Aus der Tierklinik für Fortpflanzung
des Fachbereichs Veterinärmedizin der Freien Universität Berlin

Optimization of work processes on dairy farms considering calf management

Inaugural-Dissertation
zur Erlangung des Grades eines
Doktors der Veterinärmedizin
an der Freien Universität Berlin

vorgelegt von
Anne Hesse
Tierärztin aus Berlin

Berlin 2020
Journal-Nr.: 4192

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Gedruckt mit der Genehmigung des Fachbereichs Veterinärmedizin
der Freien Universität Berlin

Dekan: Univ.-Prof. Dr. Jürgen Zentek
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Deskriptoren (nach CAB-Thesaurus):
dairy cows, calves, quality controls, surveys, work routine, calf housing, calf production, training

Tag der Promotion: 01.07.2020

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1 INTRODUCTION

Quality assurance programs help companies and factories to improve and maintain process and product quality. Several such programs exist for a variety of industrial productions, such as the airline and automotive industry and human medicine. Key elements of such programs are protocols and standard operating procedures (**SOP**). Protocols are company specific and provide information on what to do in certain situations. The SOP within a protocol systematically describe how to do it (Barragan et al., 2016), providing the employee with clear instructions on how to perform a particular task (Amare, 2012). Such written instructions can manage variation that arises when multiple individuals perform tasks in different ways. Hence, quality of work performance and productivity are increased (Stup et al., 2006).

In contrast to the quality management in manufacturing and service industries, however, a model for quality assurance in agriculture and medical science is only starting to develop. Many farmers and veterinarians lack the awareness of strictly performed quality assurance programs, although they bear a major responsibility in the food chain (Windhaus et al., 2007). Critical topics, such as animal welfare and animal health are increasingly being discussed within the general public (von Keyserlingk and Hotzel, 2015; Almeida et al., 2015). For the past decades, the dairy industry has been experiencing a trend towards larger farms with more animals and workers per farm (USDA, 2018). An increasing number of farms rely on temporary labour and foreign work force (Bewley et al., 2001; Reynolds et al., 2013; Barkema et al., 2015) resulting in different challenges, such as communication difficulties (Stup et al., 2006) due to language barriers and insufficient training of the workforce (Barkema et al., 2015). New employees mostly receive training by co-workers and refer to them for gaining new knowledge (Sischo et al., 2019). Those farms can profit from the implementation of SOP (Cummins et al., 2016) as they provide direction, and improve communication and work consistency (Streyl et al., 2011). This leads to predictable results and increases workers' confidence (Stup, 2001; Erskine et al., 2015). Furthermore, errors due to misinterpretation or miscommunication can be minimized (Amare, 2012).

Standardization of work processes and regular training of the work force are indispensable, especially on large dairy farms that oftentimes employ workers with minimal or no farming background (Reynolds et al., 2013). However, on large dairy farms these employees are responsible for identification and treatment of sick animals (Espadamala et al., 2016). The dairy sector lacks a continuous and standardized scheme for diagnosis and subsequent treatment of health disorders (Espadamala et al., 2018).

Oftentimes, dairy farms struggle with continuous onboarding training for new employees due to high turnover rates (Rodriguez et al., 2018). Employee engagement is

directly impacted by management principles and processes (Medlin et al., 2014). Engagement and retention are important for these dairy farms to achieve lower turnover rates, but not well-known amongst the farmers (Durst et al., 2018). Effectively writing SOP requires special know-how and training but many farmers lack the expertise, the time or motivation to create SOP and protocols even though they are aware of the importance of a stringent quality management (Hesse et al., 2017, Falkenberg et al., 2018) and effective employee training (Román-Muñiz et al., 2007). This poses a chance for veterinarians to assist farmers in SOP creation and employee training. Specific and effective training develops skills and competencies of new and current employees and is considered a key factor of improved performance and productivity (Kilpatrick, 2000; Elnaga et al., 2013, Sischo et al., 2019). Communication and training are indispensable for implementing new practices on the farm (Sischo et al., 2019). To make sound decisions on animal health, employees need certain skills and knowledge. Knowing the reason behind a given protocol and understanding why the job needs to be completed in a particular manner helps workers to realize the importance behind their work and should be part of an effective training (Román-Muñiz, 2007).

Microlearning can be effective to impart knowledge and increase motivation of employees or undergraduate students (Gassler et al., 2014; Mohammed et al., 2018). Microlearning refers to short training or e-learning units that impart knowledge within small fractions (Mohammed et al., 2018). Cloud-based microlearning lessons provide fast and easy access to knowledge at the point of need. The lessons can be taken independently, unsupervised, and at any time. This allows the employee to complete the training in his or her own time and as many times as needed until a feeling of confidence and accuracy in work performance is created. Permanent training for employees is seen as an important measure on the farm to improve working conditions and to create a positive image to other farmers and milk buying companies (Martínez et al., 2018). Worker safety training is crucial to prevent employees from injuries. Hence, most dairy owners rely on “on-the-job-training”. Providing high quality training remains a challenge, particularly given the changing workforce demographics in the agricultural sector (Rodriguez et al., 2018). It has been shown that up to 60% of dairy employees work on the farm without ever having received any safety training (Juárez-Carrillo et al., 2017). Web-enabled mobile devices can help to address this challenge and provide individual training that is independent from time and place and adjustable to the need of each employee.

The objectives of this thesis were 1) to gain insight into the organization of work processes and employee training on German dairy farms, 2) to identify the most important challenges in SOP implementation and 3) to determine if online microlearning courses were

beneficial for teaching dairy personnel to successfully perform tasks related to dairy calf health.

2 PUBLICATION I

Survey of work processes on German dairy farms

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Published in:

Journal of Dairy Science, June 2017, Volume 100, Issue 8, August 2017, Pages 6583-6591

Please find the original article via the following digital object identifier:
https://doi.org/10.3168/jds.2016-12029

2.1 Abstract

The objective of this study was to conduct a survey to gain insight into the organization of work processes on commercial German dairy farms analyzing the use of standard operating procedures (SOP). Practices and routines were surveyed regarding the existence, creation, and use of SOP. A total of 250 survey forms were returned, and 248 could be used for final analysis.

The existence of SOP was indicated by 82% of all respondents, but only 54% stated that these SOP were written down. Existence of SOP correlated with farm size such that larger farms were more likely to implement SOP than smaller farms. However, many farmers lacked the time (41%) or ability (42%) to create SOP to provide the employees with detailed instructions on how to perform a specific task. The majority of respondents (59%) were interested in using ready-made SOP that could be adjusted to their farm. An obvious discrepancy exists between the motivation of the farmers to improve the performance on their farm and their expertise in attaining these goals and intentions.

2.2 Key words:

survey, protocol, standard operating procedure, quality management

2.3 Introduction

Quality assurance programs are designed to help companies improve and maintain process and product quality. Key elements of such programs are protocols and standard operating procedures (**SOP**). Protocols are company specific and provide information on what to do in certain situations, whereas the SOP within the protocols systematically describe how to do it (Barragan et al., 2016). These SOP define work processes in a detailed and step-by-step manner, providing the employee with clear instructions on how to perform a particular task (Amare, 2012). Consistency of work performance is increased because written instructions manage the variation that arises when individuals perform tasks in different ways (Stup et al., 2006). Consequently, fluctuations in product quality are reduced. Regular performance reviews and assessment of the compliance with a given SOP can ensure a high quality of work performance and productivity (Stup et al., 2006). There exist different quality assurance programs (e.g., Total Quality Management, Six Sigma, Hazard Analysis Critical Control Points) as well as a management system standard of the International Organization for Standardization. The aim of these programs is to establish and implement standards of

frequently performed work processes that are consistently reviewed (Manghani, 2011). Quality assurance programs for industrial manufacturing were introduced a long time ago (Yu et al., 1999); however, such concepts are only starting to be developed in human medicine. Recently, SOP have been established for the improvement of cancer diagnostics (Keswani et al., 2015), for the treatment of intensive care patients (Friesecke et al., 2014), for orthopedics and trauma surgery (Ewerbeck, 2014), and for reducing the dose of pediatric X-rays (Kloth et al., 2016). The application-based SOP management program SOPHIA (SOPHIA, 2014) was designed particularly for hospitals to generate and manage SOP and make them available on mobile devices. The developers wanted to ensure the creation of SOP that are widely accepted and always up to date (Bauer et al., 2015). In human medicine, SOP implementation becomes highly important to ensure safety in the practice of medicine and pharmaceutical care (Amare, 2012). Many hospitals, however, still lack the awareness and conditions of strictly performed quality management (Ewerbeck, 2014). This likely applies even more to agriculture and veterinary medicine, even though farmers and veterinarians have major responsibilities in the food chain (Windhaus et al., 2007). Critical issues such as animal welfare and agricultural sustainability (von Keyserlingk and Hotzel, 2015; German et al., 2016), animal health (Almeida et al., 2015), and the use of critically perceived drugs such as hormones and antibiotics (Banati, 2014; Pieper et al., 2016) are increasingly being discussed among the general public. Therefore, control, consistency, and transparency of production processes are important to ensuring consumers' trust (McCrea, 2005) and satisfying their needs and expectations (Manghani, 2011). On the other side, dairy farm managers, herdsmen, and workers can benefit from SOP because they provide direction and improve communication and work consistency (Streyl et al., 2011), which lead to predictable results and increase workers' confidence (Stup, 2001; Erskine et al., 2015). Furthermore, the agricultural sector is observing a trend toward larger farms (Moore et al., 2016) with more animals and consequently a higher percentage of nonfamily labor (Bewley et al., 2001; Reynolds et al., 2013; Barkema et al., 2015). In this context, challenges on large dairy farms are caused by communication difficulties, particularly with foreign workers (Stup et al., 2006), and insufficient training of the workforce (Barkema et al., 2015). Those farms could benefit from the implementation of SOP (Cummins et al., 2016), which can help standardize work processes and minimize errors that occur as a result of misinterpretation or miscommunication (Amare, 2012). Thus, fluctuations in product and work quality can be reduced and labor efficiency can be increased. Currently, little information is available about the utilization of SOP and challenges related to training the workforce on commercial dairy farms. Therefore, the objective of this study was to gain insight into the organization of work processes and to

analyze the current use, development, and utilization of SOP and related challenges on German commercial dairy farms.

