392
Multiple regression model: 305*d*MY						
305dMY ~ visit frequency + VHHM satisfaction + VHHM scope + herd size + conventional/organic + husbandry system (Analysis of depending variable "305dMY" with influencing variables)						
Degrees of freedom = 47 Multiple $R^2 = 0.4489$				$p = 0.0002413$ Adjusted $R^2 = 0.3551$		
	Minimum	**25%**	**Median**	**75%**	**Maximum**	**Standard error**
Residuals	−2,413.63	−790.83	−70.86	839.75	2,055.16	1,163
			Estimate	**Standard error**	***t*-value**	***p*-value**
305dMY (visit < 1×/month + VHHM satisfaction + VHHM scope + herd size + conventional + free stall)			9,600.81	1,148.71	8.36	<0.001
Visit 1×/month			−61.99	371.33	−0.17	0.868
Visit > 1×/month			−344.31	442.22	−0.78	0.440
VHHM satisfaction			260.17	454.55	0.57	0.570
VHHM scope			13.61	9.23	1.48	0.147
Herd size			1.15	0.76	1.51	0.138
Organic			−2,078.33	726.54	−2.86	0.006
Free stall + pasture			−882.12	401.62	−2.20	0.033
Tie stall (+/− pasture)			−2,778.18	896.40	−3.10	0.003
Multiple regression model: *A*FC						
AFC ~ visit frequency + VHHM satisfaction + VHHM scope + herd size + conventional/organic + husbandry system (Analysis of depending variable "AFC" with influencing variables)						
Degrees of freedom = 47 Multiple $R^2 = 0.5197$				$p = 1.423^{-05}$ Adjusted $R^2 = 0.438$		
	Minimum	**25%**	**Median**	**75%**	**Maximum**	**Standard error**
Residuals	−3.11	−1.07	−0.19	0.97	2.75	1.56

(Continued)

TABLE 6 | Continued

	Estimate	Standard error	*t*-value	*p*-value
AFC (visit < 1×/month + VHHM satisfaction + VHHM scope + herd size + conventional + free stall)	28.09	1.54	18.29	<0.001
Visit 1×/month	−0.82	0.50	−1.65	0.105
Visit > 1×/month	−0.49	0.59	−0.83	0.410
VHHM satisfaction	−0.56	0.61	−0.92	0.361
VHHM scope	−0.02	0.01	−1.50	0.141
Herd size	−0.002	0.001	−2.05	0.046
Organic	5.32	0.97	5.48	<0.001
Free stall + pasture	0.11	0.54	0.21	0.834
Tie stall (+/– pasture)	1.66	1.20	1.39	0.173

possible explanation for the big amount of VHHM participants whose subjective definition leaned toward pregnancy checks, which does not symbolize the all-encompassing attempt (44).

All Participants

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.

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.

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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

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  - developing of questionnaire
  - collection and evaluation of data
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Discussion

The aim of this cross-sectional study was to assess the prevalence of Veterinary Herd Health Management on German dairy farms. The sample size was small compared to the possible total size of the target population and the response rate was 0.38%. The low rate must be regarded when assessing the results, as a representativeness of the target population is very unlikely. The reasons for this low response rate are manifold. The questionnaire was distributed exclusively online, e.g., by sending links via e-mail distribution lists of agricultural associations. Since participation was only possible with corresponding online access, it could be assumed that mainly people with an affinity to the internet and further motivation for this topic were addressed (Dillman 2000). When interpreting the results, it must also be taken into account that the average number of animals per farm was higher than the nationwide average (Federal Statistical Office 2020a, 2020b). The fact that previous studies could also prove this is possibly due to the fact that farm managers of larger livestock farms tend to be more proactive and interested in current affairs (Pennings et al. 2002; Derks et al. 2012). Half of all participants reported attending a VHHM program. Due to the bias discussed earlier, it is important to consider that this proportion may have been overrepresented in the study.

The participants' answers must also be evaluated against the background that questionnaires are always answered subjectively. Despite guaranteed anonymity, participants tend to present a better picture of themselves (Bensch et al. 2019). Particularly in the case of the operating figures used for a benchmark, an attempt was made to prevent this problem by having asked the participants at the beginning to have the current MLP at hand and having provided them an exact page where required values could be found. Therefore, it was assumed that the data basis was as representative as possible.