2.4 Materials and methods

A comprehensive questionnaire was developed that consisted of 16 questions and 9 statements focusing on general farm data; the generation, implementation, and handling of SOP; and assessment of challenges in handling work processes on the farm (Supplemental Figure S1; https://doi.org/10.3168/jds.2016-12029). The questionnaire was distributed in different ways using 3 convenience samples. The first sample included farmers who attended different continuing education events during the third and fourth quarters of 2015. Approximately 100 farmers attended each of the 3 continuing education events. For the second sample, the survey form was sent by mail to farms mainly in the eastern, northern, and southern regions of Germany. Farms were contacted via mail in cooperation with 2 German breeding organizations (Rinderallianz GmbH, Woldegk, Germany; Rinderunion Baden-Wurttemberg e.V., Herbertingen, Germany) and a German agricultural publishing company (DLG AgroFood Medien GmbH, Bonn, Germany). Overall, approximately 8,000 farms were contacted. Participation in the survey was voluntary, and the forms were returned anonymously by mail or collected after the education events. The survey form contained a link and a quick response code that offered participants the option to anonymously fill out an online version of the questionnaire developed with the survey software QuestBack (QuestBack GmbH, 2016). Farmers who answered the questionnaire online composed the third sample. The questionnaire started with a question referring to the types of employment positions. The participant could choose 1 of 4 answers: owner or manager, herdsman, employee, or trainee. The first 6 questions covered general farm information, such as the number of cows, number of employees, annual milk yield, reproductive performance, and bulk milk SCC. Ten questions addressed the development, implementation, and handling of SOP. The last part consisted of 9 statements that participants had to rate on a 5-point Likert scale ranging from fully agree (1) to fully disagree (5). After the education events, 1 question (question 15) was added to the test instrument. Therefore, the number of questions on the forms differs. The data were entered into Excel spreadsheets (version 2013, Microsoft Inc., Redmond, WA) and statistically analyzed using SPSS Statistics for Windows (version 22.0, IBM Deutschland GmbH, Ehningen, Germany). Data were screened for plausibility, resulting in the exclusion of implausible answers from the analysis (n = 1). Normality of distributions of continuous parameters was assessed by plotting and visually examining the data, calculating a quantile–quantile plot, and using the Shapiro–Wilk test. Means and corresponding standard deviations as well as the interquartile range (**IQR**) were computed for continuous and ordinal variables,

respectively. The IQR is the difference between the third and first quartiles in a data set and is a measure of how the data spread around the median. Frequencies were calculated for categorical variables. Percentages were rounded to the nearest whole percentage point. The interrelation between 2 categorical variables was summarized using cross-tabulations, Cramer's V, and Spearman correlation. Binary logistic regression models were calculated to verify the association between various parameters and binary outcome variables. Odds ratios and 95% CI were estimated to determine the association between different management procedures and opinions of the farmers. Further analyses on continuous variables (i.e., annual milk yield, first-service conception rate, SCC) were carried out applying a linear mixed-model ANOVA. All models were built according to the model-building strategies provided by Dohoo et al. (2009). The effect of individual parameters and interactions between relevant parameters was checked. Estimated marginal means and corresponding standard error were reported to illustrate the results. The significance level was set at $P \leq 0.05$, and trends were discussed at $0.05 < P \leq 0.10$. Because this study is the first of its kind, reported data for a preceding sample size calculation were not available in the literature. Therefore, a post hoc power analysis was performed using G*Power (version 3.1.3, University of Dusseldorf, Dusseldorf, Germany) to verify the level of the effect of varying SOP on productions parameters (i.e., milk yield, SCC, first service conception rate). Furthermore, the statistical power of calculations concerning the effect of farm size on the probability of the existence of different SOP was determined. The power of analysis ($1 - \beta$) was calculated, accepting a null hypothesis error of 0.05.

2.5 Results

A total of 250 questionnaires were returned, and 2 forms were excluded from analysis (1 form was filled out by a beef producer, and 1 form was excluded due to the implausibility of the answers). The majority of the questionnaires (58%) were collected after the education events mentioned earlier. Another 29% of participants returned their forms by mail, and 12% of participants answered their questionnaires online. The questions covering general farm data were answered by 94% of all participants. A question regarding the benefits of SOP (question 15) was added after the first seminar, leading to only 186 answers out of 248 for that question. The percentage of questions answered ranged from 75 to 98% (Table 1).

2.5.1 General Farm Data

The majority of respondents (64.3%) were farm managers; 27% were herdsmen, 7.4% were employees, and 1.2% were trainees. The number of cows kept on each farm ranged from 12 to 2,650, and mean (± SE) annual milk yield was 9,611 ± 74 kg. The annual bulk milk SCC

averaged 196,000 ± 59,470 cells/mL. Categorizing farms based on cow numbers, 23% of the farms were small (up to 100 cows; mean ± SE = 75.4 ± 2.7), 52% were medium (101–500 cows; mean ± SE = 265.8 ± 10.4), and 23% were large (>500 cows; mean ± SE = 935.9 ± 55.9), respectively. Five questionnaires did not indicate the number of cows. As expected, the number of employees increased with the number of cows kept on a farm (r = 0.896; $P < 0.001$), with an average of 3.0 ± 0.8, 6.2 ± 0.6, and 19.7 ± 0.8 employees on small, medium, and large farms, respectively ($P < 0.001$). A median of 6 full- or part-time equivalents (minimum = 1; maximum = 68) were employed in the milk production sector. On average, each employee (either full or part time) was responsible for 42 ± 18 cows. The median first-service conception rate (**FSCR**) for cows was 50% (IQR = 33–60%); 23, 45, and 32% of the farms were categorized as having good (>60%), moderate (>40 to 60%), and low (≤40%) reproductive performance, respectively. The FSCR as well as milk yield depended on farm size ($P < 0.001$), such that larger farms had lower FSCR and higher milk yields (Table 2).

2.5.2 SOP

The majority of all respondents (82%) indicated the existence of SOP in general. The presence of SOP was significantly influenced by farm size (Table 3; $P = 0.007$). Compared with small farms, medium and large farms were 2.11 (95% CI = 1.04–4.29; $P = 0.039$) and 5.63 (95% CI = 1.78–17.83; $P = 0.003$) times more likely to have SOP, respectively. Standard operating procedures most frequently existed for feeding (73%), milking (73%), calf handling (64%), and management of fresh cows (54%). Medium and large farms were more likely to have SOP for these areas than small farms (Table 4). Interestingly, SCC was significantly higher on farms with an SOP for milking procedures (mean ± SE: 201,168 ± 4,579 cells/mL) than on farms without an SOP for milking procedures (181,318 ± 7.284 cells/mL; $P = 0.023$). Annual milk yield, however, was higher on farms where SOP were available in general (9,690 ± 176 kg) than on farms without any SOP (9,286 ± 82 kg; $P = 0.038$). This was also true for farms that had implemented an SOP for milking procedures (farms with milking SOP, 305d lactation = 9,730 kg; farms without milking SOP, 305d-lactation = 9,309 kg; $P = 0.012$). In addition, the association between annual milk yield and the existence of a feeding SOP was significant ($P < 0.001$), with the estimated marginal means showing a higher milk yield when SOP were present (farms with feeding SOP = 9,780 kg; farms without feeding SOP = 9,171 kg). Also, farms that had a milking SOP were 11.00 times more likely to have an SOP for fresh cow management (95% CI = 5.36–22.60; $P < 0.001$). The FSCR were lower on farms with an SOP for heat detection (45.8 ± 2.1%) than on farms without an SOP for heat detection (51.6 ± 1.6%, $P = 0.026$). Furthermore, farms with a written SOP for heat detection had lower FSCR (45.0 ± 1.8%) compared with farms that did not put their SOP in writing (52.2 ± 2.2%; $P = 0.012$). Farms that had an SOP for calving management were 15.05 times more likely to also have an

SOP for managing their fresh cows (95% CI = 7.96–28.48; $P < 0.001$). In addition, farms implementing an SOP for feeding were 10.9 times more likely to have an SOP for claw trimming (95% CI = 4.18–28.42; $P < 0.001$). Although most respondents (82%) indicated the existence of SOP, only 54% stated that the SOP were available in writing. Whether the SOP were written down depended on farm size ($P = 0.002$) such that medium and large farms were 2.08 times (95% CI = 1.08–4.03; $P = 0.030$) and 7.24 times (95% CI = 3.21–16.32; $P < 0.001$) more likely to write down their SOP, respectively, compared with small farms. The existence of written SOP was associated with lower FSCR (without SOP = 52.23 ± 2.2; with SOP = 45.01 ± 1.8; $P = 0.012$) but higher annual milk yield (without SOP = 9,477.2 ± 119.7 kg; with SOP = 9,827.9 ± 103.8 kg; $P = 0.028$). Another correlation was found between farm size and the inclusion of employees in SOP creation ($P = 0.021$). Interestingly, employees on large farms were 2.84 times more likely to be involved in the development of SOP compared with employees on small farms ($P = 0.007$; Table 3). Seventy percent of the farms did not provide SOP for their trainees. There was a higher probability that written SOP were available on large farms compared with small farms ($P = 0.004$; Table 3). Furthermore, large farms were more likely to seek assistance in developing SOP compared with small farms (95% CI = 0.22–0.81; $P = 0.013$; Table 3). Most of the farmers who sought assistance (42%) referred to the veterinarian as their primary advisor. Other sources were feeding consultants (28%), the local DHIA (12%), extension experts (9%), other farmers (6%), and breeding companies (3%). Sixty-three percent of the respondents stated that they do not check the validity of their SOP on a regular basis. It is noteworthy that on 48% of the farms employees did not have free access to the SOP at all times.

2.5.3 SOP and Attitude Toward Employment

Almost all respondents (98%) wanted to improve certain areas. The majority of the farmers saw the need for improvement in managing fresh cows (49%), heat detection (47%), and managing calves (44%). The question regarding possible benefits of SOP was answered by 179 participants; 86% considered a consistent work performance to be an obvious benefit, 49% (87/179) regarded monitoring of work processes as beneficial, and 39% (70/179) saw improvement of animal health as beneficial. Interestingly, a relationship was found between monitoring work processes as a potential benefit of SOP and the way participants assessed employees who fulfilled work processes differently than what they considered correct ($P = 0.030$). If work monitoring was considered a potential benefit, participants were more likely to state that employees fulfill work processes differently than what they considered correct. Figure 1 shows the overall assessment of the statements. Sixty-six percent of the participants agreed or strongly agreed with the statement that various employees handled the same tasks

differently. Furthermore, farmers who agreed that various employees handled the same tasks differently had a stronger interest in ready-made SOP (P = 0.084) and were more likely to provide unlimited access to SOP on the farm (P = 0.057). A relationship existed between lack of time for developing SOP and having an interest in using ready-made SOP that could be adapted to the particular farm (P < 0.001), although the correlation coefficient was weak (r = 0.203; P = 0.002). An interest in such ready-made SOP was also slightly positively correlated with farmers having difficulties in creating SOP (r = 0.186; P = 0.004). The statement that a farmer lacked time for creating an SOP had a significant effect on the existence of SOP on the farm (P = 0.006). Farmers who agreed, neither agreed nor disagreed, or disagreed with lacking time for creating SOP were 2.54 times (95% CI = 0.97–6.66; P = 0.058), 6.35 times (95% CI = 2.13–18.88; P = 0.001), and 5.82 times (95% CI = 1.95–17.36; P = 0.002) more likely to have SOP on their farm compared with farmers who fully agreed. There was no effect of farm size on the lack of time for developing SOP (P = 0.596), the interest in ready-made SOP (P = 0.256), or the interest in displaying SOP on a smartphone or tablet (P = 0.190). The power of analysis for calculations concerning the effect of SOP on milk yield, SCC, and FSCR was 0.6369 for the effect of SOP in general on milk yield, 0.7551 for the effect of milking SOP on SCC, and 0.8026 for the effect of milking SOP on milk yield. Furthermore, the statistical power for calculations concerning the effect of farm size on the probability of the existence of SOP for trainees was 0.9515. Although the power of analysis for the first calculation is low, the other calculations are within the limits set by Cohen (1988) and Prajapati et al. (2010). The chance of error in accepting the null hypothesis differed between 4.9 and 36.3%.

Table 1. Questions and statements on the test instrument

No.	Item[1]	Answered question, % (no.)
Question		
1	I am owner/manager, herdsman, employee, or trainee.	98 (244/248)
2	How many cows calve on your dairy per year?	98 (243/248)
3	What is your rolling herd average (305 d) in kilograms?	96 (239/248)
4	What was the average bulk tank SCC of the last 3 mo?	95 (236/248)
5	What is the average first service conception rate for cows in the last 3 mo?	75 (185/248)
6	How many people (including part-time employees) work in the livestock sector of the farm?	94 (232/248)
7	Are there any SOP for certain work processes or jobs on the farm?	98 (244/248)
8	Are these SOP written down?	98 (243/248)

9	Are these SOP created together with the employees?	97 (241/248)
10	Are the employees trained for the use of the SOP?	96 (237/248)
11	Do you check the validity of the SOP on a regular basis?	96 (239/248)
12	Do the employees have unlimited access to the SOP?	92 (227/248)
13	Who helped you create the SOP?	96 (237/248)
14	Do you have SOP for your trainees?	94 (234/248)
15	Do you see room for improvement for certain areas of your farm?	98 (242/248)
16	Which of the following do you consider to be an advantage of an SOP: motivation, work atmosphere, monitoring of work processes, efficiency, animal health, consistency in work completion, quality?	96 (179/186)[2]

Statement		
1	On our farm, different employees complete the same work processes differently.	98 (243/248)
2	Sometimes I get annoyed about employees not completing tasks the way I consider right.	98 (243/248)
3	In agriculture, we should implement new and scientifically sound findings.	98 (243/248)
4	Continuing education for employees is oftentimes neglected.	97 (240/248)
5	I have been thinking of writing down specific work processes in detail.	96 (239/248)
6	I find it to be difficult to write down work processes.	97 (240/248)
7	I do not have the time to create SOP.	97 (241/248)
8	I would like to use ready-made SOP and adapt them to my farm.	97 (240/248)
9	I would like to use a smartphone or tablet to display such SOP.	98 (243/248)

[1] SOP = standard operating procedures.

[2] Numbers are lower because this question was added after the first distribution of the questionnaire.

Table 2. First-service conception rate (FSCR) for cows and 305-d milk yield (mean ± SE) for small (0-100 cows), medium (101-500 cows), and large (>500 cows) dairy farms

	Farm size			
Parameter	Small	Medium	Large	*P*-value
FSCR	59 ± 2.34[a]	48 ± 1.76[b]	41 ± 2.34[c]	< 0.001
Milk yield (kg)	8,960 ± 140[a]	9,759 ± 96[b]	9,994 ± 148[b]	< 0.001

[a-c] Within a row, means with different superscripts differ significantly.

Table 3. Percentage (no.) of respondents to questions related to existence and implementation of standard operating procedures (SOP) on small (0-100 cows), medium (101-500 cows), and large (>500 cows) dairy farms

	Farm size			
Statement	Small	Medium	Large	*P*-value
Existence of SOP	69 (43/62)[a]	83 (105/127)[b]	93 (51/55)[b]	0.007
Inclusion of employees in creating SOP	39 (24/61)[a]	47 (59/126)[a]	63 (32/51)[b]	0.021
Availability of SOP for trainees	15 (9/60)[a]	31 (38/123)[b]	45 (22/49)[b]	0.004
Farms seeking assistance for creating SOP	55 (33/60)[a]	48%(59/123)[a]	66 (33/50)[b]	0.044

[a,b] Within a row, means with different superscripts differ significantly.

Table 4. Logistic regression model predicting the probability of having standard operating procedures in different management areas in German dairy herds (n = 234)

Management area	Farm size[1]	Odds ratio	95% CI for odds ratio	*P*-value
Feeding				< 0.001
	Small	Referent		
	Medium	2.45	1.29 – 4.64	0.006
	Large	6.73	2.51 – 17.99	< 0.001
Milking procedures				< 0.001
	Small	Referent		
	Medium	3.09	1.63 – 5.88	0.001
	Large	10.00	3.52 – 28.45	< 0.001
Heat detection				0.002
	Small	Referent		
	Medium	2.21	1.09 – 4.50	0.28
	Large	4.20	1.87 – 9.44	0.001
Fresh cows				< 0.001
	Small	Referent		
	Medium	3.95	2.04 – 7.64	< 0.001
	Large	4.65	2.88 – 14.45	< 0.001
Calving				< 0.001
	Small	Referent		
	Medium	4.51	2.19 – 9.26	< 0.001
	Large	9.31	3.98 – 21.81	< 0.001
Calf management				0.004
	Small	Referent		
	Medium	1.94	1.05 – 3.60	0.035
	Large	3.82	1.69 – 8.60	0.001
Claw trimming				0.186
	Small	Referent		
	Medium	1.39	0.72 – 2.68	0.328
	Large	2.04	0.95 – 4.37	0.068

[1]Small: 0 to 100 cows; medium: 101 to 500 cows; large: >500 cows.

2.6 Discussion

Farm size in our study was categorized based on number of cows as in previous surveys (Kehoe et al., 2007; Heuwieser et al., 2010; Espadamala et al., 2016), and a relationship exists between number of cows and number of employees (USDA, 2008). Globally, the agricultural sector in many countries has been changing toward larger operations and away from small, family-owned businesses (Barkema et al., 2015). The German dairy industry is undergoing this shift as well. There are, however, regional differences. Herd sizes and annual milk yield are higher in eastern regions compared with western and southern regions. Most of the small, family-owned farms in the Southwest stay below the German average herd size of 60 cows and the average milk yield of 7,628 kg/yr, whereas the herd sizes and milk yields of larger dairy operations in the East are above average (ZMB, 2016). Furthermore, the proportion of nonpermanent employed workers has been increasing over the past years. Interestingly, 90% of these nonpermanent workers come from countries other than Germany (DBV, 2015). As dairy farms expand, they increasingly rely on nonfamily labor (Bewley et al., 2001; Barkema et al., 2015) and a foreign workforce (Susanto et al., 2010), thus leading to more communication challenges (Barkema et al., 2015; Erskine et al., 2015). On those farms, dairy managers have the responsibility of ensuring that employees are performing high-quality work (Stup et al., 2006). It has been described that managers of larger herds place more emphasis on details to improve important herd performance measures (Bewley et al., 2001), which led us to assume that larger farms are more likely to have SOP than small farms. Also, herd managers from large farms may interact with veterinarians and consultants more often. Both observations could have influenced the results. Standard operating procedures existed on the majority of farms, but, interestingly, they were not written down. Respondents did not see the importance of written SOP for the consistency of work performance. It has been pointed out, however, that meaningful records are essential for implementing corrective measures and adjusting management (Barragan et al., 2016). Another possible explanation is that some managers and producers lack the capacity to address human resource management (Erskine et al., 2015) or struggle with the transition toward it (Reynolds et al., 2013) and therefore consider a verbal instruction or explanation to be an SOP without being aware of the importance of a formal written SOP. Nevertheless, it was more likely for SOP to be written down on large farms than on small farms. The availability of competent labor is often problematic (Winsten et al., 2010), and dairy producers consider its recruitment to be a major problem (Bewley et al., 2001). Whereas work on small farms is completed primarily by family members, large farms need to overcome language barriers and avoid communication problems that are attributable to the higher proportion of foreign workers. To be successful, a high level of management ability is required (Bewley et al., 2001; Winsten et al., 2010), and