All Participants

Intentionally, no definition of VHHM was provided in the self-assessment of VHHM participation, in order not to prevent people from participation. Nevertheless, this freedom of interpretation leads to a possible share of erroneous grouping. A possible reflection of this problem could have been the large proportion of participants who weighted the subjective definition primarily on pregnancy examinations and veterinary service in herd fertility. This understanding did not do justice to the all-encompassing approach of a VHHM program, which is why the answers must be reflected against this background (Kruif et al. 2014). Since 40% of the non-VHHM participants also understood VHHM as a service in the field of herd fertility, it is particularly important to emphasize the all-encompassing approach when advertising this veterinary service so that interested parties can evaluate the entire spectrum.

It was also found that farms supported by a VHHM program had on average a larger number of animals than the non-VHHM participants. The result of the question about future plans in the next ten years could be related: a larger share of the VHHM-participants stated that they planned to continue as before or to grow. A possible conclusion of both results could be that VHHM participants are more proactively and visionary and experience the current development of structural change (Federal Statistical Office 2021). At the same time, the two groups showed significant differences in performance: for example, in multifactorial modelling, milk yield was 660kg higher in herds participating in VHHM, while AFC was one month earlier. Economic conditions force on-farm management to optimize production conditions, so it could be assumed from the combination of the results above that VHHM participants implemented these better. This was also supported by the results that those farms discussed animal health issues more frequently with the veterinarian and in parallel indicated a higher level of satisfaction with the veterinarian.

The results on the staff structure on the farms showed descriptive differences. However, it must be reflected that data collection was complicated by the limitations of a questionnaire format. Due to an unexpectedly high amount of incomplete data in that area, the study results under this heading were not given the attention originally planned to avoid confounding. The

aim of further research could therefore be to focus on the personnel structure of German dairy farms, as this resource may be a factor that determines success.

VHHM Participants

The results on the motivation to participate in a VHHM program showed that the health of the herd was most important to the participants and pure economics were rather secondary. The approach of placing animal health and welfare in the focus of production speaks for the sustainable mindset of those dairy farmers and has already been proven in previous studies (Kristensen and Enevoldsen 2008; Hall and Wapenaar 2012). Also, perceived benefits of participation go hand in hand with a potentially more proactive approach of VHHM participants compared to non-VHHM participants: veterinary support was seen as a tool to preserve operational blindness, as shown before (Lievaart et al. 2008). The awareness of this potential hazard reflects the proactive mindset of those farm managers. Subjectively perceived disadvantages were of little importance in this study, although the cost and time involved should not go unmentioned, and were similarly documented in previous studies (Hall and Wapenaar 2012; Svensson et al. 2018). The results on satisfaction with the billing method showed that the way of billing may be addressed by veterinarians on farms, if necessary, as only about half were completely satisfied with the method itself. Not only because economic constraints demand it, but also to make the success of advice monetarily quantifiable, it would be advisable for veterinarians to use cost-benefit analyses. According to the survey, the use of cost-benefit analysis is still in need of improvement, despite the fact that there is sufficient literature on veterinary costs in the dairy sector (Liang et al. 2017). Nevertheless, only 3% of VHHM-participants disagreed with the statement "Progress through VHHM pays for the effort/cost", so the cost issue is of legitimate interest, but does not seem to be all-important. This is also supported by the fact that <10% of the participants would stop participating in VHHM if the costs were increased. However, the economic aspect also included the finding that only one in five farmers is charged for off-farm time. The conviction that veterinary advisory services have as much value as curative practice is still in its infancy, so the veterinary profession has a lot of catching up to do here, especially compared to other industries where advice is charged by the minute. Cost-benefit analyses can be helpful in revealing this intellectual value, so that farmers invest in it out of good conviction.