implementation of SOP becomes an essential management tool (Barragan et al., 2016). As farm size increases, producers spend more time managing employees, allowing them to adjust to the challenges of employee management sooner (Bewley et al., 2001). This explains why in our data set large farms were more likely to provide SOP for their trainees compared with small farms that rely mostly on family workers and often do not have any trainees. Considering the ongoing trend toward larger dairy herds (Bewley et al., 2001), a focus needs to be placed on the implementation of best management practices (LeBlanc et al., 2006; Cummins et al., 2016). A better understanding of the importance of a quality assurance system makes it more likely for large farms to seek assistance compared with small dairy producers. Most farmers stated that they sought the assistance of a veterinarian. Veterinarians clearly are seen as important advisors on many dairies, as previously stated (Moore et al., 2016). Human resource management characterizes a set of practices that managers use to ensure quality employee performance (Stup, 2001). To optimize overall performance, different employees need to complete the same tasks similarly, which is encouraged by the implementation of SOP. This is important because dairy cattle thrive on consistency (Maunsell, 2012). Milk quality and quantity are directly affected by employee performance (Stup et al., 2006). This could explain the significantly higher milk yield on farms that had written SOP compared with those that did not. Poor human–animal relationships result in low work comfort and efficiency and are associated with reduced milk production (des Roches Ade et al., 2016). The greater the number of employees working on a farm, the more difficult it is to ensure consistency of work performance. The majority of respondents stated that different employees completed the same tasks differently. Farms with such conditions would particularly benefit from SOP because these prevent variations regardless of the operator and time of operation (Amare, 2012). On large farms, the management is more likely to create SOP together with their employees because the owners, managers, and veterinarians rely on the employees to identify sick cows under variable formal training and supervision (Espadamala et al., 2016). This observation, however, is put into perspective as small farms are often family owned and less likely to hire employees as opposed to medium and large farms. The best practice for developing SOP requires the active involvement of workers (Amare, 2012). However, implementing a quality management system with SOP is time consuming and requires specific know-how. This aspect can explain the observed interest of farmers (59%; 141/240) in ready-made SOP. Interestingly, the biggest challenge for producers after expansion seems to be labor management (Bewley et al., 2001); many herd owners and managers are neither trained nor inclined to serve as an educator (Erskine et al., 2015). Considering this challenge and the evolution of veterinarians from task-oriented providers to advice-oriented consultants (LeBlanc et al., 2006), an opportunity opens for veterinarians to maintain or reestablish an important

role on the dairy farm through development and communication of treatment protocols for animal care and well-being (Moore et al., 2016). In addition, in a valid veterinary–client relationship, the veterinarian should provide written treatment protocols and guidelines for commonly occurring and easily recognizable conditions (AABP, 2013). These protocols and SOP should be user friendly and easy to understand because they are targeted at diverse employees from different cultural backgrounds. Our data show that veterinarians are an important source of assistance for farmers who create SOP as part of their human resource management. Because effectively writing SOP requires special know-how and training, such expertise should be included in veterinary education. Interestingly, the SCC was higher on farms that had SOP for milking procedures compared with farms without such SOP. Additionally, SOP were more likely to be written down on farms with a lower FSCR. Furthermore, farms with a lower FSCR were more likely to have SOP for heat detection. We do not assume that higher SCC and lower FSCR are caused by the implementation of SOP. A possible explanation for this result could be the implementation of SOP as a corrective measure to improve workers' performance and productivity on these farms. The study design, however, allows only an insight into the current status of the participating dairies and does not justify making a statement about cause and effect. This finding is in line with the observation that SOP sometimes are used to correct poor performance (Stup et al., 2006) and indicates that farmers are aware of the importance of good farm management for product quality and efficiency. Our data reflect this assumption, as large farms were more likely to have implemented SOP and had higher milk yields. Regardless, the assumption that having written SOP has a positive effect on outcomes of value to a given producer or the industry as a whole needs to be demonstrated. As in other studies surveying certain management practices related to, for example, reproductive performance, postpartum disorders, or colostrum management (Caraviello et al., 2006; Kehoe et al., 2007; Heuwieser et al., 2010), our study had limitations. Such surveys rely on voluntary responses of the target population (i.e., generally a convenience sample of a certain geographical region). It is difficult to conclude whether the dairies that responded to the survey are representative of all dairies of the given region but reasonable to assume that the farms that responded were more interested in human resource issues than the nonresponding farms. Despite these limitations, surveys have provided important insights into current dairy management practices and experiences in a variety of areas, such as animal health and welfare, facility characteristics, and feeding. Similar to a recent study on management practices related to bovine respiratory diseases in calves (Love et al., 2016), responses were recruited from several sources. Therefore, a response rate could not be calculated. Considering the large number of questionnaire forms sent out, only a small number of farms participated in the survey. German dairy farmers clearly did not

perceive management of work processes to be as important as other areas such as reproductive performance, postpartum disorders, or drying-off practices, for which studies reported response rates of 67, 12, and 49%, respectively. The survey was based on the farmers' voluntary participation and relied on the participants' assessment of the situation on their farm. However, the study did not include any farm visits or personal interviews, which should be part of a follow-up study. The mean herd size in our study was 230 cows, which is greater than demographic data on the German dairy industry (DBV, 2015).

2.7 Conclusions

The majority of respondents saw a need for improvement of certain management areas and indicated the existence of SOP. The SOP were written down in only 54% of cases and were available to trainees in 30% of cases, and both were associated with farm size. Many respondents indicated a lack of time or ability to create written SOP. Further research is warranted to study the efficacy and compliance of ready-made SOP considering the type of training material.

2.8 Acknowledgements

We thank Rinderallianz GmbH (Woldegk, Germany), Rinderunion Baden-Wurttemberg (Herbertingen, Germany), and Deutsche Landwirtschaftliche Gesellschaft AgroFood Medien GmbH (Gros-Umstadt, Germany) for their support in conducting this survey. Anne Hesse was sponsored in part by QS, Qualität und Sicherheit GmbH (Bonn, Germany), and Tiergyn e.V. Berlin (Berlin, Germany).

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3 PUBLICATION II

Short communication: Microlearning courses are effective at increasing the feelings of confidence and accuracy in the work of dairy personnel

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Published in:

Journal of Dairy Science, August 2019, Volume 102, Issue 10, October 2019, Pages 9505–9511

Please find the original article via the following digital object identifier: https://doi.org/10.3168/jds.2018-15927

3.1 Abstract

Optimization of work processes and personnel compliance becomes progressively essential to ensure high process and product quality on dairy farms with an increasingly nonfamily work force. Standard operating procedures (SOP) are important to minimize variation. In addition to having a set of protocols and SOP, regular training of employees is indispensable to reduce procedural drift. A total of 243 farm owners, employees, and veterinarians from 35 farms were invited to take 3 microlearning lessons for colostrum management and provide feedback in an embedded survey. The overall response rate was 48%, and almost all participants accessed the SOP within the course (i.e., 92, 90, and 96% in the first, second, and third course, respectively). Overall, 59% (22/37) launched the course in their leisure time and 80% stated that they were convinced to work more accurately after having taken the course. Most employees underestimated the time spent in the course (76%), accessed background information (89%), or provided feedback (55%). These observations are indicative of high engagement. Overall, 78% of employees felt more confident in correct task completion after the training.

3.2 Key words

training, e-learning, standard operating procedure, employee engagement

3.3 Short Communication

In recent decades, the US dairy industry has been experiencing a trend toward larger farms with more animals (USDA Economic Research Service, 2018). This circumstance generates new challenges on a dairy farm such as a higher number of employees per farm (Moore et al., 2016), many of whom are foreign laborers with minimal or no farming background (Reynolds, 2013), language and communication barriers (Stup et al., 2006), and limited educational attainment (Arcury et al., 2010). Protocols (“what to do”) and SOP (“how to do it”) ensure high process and product quality by standardizing management practices (Barragan et al., 2016) and are essential on these farms to minimize errors (Barkema et al., 2015). Standard operating procedures define work processes in a detailed and step-by-step way to provide the employee with clear instructions on how to perform a particular task (Amare, 2012). Variation arises when individual employees perform tasks in different ways, potentially leading to fluctuations in product quality (Stup et al., 2006). Several studies have shown a positive effect of SOP on work performance (Barkema et al., 2015; Barragan et al., 2016), employee motivation (De Treville et al., 2005), and employee turnover (Ton and Huckman, 2008). Nevertheless, many farmers lack the expertise, time, or motivation to create SOP and protocols even though they are aware of the importance of stringent quality management (Hesse et al., 2017; Falkenberg

et al., 2019). Most interesting, a recently published study showed that employers often underestimate employees' interest in learning and commitment to the success of the farm (Durst et al., 2018). The demographic change of dairy farms may be one of the causes for this discrepancy as managers face a shift in their responsibilities toward managing human resources. Furthermore, regular training of employees is indispensable to reduce procedural drift (Biagiotti, 2016). However, for many managers who started their jobs on smaller farms, this is an unfamiliar area (Reynolds, 2013). Employee engagement and retention are important factors for dairy farms to improve turnover rates. However, the importance of these factors is not well known among dairy producers (Durst et al., 2018). Multiple studies have shown a positive effect of microlearning to impart knowledge and increase motivation of employees or undergraduate students (Gassler et al., 2004; Mohammed et al., 2018). Microlearning refers to short training or e-learning units that impart knowledge within small fractions with a specific goal (Mohammed et al., 2018). Cloud-based microlearning lessons provide fast and easy access to knowledge at the time of interest. The lessons can be taken independently, unsupervised, and at any time of choice. This might increase workers' motivation to accomplish the training (Mohammed et al., 2018). A review of operations management literature suggested that SOP use could result in increased self-efficacy beliefs - that is, the conviction that one is capable of achieving a given goal (Treville et al., 2005). Although training resources such as instructor-led seminars and online training are plentiful for dairy employees, science-based information on the efficacy of e-learning modules in the dairy industry is scarce. One computer-assisted training program for teaching reproductive management received positive feedback from students, veterinarians, and producers (Johnson et al., 1992). More recently, a comparison of online and hands-on training approaches for teaching cautery disbudding technique to dairy producers suggested that online training can be a useful tool for motivated producers who lack access to hands-on training (Winder et al., 2018). The objective of this study was to determine whether an SOP embedded into an online microlearning course was accessed by dairy personnel and whether it could improve self-estimated performance of tasks related to dairy calf health. Our working hypothesis was that such microlearning courses were effective at creating feelings of confidence and accuracy in work performance. The project was introduced at 3 different continuing education events for farmers that were conducted in Germany in the fourth quarter of 2017 and the first quarter of 2018. The audience at these events consisted of a mixed number of farm owners, herd managers, employees, and trainees. Interested farmers could provide their contact information on a handout or send the contact details of their interested employees to the project team via email. Additionally, farmers were able to provide their contact information after the first course was launched. All interested persons were then provided with the uniform resource locator (URL) and registration

information. To limit the number of participants, application for course participation was closed after the second course was launched. From February to May 2018, all persons were contacted 6 times by email or WhatsApp (i.e., 1 initial email and 1 reminder email 4 d later for each of the 3 courses). The email contained a brief introduction to the course, the URL, and instructions on how to launch the course. Three online microlearning courses addressing colostrum management as a fundamental basis of dairy calf health (i.e., tube feeding colostrum, bottle feeding colostrum, measuring colostrum quality) were developed with a cloud-based authoring software (Gomo Learning, Brighton, UK). The courses were accessible online and could be taken by any person who received the URL. The URL for each course was sent individually via email or WhatsApp, and the course could be accessed at any time and repeatedly. The email address of each participant had to be preregistered before participation to ensure that only persons enrolled in the learning management system were able to access the course using their preregistered email account and a password provided by the researchers. Participants could display the courses on any web-enabled device (i.e., desktop computer, smartphone, tablet computer). The first 3 screens obtained informed consent from the participants, showed a disclaimer, described the privacy policy, and explained the navigation. A typical SOP should include the purpose of the task, the equipment and materials required, and how to perform the task (Edelson and Bennett, 1998). Therefore, the course structure was based on 4 parts: (1) learning objectives; (2) the SOP, which was divided into 2 parts (“what do you need” and “how do you do it”); (3) relevant background information; and (4) a quiz for self-evaluation. The learning objectives consisted of 3 descriptions that defined what the participants should know and be able to do after completing the course. The first part of the SOP showed pictures and names of all materials needed for completing the task. The second part was a step-by-step description of the task with a title, image, and brief text beneath each image. Part 3 provided background information about each task. Eight questions per course, such as “Why 4 hours?” and “Why is quality testing of colostrum important?”, allowed the participants to gain additional relevant background information relative to the SOP. This information consisted of brief texts, graphs, and images. In a concluding quiz, participants had the opportunity to take a self-evaluation consisting of 4 questions relative to the presented materials. The tube feeding course provided a detailed description of how to tube feed colostrum to newborn calves. In addition to the SOP images and text, 2 short videos showing the process of administering and pulling out the tube were available. Background information included general information about colostrum (e.g., how much colostrum should be administered, the importance of timely administration, and how to check the correct position of the tube). The bottle feeding course provided details about colostrum administration (e.g., colostrum temperature, heating frozen colostrum) and

cleanliness of materials. In this course, we referred to the tube feeding course in case of the calf not voluntarily drinking 4 L of colostrum within 4 h after birth. The third course, colostrum quality, explained how to use a digital Brix refractometer to check colostrum quality. After reading the SOP, the participants could watch the process in a short video that was embedded at the end of the SOP. Relevant background information included details about the functioning of the refractometer, the importance of testing colostrum quality, and the importance of calibration. The concluding quizzes consisted of multiple-choice questions (1 correct out of 4 possible answers) relating to each course. If the answer selected was incorrect, the participants were able to answer again. We advised all participants that the training courses were free of charge and did not require further commitment and that they could exit the course at any point. Further, we stated that all answers were treated confidentially. Participants were able to contact the project team at any time with questions or when they experienced any problems or wanted to provide feedback. Participants did not receive an incentive. The study instrument was submitted to the human ethics committee of the Freie Universität Berlin. Only one identical microlearning approach was used for all employees, and participation was voluntary. Therefore, it was exempt by approval of the human ethics committee. However, a description of the terms and conditions of use and the privacy and data protection policies had to be provided on the first page of the course. Consent was obtained from all participants. A 12-item survey form was embedded into each course that provided data on course perception and feedback. Two questions covered the time of course completion (i.e., whether the course was accessed during work or leisure time). One of these questions was added to the survey form when the second course was created. Further, the participants were asked to estimate the amount of time they had spent on each course. Other questions referred to the participant's position on the farm, their experience in completing the particular task, and how they completed the course (i.e., alone, with someone else, as farm training). Furthermore, they were asked to rate the course on a 5-point Likert scale (i.e., from 1 to 5, 1 being very good and 5 being poor) and rate how much they had learned during the course. Participants could also state whether the course convinced them to perform the task more accurately and whether they felt more confident in conducting the task. In addition, we asked the participants whether the SOP was feasible on their farm and whether such repetitions of knowledge were considered valuable. Two open text fields (i.e., "What was the most important thing you learned in the course?" and "We appreciate your comments and suggestions") allowed participants to provide statements, feedback, and suggestions, which could also be provided via email or WhatsApp text messages. Learner experiences such as access, page visits, total time spent, completion, and quiz scores were observed with the learning management system (Gomo Learning). Quantitative data were collected with 5-point Likert scales and reported as

frequencies and percentages. Qualitative feedback regarding the microlearning courses that was entered into open text fields was summarized and is reported below. Seventy-nine interested persons were invited to take the first course (tube feeding colostrum), and 49 (62%) participated. Three farmers contacted the researchers after the first course was launched, leading to 82 invitations being sent out for the second course (bottle feeding colostrum) and the third course (measuring colostrum quality). For all 3 courses combined, 243 invitations were mailed out and 117 participants (48%) launched the courses. The courses were cloud based and accessible with web-enabled devices. The majority took the tube feeding (62%) and bottle feeding (i.e., 79%) courses on a desktop computer, whereas the remaining participants accessed these 2 courses with their smartphones. One person used a tablet computer to launch both courses. The launches for the colostrum quality course showed a converse distribution, as 40% used a desktop computer and 60% used a smartphone to launch the course. The number of participants decreased after the first course to 48% and to 39% for the second and third courses, respectively. Most participants launched the first, second, and third course once (69, 77, and 90%, respectively). The remaining 31, 23, and 10% launched the courses more than once. The “relevant background information” section was divided into several questions that could be selected at the participant’s own discretion by clicking a button that provided important information about the task described. In the first, second, and third courses, 86, 90, and 93% of participants accessed this part (Table 4). After selecting “relevant background information,” most participants selected 2 or more questions (i.e., 83, 77, and 56% in the first, second, and third courses, respectively). The SOP represented one part within the course, displaying the necessary materials and the step-by-step instructions on how to perform the task. Almost all participants selected the SOP [92% (45/49), 90% (35/39), and 96% (27/28) in the first, second, and third courses, respectively]. For all 3 courses, 55% of the participants completed the embedded survey. Overall, most participants were owner (26%), herdsperson (24%), or employee (23%) on the farm (Table 1). The remaining persons were family members (15%), trainees (6%), or veterinarians (6%). Overall, the majority of participants (22/39, 56%) of courses 2 (bottle feeding) and 3 (colostrum quality) had launched the course in their leisure time. The learning management system allowed us to accurately track the time that the participants spent on the courses. On average (mean ± SD), the participants spent 11:33 (±6:21), 11:14 (±6:17), and 10:04 (±5:40) min:s on the first, second, and third courses, respectively. After course completion, the participants were asked to estimate the time they spent on each course by selecting 1 of 5 items. Estimated time spent on each course was on average (mean ± SD) 7:20 (±2:34), 5:01 (±4:18), and 5:12 (±5:17) min:s shorter than the actual time spent on the first, second, and third courses, respectively (Table 2). Participants were asked on a 3-point scale (i.e., absolutely, undecided, not really)

whether they were convinced to perform the task more accurately after completion of the course. Eighty-five percent stated that they were absolutely convinced to perform the task more accurately after the first course, whereas 76 and 75% chose this statement after the second and third courses, respectively. Overall, 80% were convinced to work more accurately. Furthermore, participants were asked whether they felt more confident in correct task performance after having taken the course. The answers were given on a 3-point scale (i.e., absolutely, undecided, not really) and are summarized in Table 3. Overall, 77% felt more confident in performing the task correctly. After the second and third courses, 76 and 83% of participants, respectively, strongly agreed that repetition of such knowledge was worthwhile. This question was added to the survey form after the first course had been created, and answers could be given on a 3-point scale (i.e., strongly agree, undecided, and disagree). Only one person disagreed with this statement after having taken the bottle feeding course (Table 4). Overall, the 3 courses were rated as very good or good by 89% of the participants. Labor expenses range from 15 to 30% of the gross income on a dairy farm (Mugera and Bitsch, 2005). Regular training of farm personnel is essential to increase productivity (Kilpatrick, 2000) and to ensure and maintain up-to-date knowledge and necessary competence of the workers (Liao and Tai, 2006; Román-Muñiz et al., 2007) and seems to be critical for motivating and engaging the workforce (Durst et al., 2018). Employee engagement is well recognized as a key component of employee and business performance (Medlin and Green, 2014). The ability and encouragement to develop employees' skills helps to motivate employees and decrease turnover rate (Heathfield, 2017). On dairy farms, however, proactive and systematic human resource management is a challenge (Stup et al., 2006). Most dairy managers lack sufficient knowledge and know-how to provide their workers with adequate continuing education (Hesse et al., 2017) and do not encourage or value critical input by their employees (Durst et al., 2018). One prerequisite for participation in our study was either an email address or a smartphone with WhatsApp to receive the URL for the courses. Furthermore, access to the internet (stationary PC) or a data plan using cell phones was required to participate in this study. Interestingly, approximately 10% of the attendees of the continuing education events were interested but did not own either and could not participate in the study. Rural areas have less internet access than urban areas, and fewer rural residents are online compared with urban residents in both Germany and the United States (FCC, 2016; Statista, 2018a). Overall, 48% of the invited personnel accessed the courses. Most enrolled in more than 1 course, and we assume that some participants took the courses in pairs or as a group. Thus, response rate could be somewhat higher. However, 78% stated that they completed the courses alone. There are multiple reasons for this limited response. First, the farm owners or managers interested in the courses might not have encouraged participation