To do justice to a sustainable approach, the farmer-vet team should emphasize the all-encompassing approach of the VHHM program in their cooperation. The VHHM scope of this study showed that on average only a third of all possible areas of support was utilized. Thus, regardless of farm type and size, a strategic cooperation approach is of immense importance (Cannas da Silva et al. 2006). In addition, the predominant focus, both in the understanding of the farmers and in the question of the extent of support, has so far been on herd fertility, while other, economically highly relevant areas (claw health, young stock rearing, etc.) were still in the background. Since today's husbandry systems are associated with the development of production-related diseases across all production levels, sophisticated management of all resources would serve to maintain the balance and may be the key to success (Nir Markusfeld 2003). Nevertheless, it should be kept in mind that the concept of a VHHM program is based on preventive measures. A solid cooperation in this economically tight and occasionally emotionally loaded field of tension requires a high degree of mutual trust (Crowe and Oxtoby 2019), because invested work and costs are often investments in the future and the benefit of measures is sometimes difficult to quantify (Derks et al. 2014b). Therefore, satisfaction with the working partner, here the veterinarian, is an important aspect of cooperation (Bard et al. 2019), which in our study was significantly higher among VHHM participants than among non-VHHM participants. It is questionable, but at the same time likely, that satisfaction and program participation were mutually dependent. Satisfaction with the VHHM program as such was also high, so that the results were in line with those of other studies (Kristensen and Enevoldsen 2008; Ritter et al. 2018).

A weak point of the study was that within the VHHM participants no correlation between scope of VHHM and herd performance parameters could be shown. This issue should be addressed

in the future because it would be desirable to see whether more intensive support is reflected in the performance potential of the herd. Reasons for the lack of effect in our study could be, on the one hand, the small sample size and, on the other hand, the purely theoretical data collection based on information from the questionnaire participants. How this could contribute to bias was discussed above. Based on the available results, however, it could be stated that the scope of VHHM support did not seem to be of primary importance.

Non-VHHM Participants

It is not new knowledge that the veterinary community has a lot of open potential in the marketing of VHHM programs (Svensson et al. 2018). Therefore, it should be of particular interest for them to get to know the group of non-participants better. After all, only less than 10% stated that they had no need for support through a VHHM program. The remaining 90% thus represented a receptive target group that could certainly be addressed with an offensive. Cost was also not an obstacle for at least one third of all non-participants, as they were willing to pay the hourly rate for veterinary advisory services indicated in the survey. The latent class analysis revealed that one in five of the non-participants showed strong interest and potential for implementing a VHHM program. The reasons why the respective veterinarian has not (yet) addressed this issue are innumerable. One possible reason is that the supervising veterinarian offers VHHM but shies away from a proactive attempt and approaching the farmer. Thus, if a farm manager does not address this issue himself in a conversation, there is silent coexistence in this area. Another reason could be the upcoming generation change in the field of farm veterinarians: The old generation has grown up and earned money with purely curative work, so that an interested farm that has been looked after by such a veterinarian so far simply has not yet had any contact with it. It is possible, however, that the problem of the outgrowing old generation will be replaced by the problem of the shortage of veterinarians in the coming generation, so that even then not everyone who is interested will experience the possibility of support. However, the members of the latent class with an active interest in support showed a similar farm structure to the VHHM participants, so that a marketing approach to these farmers could be promising. Practical veterinarians would do well to identify these receptive farmers within their clientele and approach them in the future.

„Nutzen der Integrierten Tierärztlichen Bestandsbetreuung in deutschen Milchviehbetrieben für die Tiergesundheit und das Tierwohl“

Zusammenfassung
Die Ergebnisse dieser kleinrahmigen Studie zeigten, dass etwa die Hälfte der Landwirte in deutschen Milchviehbetrieben an einem ITB-Programm teilnahm. Die subjektive Definition von ITB war in beiden Gruppen die tierärztliche Leistung im Bereich Herdenfruchtbarkeit, wie z.B. regelmäßige Trächtigkeitskontrollen, als ein allumfassender Ansatz. Die Landwirte gaben an, in erster Linie aus direktem Interesse an der Tiergesundheit zur Teilnahme motiviert zu sein. Eine multifaktorielle Analyse der Leistungsdaten von ITB-Teilnehmern und Nicht-ITB-Teilnehmern ergab, dass die Herde von ITB-Teilnehmern eine um 660 kg höhere 305-Tage-Milchleistung aufwies. Darüber hinaus war das Erstkalbealter jener Betriebe einen Monat niedriger als das der Vergleichsgruppe. Bei den ITB-Teilnehmern gab es dagegen keine Leistungsunterschiede, so dass in erster Linie die ITB-Teilnahme wichtig war und erst in zweiter Linie das Ausmaß jener. Bei den Nicht-ITB-Teilnehmern konnten mit Hilfe einer Latenten Klassen Analyse zwei Klassen identifiziert werden. Eine davon, in die jeder fünfte Landwirt fiel, hatte ein großes Interesse an einer Unterstützung durch ein ITB-Programm.