in the microlearning courses among their employees. Second, employers might not have given their employees the opportunity to take the courses during work hours. Furthermore, participation was voluntary, and we did not offer any monetary incentive. Last, insufficient internet coverage at work might have prevented some less intrinsically motivated employees from launching the courses at all. The courses could be accessed with any web-enabled device and were fully responsive (i.e., pages adapted automatically to different screen sizes and devices). The percentage of smartphone users in Germany varies between 88% (50–64 yr of age) and 97% (30–49 yr of age; Statista, 2018b). It was therefore surprising that the majority of participants accessed the courses via desktop computer and not via smartphone. Slow or lacking internet coverage, especially in the northern (i.e., rural) regions of Germany, could have been one reason for this observation. The microlearning course “bottle feeding colostrum” was created and launched because some participants in the first course (i.e., “tube feeding colostrum”) commented that they do not tube feed colostrum and requested specific training materials to revisit their practices on bottle feeding colostrum. The microlearning approach allowed us to address this knowledge gap in a short period of time. On the other hand, the resulting order of the 3 courses might have affected participation because bottle feeding colostrum is a daily routine conducted on almost every dairy farm, is less complicated than tube feeding, and poses fewer risks of injury for the calf. Some participants probably perceived this topic as needless or boring, which might have affected their interest in further courses. This might explain the decreasing participation in the second and third courses. Measuring colostrum quality is perceived as important by 45% of the producers in the United States, but only 10% implemented a protocol on their farm (Pempek et al., 2017). Comparable values are not available for Germany. We speculate that some farmers use colostrometers and might have perceived the course title “measuring colostrum quality” as unappealing and therefore did not launch the third course. The “relevant background information” section was accessed by almost all participants who launched the courses. Clearly, the participants were interested not only in the SOP but also in relevant knowledge pertaining to the process. This is in line with a recent report describing anecdotal evidence from the field that states that it is important to provide the “why” behind the “how” (Liebenow, 2018). It is argued that successful knowledge transfer leads to workers understanding their work and the importance of following the protocol (Wenz, 2007). A total of 40 (65%) and 33 (53%) participants responded to the 2 open test fields (“What was the most important thing you learned in the course?” and “We appreciate your comments or suggestions”). Of those, 10 (8%) participants stated that they found the information exceeding the mere steps of the procedure to be very useful (e.g., “Most importantly, the courses explain the details that should be complied with, otherwise one does the task as somebody else told you” and “The additional side information [is] valuable”). In

addition, most participants who filled out the survey fully agreed that the repetition of knowledge was worthwhile. This shows the value of regular training and refreshing one's knowledge. Furthermore, it supports the finding of a recent survey that most workers are interested in learning (Durst et al., 2018) and want to know why they have to complete a task in a particular way (Liebenow, 2018). Almost two-thirds of participants took the courses in their leisure time. Clearly, the participants were eager to gain knowledge and were willing to use their leisure time for their training. The high level of motivation was substantiated by the underestimation of the time spent on the courses. We speculate that this finding is indicative of the participants having fun and a high intrinsic motivation while taking the courses, as has been suggested previously for undergraduate students (Conti, 2001). A positive perception is evidenced by the observation that most participants rated the courses as very good or good. Clearly, the courses were effective at creating a feeling of confidence and accuracy in work performance, as most people were convinced to work more accurately after having taken the courses. The study design, however, does not allow drawing any conclusions about knowledge and skills that participants gained by taking the courses. Causalities and associations between parameters, such as position on the farm and assessment of the courses, could not be calculated due to the limited number of participants and the exclusively descriptive analysis. Further research with a larger number of farms is warranted to determine whether SOP embedded in microlearning courses can affect measurable performance parameters of value for the farms and to study strategies to increase participation rate.

Table 2. Role (no.; % in parentheses[1]) of 66 participants who completed a 12-item survey embedded in 3 microlearning courses on tube feeding, bottle feeding, and measuring colostrum quality

Participant role	Tube feeding	Bottle feeding	Colostrum quality	All 3 combined
Trainee	1/27 (4)	2/25 (8)	1/14 (7)	4/66 (6)
Employee	7/27 (26)	5/25 (20)	3/14 (21)	15/66 (23)
Family Member	3/27 (11)	4/25 (16)	3/14 (21)	10/66 (15)
Herdsperson	6/27 (22)	7/25 (28)	3/14 (21)	16/66 (24)
Owner	8/27 (30)	6/25 (24)	3/14 (21)	17/66 (26)
Veterinarian	2/27 (7)	1/25 (4)	1/14 (7)	4/66 (6)

[1]Due to rounding, percentages do not always add up to exactly 100%.

Table 2. Average (±SD) recorded contact times and estimated time spent (no.; % in parentheses[1]) of 62 participants for 3 microlearning courses on tube feeding, bottle feeding, and measuring colostrum quality

Item	Tube feeding	Bottle feeding	Colostrum quality
Actual time spent (min:s)	11:33 ± 06:21	11:14 ± 06:17	10:04 ± 05:40
Participant-estimated time			
<4 min	3/26 (11)	2/25 (8)	1/11 (9)
4-5 min	8/26 (30)	8/25 (32)	4/11 (36)
6-8 min	6/26 (22)	4/25 (16)	4/11 (36)
9-10 min	8/26 (30)	6/25 (24)	0/0 (0)
>10 min	1/26 (4)	5/25 (20)	2/11 (18)

[1]Due to rounding, percentages do not always add up to exactly 100%.

Table 3. Frequency distribution (no.; % in parentheses) of 64 participants who completed a survey embedded in 3 microlearning courses on tube feeding, bottle feeding, and measuring colostrum quality

Answer[1]	Tube feeding	Bottle feeding	Colostrum quality	All 3 courses combined
Absolutely	23/27 (85)	19/25 (76)	8/12 (66)	50/64 (78)
Undecided	2/27 (7)	5/25 (20)	2/12 (17)	9/64 (14)
Not really	1/27 (4)	1/25 (4)	2/12 (17)	4/64 (6)
Not answered	1/27 (4)	0/0 (0)	0/0 (0)	1/64 (2)

[1]Participants answered the question “Do you feel more confident to perform the task after taking the course?” on a 3-point scale: absolutely, undecided, and not really.

Table 4. Number (% in parentheses) of participants who navigated through the “relevant background information” section and who selected the “standard operating procedure” section for 3 microlearning courses on tube feeding, bottle feeding, and measuring colostrum quality

Section	Tube feeding	Bottle feeding	Colostrum quality
Relevant background information	42/49 (86)	35/39 (90)	27/29 (93)
0 or 1 question(s) selected	7/42 (17)	8/35 (23)	12/27 (44)
≥2 questions selected	35/42 (83)	27/35 (77)	15/27 (56)
Standard operating procedure	45/49 (92)	35/39 (90)	27/28 (96)

3.4 Acknowledgements

We gratefully appreciate the cooperation and patience of the farms that allowed us to use their facilities and animals for standard operating procedure creation. Anne Hesse was partially funded by Tiergyn e.V. (Berlin, Germany).

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4 ADDITIONAL WORK

4.1 SOP 1: Tube feeding colostrum to newborn calves

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Tube Feeding Colostrum

Dairy Routines

QA made easy…

General Description

This SOP describes how to correctly apply colostrum to newborn calves with a tube feeder. Colostrum feeding is the most important measure to prevent disease if the calf does not drink enough colostrum voluntarily within the first 4 hours after birth.

Safety Instructions

Restrain the calf securely and handle it with care during the procedure to avoid unnecessary stress or injury.

Clean and disinfect all materials after use.

Wear disposable gloves.

We recommend using a colostrum feeder consisting of a bag and flexible tube.

A dairy farm is a hazardous environment. Beware of cow movement and heavy machinery.

Apply low stress stockmanship skills. Adhere to animal welfare guidelines.

Materials			
No	**Image**	**Name**	**Description**
1		Esophageal tube feeder for calves	Use a colostrum feeder consisting of a bag and a flexible tube. The clip stops or starts the flow. Check the tube and bulb for damages prior to every use. There must not be any sharp edges.
2		Colostrum	By the time of feeding, the colostrum should have a temperature of 100-102°F (38-39°C).

Steps		
Description	**Image**	**Instruction**
Fill the feeder		The colostrum temperature must not exceed 108°F (42°C). During feeding, the temperature should be between 100-102°F (38-39°C)
Lubricate tube		Moisten the end of the tube with clean water.
Restrain calf		Securely hold the calf and support its head.
Beware		If the calf is unable to stand, restrain it in sternal recumbency and support its head. It must not lie flat on the side during tube feeding!
Insert tube		Raise the calf's head and open the mouth. Introduce the tube slowly to the back of the throat. Slide the tube along the roof of the mouth to either side of the tongue.

Wait for swallowing		You will feel a resistance when the tube reaches the larynx. Wait for the calf to swallow the tube.
Slide tube		When the calf swallows the tube, gently slide it down the esophagus until the rigid part of the tube is level with the nose. If the calf starts coughing, pull out the tube and re-insert.
Check position		Hold the tube in place. Check its position on the left side of the neck. You should feel the bulb of the tube in the neck. If you cannot feel the bulb, do not administer colostrum! Instead, pull back the tube and re-insert.
Open clip		Open the clip to start the colostrum flow.
Administer colostrum		Raise the feeder above the calf's head and let the colostrum flow through the tube.

Hold tube in place		The calf may vocalize. If it starts coughing, stop the colostrum flow immediately and check the position of the tube.
Feed at slow speed		The lower you hold the feeder, the slower the colostrum will flow. Administer colostrum slowly to avoid regurgitation.
Close clip		Close the clip before removal.
Remove tube		Remove the tube gently in one swift movement.
Clean equipment		Clean and disinfect the feeder immediately after use and let it dry.

Important

To ensure an optimal supply with antibodies, the newborn calf needs one gallon (3,6 ltr) of colostrum within the first 4 hours after birth. If the calf does not (or cannot) drink this amount voluntarily apply the colostrum with the esophageal tube feeder. This can help to save the life of the calf.

High quality colostrum must be harvested within 4 hours after birth. If this time is exceeded, the colostrum must not be used for initial colostrum feeding.

To restrain the calf securely, back it into a corner. Alternatively, seek assistance with a second person.

Always double check the correct position of the tube in the esophagus. Palpate the left side of the calf's neck. You should feel the bulb of the tube in the neck. If you cannot feel the bulb, do not administer colostrum!

If you find the tube to be misplaced, abort the procedure. Retry after the calf is breathing normally again.

It is very important to use clean equipment. Pathogens result in a significant restriction of antibody absorption and cause severe diseases.

All equipment must be in perfect condition. Damaged materials cannot be cleaned and disinfected properly resulting in higher numbers of pathogens.

Related SOP

Cleaning calf utensils

Harvesting high quality colostrum

Storaging and heating colostrum

Pasteurizing colostrum

Checking colostrum supply in calves

Imprint

Species	Dairy
Version	1.0
Last update	Mar-21-2017
Valid until	Sep-20-2017
Generated by	**Anne Hesse; Blake Ngyuen**
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Disclaimer

This Standard Operating Procedure (SOP) was developed based on a compilation of science based information, knowledge, field experience, and general industry practices to provide guidance to specified personnel in performing the activities defined herein, in a consistent and standardized manner. This document does not contain regulatory or statutory requirements unless specified.
We have made every attempt to present the information in a clear and concise manner for a variety of users. However, we are not responsible for the misuse or misinterpretation of the information presented herein. Under no circumstances shall we be liable for any actions taken or omissions made by users of this document.

4.2 SOP 2: Cornell Vet School TD Milking Routine

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Cornell Vet School TD Milking Routine

Dairy Routines

QA made easy…

General Description

This SOP explains the milking routine for the Cornell Vet School Teaching Dairy.

Safety Instructions

Wear disposable gloves.

A dairy farm is a hazardous environment. Beware of cow movement and heavy machinery.

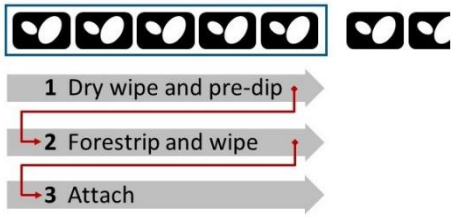
Apply low stress stockmanship skills. Adhere to animal welfare guidelines.

Operate crowd gate with care.

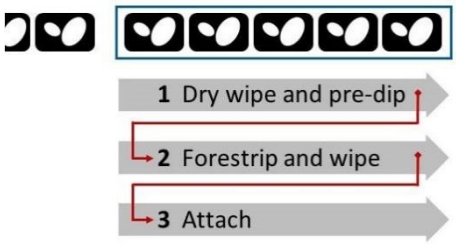
Materials

Disposable gloves
Clean, dry cloths

Steps

No	Image	Description
Start point		Start with the first cow that walked into the parlor.
Leg bands		Watch for leg bands and inflamed quarters (see “Important Information”).
Work in zones		Work in zones of 5 cows with 3 passes: **1** Dry wipe and pre-dip **2** Forestrip, check for signs of mastitis, and wipe **3** Attach
Wipe and dip		Dry wipe and pre-dip each teat of the first cow.
Work thoroughly		Cover each teat entirely with pre-dip. Dry-wipe and pre-dip the next 4 cows.

Forestrip		Return to the first cow. Forestrip: 3-4 strips from each teat.
Check milk		Look for signs of mastitis. Cows with abnormal milk must be milked into a pail.
Wipe each teat		Wipe pre-dip off completely. Forestrip, check milk, and wipe the next 4 cows.
Check teat ends		Make sure the teat ends are clean.
Return to first cow		Attach the unit. The machine should hang directly below the udder. If you hear squawks, realign. Attach the next 4 cows.

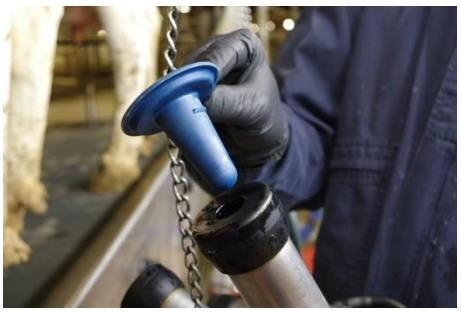
Next zone		Repeat the 3 passes for the next zone.
Post dip		When units come off, post-dip. Cover the teats completely

Important

Three-quartered cows wear leg bands on the side of the dry quarter. These quarters must not be milked.

YELLOW → FRONT

BLUE → REAR



Plug the respective teat cup.

Cows wearing 2 red or pink leg bands must be milked into a pail.

Do not forget to put on “manual”. 

Ensure proper unit alignment to avoid unbalanced milking and squawks.

If necessary, adjust the units.

Related SOP

Collecting sterile milk samples

Milking into a pail

Imprint

Species	Dairy
Version	3.0
Last update	Mar-13-2017
Valid until	Sep-12-2017
Generated by	**Paula Ospina; Anne Hesse**
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Disclaimer

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We have made every attempt to present the information in a clear and concise manner for a variety of users. However, we are not responsible for the misuse or misinterpretation of the information presented herein. Under no circumstances shall we be liable for any actions taken or omissions made by users of this document.

5 DISCUSSION

The objectives of this thesis were 1) to gain insight into the organization of work processes and employee training on German dairy farms, 2) to identify the most important challenges in SOP implementation and 3) to determine if online microlearning courses were beneficial for teaching dairy personnel to successfully perform tasks related to dairy calf health.

The results from the first study indicated that farmers see the need for improvement on their farm but lack the know-how and the time to implement written instructions or do not see the importance of written SOP for the consistency of work performance. However, the demographic change of the dairy industry requires dairy managers to increasingly manage employees and implement best management practices (LeBlanc et al., 2006; Cummins et al., 2016). Especially farmers that used to manage small family businesses struggle with this transition (Reynolds et al., 2013) which is substantiated by our finding that medium-sized and large farms were more likely to have SOP than small farms, respectively. Expanding dairies increasingly rely on nonfamily and foreign labour (Bewley et al., 2001; Barkema et al., 2015; Susanto et al., 2010) and an increasing percentage of dairy employees has no farming background and has not received formal agricultural training (Reynolds, 2013). Thus, herd managers on such farms have to overcome language barriers and communication challenges (Barkema et al., 2015; Erskine et al., 2015) even though they are not trained nor inclined to serve as an educator (Erskine et al., 2015). This might explain the discrepancy of the farmers stating to have SOP which are neither written down, nor accessible to employees at all times. Seventy percent of the farmers did not provide any SOP for their trainees, even though trainees might benefit from SOP the most. Obviously, farmers did not see the importance of SOP for the consistency of work performance even though the majority of respondents stated that different employees completed the same tasks differently. In addition, larger farms require a higher level of management ability to ensure high quality work of their employees (Bewley et al., 2001; Winsten et al., 2010). The implementation of SOP becomes an essential management tool (Barragan et al., 2016). Supporting this hypothesis is the finding in our study, that large farms were more likely to have SOP than small farms. Furthermore, herd managers on larger dairy farms are more likely to interact with veterinarians and consultants on a regular basis. This allows for regular revising of the SOP and protocols to implement corrective measures, if needed (Barragan et al., 2016). However, Sixty-three percent of the respondents stated that they do not check the validity of their SOP on a regular basis. Veterinarians are seen as important advisors on many dairies (Moore et al., 2016) and hold a unique position to provide inputs (van der Leek, 2015). Most respondents stated that they sought the assistance of a veterinarian in developing SOP. This finding increases the importance of the vet's role in

assisting and mentoring on the farm. As part of a valid veterinary-client relationship, veterinarians should provide written treatment protocols (AABP, 2013). However, the awareness for the importance of employee management is yet increasable (Durst et al., 2018). The diversity of farm structures has been pointed out as one challenge of standardized mastitis control programs (Schewe et al., 2015). This diversity requires SOP and treatment protocols that are farm-specific and revised regularly. The design of generic SOP that can be adapted to the needs of a particular farm could be one possibility to support farmers implementing SOP on their farm. In addition to SOP implementation, regular training is important to improve employee performance (Elnaga, 2013) and avoid procedural drift (Biagiotti, 2016). It has been stated that the physical health and well-being of farm workers is not often proactively addressed on modern dairy farms (Reynolds et al., 2013). Employment of an increasing percentage of foreign workers and employees without any farming background increases the importance of training.

For our second study, we embedded calf related SOP into online microlearning courses related to calf health. The objective was to determine whether dairy personnel accessed these courses and could improve their self-estimated performance. It has been stated that computer-assisted instructions can be a useful addition or even alternative to traditional teaching methodologies in animal science (Johnson et al., 1992) and training of medical students (Xeroulis et al., 2007). However, taking into account the diversity of dairy employees (e.g., cultural background, language, social media experience, age) could be valuable when developing training (Sischo et al., 2019). Microlearning that is available online poses a great opportunity to address this diversity, as it is easily adjustable and can be provided in any language. Colostrum management is one of the most important factors for dairy calf health. Measuring colostrum quality has been perceived as important by 45% of the dairy producers in the United States and yet, only 10% had implemented a protocol on their farm (Pempek et al., 2017). This goes in line with the findings in our first study and clearly shows the discrepancy between the awareness for important management practices on the farm and the actual state. Studies have shown that most workers are interested in learning (Durst et al., 2018) and want to know why they have to complete a task in a particular way (Liebenow, 2018). The participants in our second study mostly took the courses in their leisure time and underestimated the time they spent in the courses. This is indicative for a high level of motivation as has been stated by Conti, 2001. The courses received a high rating and participants embraced the possibility to provide feedback and to pose questions related to the execution of the courses. Some participants contacted the researchers several months after the study had been conducted to express their interest in further microlearning courses. Most participants were convinced to work more accurately after having taken the courses.