Die Ergebnisse dieser Studie können den Tierärzten eine gute Diskussions- und Argumentationsgrundlage für eine proaktive Vermarktung von ITB als tierärztliche Dienstleistung liefern. Gerade nach der gesetzlichen Änderung und Verpflichtung zur Teilnahme ist es wichtig, alle Landwirte mit ins Boot zu nehmen und durch eine maßgeschneiderte Unterstützung auf das bestmögliche Ergebnis abzuzielen.

Gegenstand weiterer Forschungsprojekte kann die detaillierte Analyse der Tiergesundheits- und Tierschutzsituation vor Ort sowie die charakterliche Bewertung des Landwirts sein, da die Literatur gezeigt hat, dass dies von großer Bedeutung sei. Anschließend kann dies mit den Ergebnissen der ITB-Teilnahme in Verbindung gebracht werden. Darüber hinaus könnte die genaue ökonomische Bewertung des Betriebes von Interesse sein, um auch unter diesem Gesichtspunkt greifbare Argumente zu haben.

Summary
The results of this small-scale study showed that about half of the farmers of German dairy farms participated in a VHHM program. The subjective definition of VHHM across both groups is service in herd reproduction, such as regular pregnancy checks, rather than an all-encompassing approach. Farmers reported being motivated to participate primarily out of interest in animal health. Multifactorial analysis of performance data of VHHM participants and non-VHHM participants revealed that VHHM participants had a 660kg higher 305-day milk yield. In addition, their age at first calving was one month lower than the comparison group. Meanwhile, within the VHHM participants, there was no difference in performance, so one conclusion was that primarily VHHM participation was important, and secondarily the extent of it. Within the non-VHHM participants, two classes could be identified by means of Latent Class Analysis. One of these, in which every fifth farmer fell, had a great interest in a support by a VHHM program.

The findings of this study can provide veterinarians with a good basis for discussion and argumentation for proactively marketing VHHM as a veterinary service. Especially after the obligation to participate due to legislation, it is significant to get all farmers on board and to achieve the best possible outcome through tailored support.

The subject of further research projects can be the detailed analysis of the animal health as well as animal welfare situation on site as well as the character evaluation of the farmer, since research showed that to be of great importance. This can subsequently be related to the possible success of VHHM programs. Furthermore, the exact economic evaluation of the farm could be of interest in order to have tangible arguments from this point of view as well.

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List of publications

- [Poster] Ries J., Jensen K.C., Müller K.-E., Thöne-Reineke C. and Merle R. (2021): Nutzen der Integrierten Tierärztlichen Bestandsbetreuung in deutschen Milchviehbetrieben. *DACH Epidemiologietagung 2021 - Bern (CH)*
- Ries J., Jensen K.C., Müller K.-E., Thöne-Reineke C. and Merle R. (2022): Benefits of Veterinary Herd Health Management on German Dairy Farms: Status Quo and Farmers' Perspective. *Front. Vet. Sci. 8*, 773779, doi: 10.3389/fvets.2021.773779
- Ries J., Jensen K.C., Müller K.-E., Thöne-Reineke C. and Merle R. (2022): Impact of Veterinary Herd Health Management on German Dairy Farms: Effect of Participation on Farm Performance. *Front. Vet. Sci. 9, 841405, doi: 10.3389/fvets.2022.841405*

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Declaration of Independence
I hereby confirm that I have written this thesis independently. I certify that I have used only the sources and aids indicated.

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