Furthermore, most participants that completed the embedded survey stated that even a repetition of existent knowledge was worthwhile. This indicates the value of providing employees with regular training units and online training material that they can access in point of interest. It has been shown that the farmer's intention of using smartphone apps is positively influenced by its perceived usefulness and ease of use (Michels et al., 2019). A recently published study found a correlation between herd size and implementation of new precision technologies (Gargiulo et al., 2018). We assume that this might be also true for the implementation of other innovative technologies, such as smartphone apps that provide training online. Interestingly, it has been stated that communicating with different farmers could be challenging due to different types of character which might have had an influence on participation in our studies (Jansen et al., 2010).

6 SUMMARY

Optimization of work processes on dairy farms considering calf management

The objectives of this thesis were 1) to gain insight into the organization of work processes and employee training on German dairy farms, 2) to identify the most important challenges in SOP implementation and 3) to determine if online microlearning courses were beneficial for teaching dairy personnel to successfully perform tasks related to dairy calf health.

The German dairy industry is undergoing a trend towards larger farms with more employees and a higher percentage of non-family labor. Farm owners and herdspersons need to expand their management skills towards managing work force and ensuring quality employee performance. To gain insight into the organization of work processes and employee training on German dairy farms, farmers were invited to complete a comprehensive questionnaire that consisted of 16 questions and 9 statements focusing on general farm data; the generation, implementation, and handling of SOP; and assessment of challenges in handling work processes on the farm. A total of 248 questionnaires was included into the analysis. Categorizing farms based on cow numbers 23% of the farms were small (up to 100 cows; mean ± SE = 75.4 ± 2.7), 52% were medium (101–500 cows; mean ± SE = 265.8 ± 10.4), and 23% were large (>500 cows; mean ± SE = 935.9 ± 55.9), respectively. The majority of respondents (82%) indicated that SOP existed on their farm. Farm size had a significant influence on the existence of SOP, such that medium and large farms were 2.11 (95% CI = 1.04–4.29; P = 0.039) and 5.63 (95% CI = 1.78–17.83; P = 0.003) times more likely to have SOP than small farms. Standard operating procedures most frequently existed for feeding (73%), milking (73%), calf handling (64%), and management of fresh cows (54%). Interestingly, merely half of the respondents (54%) stated that their SOP were available in writing and on 48% of the farms, the employees did not have free access to the SOP at all times. Whether the SOP were written down depended on farm size (P = 0.002) such that medium and large farms were 2.08 times (95% CI = 1.08–4.03; P = 0.030) and 7.24 times (95% CI = 3.21–16.32; P < 0.001) more likely to write down their SOP, respectively, compared to small farms. Almost all respondents (98%) saw the need for improving certain areas on their farm and 66% percent of the participants agreed or strongly agreed with the statement that various employees handled the same tasks differently. Consistent work performance, monitoring of work processes and improvement of animal health were considered potential benefits of SOP by 86%, 49% and 39% of the respondents, respectively. However, many farmers lacked the time (41%) or ability (42%) to create SOP to provide the employees with detailed instructions on how to perform a specific task. The majority of respondents (59%) were interested in using ready-made SOP that could be adjusted to their farm.

The objective of the second study was to determine whether an SOP embedded into an online microlearning course was accessed by dairy personnel and whether it could improve self-estimated performance of tasks related to dairy calf health. Our working hypothesis was that such microlearning courses were effective at creating feelings of confidence and accuracy in work performance. Three online microlearning courses addressing colostrum management as a fundamental basis of dairy calf health (i.e., tube feeding colostrum, bottle feeding colostrum, measuring colostrum quality) were developed with a cloud-based authoring software (Gomo Learning, Brighton, UK). The courses were accessible online and could be accessed at any time and repeatedly. A 12-item survey form was embedded into each course that provided data on course perception and feedback. Two questions covered the time of course completion (i.e., whether the course was accessed during work or leisure time). Learner experiences such as access, page visits, total time spent, completion, and quiz scores were observed with the learning management system (Gomo Learning). Quantitative data were collected with 5-point Likert scales and reported as frequencies and percentages. For all 3 courses (i.e. tube feeding colostrum, bottle feeding colostrum, measuring colostrum quality) combined, 243 invitations were mailed out and 117 participants (48%) launched the courses. The SOP represented one part within the course and was accessed by almost all participants (i.e., 92, 90, and 96% in the first, second, and third course, respectively). Overall, 59% (22/37) launched the course in their leisure time and 80% stated that they were convinced to work more accurately after having taken the course. Most employees underestimated the time spent in the course (76%), accessed background information (89%), or provided feedback (55%). These observations are indicative of high engagement. Overall, 78% of employees felt more confident in correct task completion after the training. After the second and third courses, 76 and 83% of participants, respectively, strongly agreed that repetition of such knowledge was worthwhile. Overall, the 3 courses were rated as very good or good by 89% of the participants. The participants were eager to gain knowledge and were willing to use their leisure time for their training. The high level of motivation was substantiated by the underestimation of the time spent on the courses. Clearly, the courses were effective at creating a feeling of confidence and accuracy in work performance, as most people were convinced to work more accurately after having taken the courses.

Overall, the results of this thesis show that there is a need for standardization of work processes on German dairy farms. Farmers oftentimes lack the time and know-how of SOP implementation and they appreciate the allocation of ready-made SOP and background information. This poses an opportunity for veterinarians and consultants to support the farmers and improve employee management and work processes on the farm.

7 ZUSAMMENFASSUNG

Optimierung von Arbeitsabläufen auf Milchviehbetrieben, dargestellt am Beispiel der Kälberaufzucht

Ziel dieser Studie war es, 1) Einblicke in die Organisation von Arbeitsprozessen und Mitarbeitertraining auf deutschen Milchviehbetrieben zu erhalten, 2) die wichtigsten Hürden im Erstellen und Implementieren von SOPs zu ermitteln und 3) die Wirksamkeit Web-basierter Trainingseinheiten auf die korrekte Arbeitsausführung im Bereich der Kälbergesundheit dahingehend zu prüfen.

Die deutsche Milchviehindustrie verzeichnet seit Jahren einen Trend, weg von kleinen Familienbetrieben und hin zu größeren Betrieben mit mehr Angestellten und Fremdarbeitskräften. Diese Entwicklung erfordert es, dass Betriebseigentümer und Herdenmanager ihre Fähigkeiten erweitern müssen, um durch gezieltes Personalmanagement eine gute Qualität in der Arbeitsausführung der Mitarbeiter sicherzustellen.

Ein detaillierter Fragebogen wurde entwickelt, um einen Einblick in die Struktur von Arbeitsprozessen und Mitarbeitertraining auf den Betrieben zu erhalten. Erfragt wurden allgemeine Betriebsdaten, Details zum Vorhandensein, der Generierung und Implementation, sowie der Umgang mit SOP auf dem Betrieb. Weiterhin konnten die Teilnehmer Angaben zu Problemen und Herausforderungen bezüglich des Umgangs mit Arbeitsprozessen auf ihrem Betrieb machen.

Insgesamt konnten die Fragebögen von 248 Teilnehmern in die Analyse eingeschlossen werden. Nach der Erstellung von 3 Größenkategorien anhand der Tierzahl, wurden 23% der Betriebe als klein (0-100 Kühe; Durchschnitt ± SE = 75.4 ± 2.7), 52% als mittelgroß (101-500 Kühe; Mittelwert ± SE = 265.8 ± 10.4) und 23% als groß (>500 Kühe; Mittelwert ± SE = 935.9 ± 55.9) kategorisiert. Die Mehrzahl der Teilnehmer (82%) gab an, dass SOP auf ihrem Betrieb vorhanden waren, wobei dies signifikant durch die Betriebsgröße beeinflusst wurde. Mittelgroße und große Betriebe waren 2.11 (95% CI = 1.04–4.29; P = 0.039) and 5.63 (95% CI = 1.78–17.83; P = 0.003) Mal wahrscheinlicher SOP zu haben als kleine Betriebe. Die meisten SOP existierten im Bereich der Fütterung (73%), des Melkens (73%), der Kälberaufzucht (64%) und der Frischabkalber (54%). Interessanterweise waren die SOP nur auf etwa der Hälfte der Betriebe (54%) aufgeschrieben und auf 48% der Betriebe nicht jederzeit zugänglich für die Mitarbeiter. Die Betriebsgröße hatte entscheidenden Einfluss darauf, ob die SOP aufgeschrieben waren (P = 0.002). Die Wahrscheinlichkeit war auf mittelgroßen und großen Betrieben 2.08 Mal (95% CI = 1.08–4.03; P = 0.030) und 7.24 Mal (95% CI = 3.21–16.32; P < 0.001) größer als auf kleinen Betrieben. Annähernd alle Teilnehmer

(98%) gaben an, dass sie die Verbesserung bestimmter Bereiche auf dem Betrieb als notwendig ansahen und 66% stimmten zu, dass verschiedene Mitarbeiter die gleichen Aufgaben in unterschiedlicher Art und Weise erledigten. Mögliche Vorteile von SOP wurden in der einheitlichen Arbeitserledigung (86%), der Kontrolle von Arbeitsabläufen (49%) und der Verbesserung von Tiergesundheit (39%) gesehen. Viele Teilnehmer gaben allerdings an, dass ihnen entweder die Zeit (41%) oder die Fähigkeit (42%) fehlte, um SOP zu erstellen, die ihren Mitarbeitern detaillierte Anleitungen für bestimmte Arbeitsabläufe geben würden. Die Mehrzahl der Teilnehmer (59%) war interessiert an fertiggestellten SOP, die man nach Bedarf an den Betrieb anpassen kann.

Im Rahmen der zweiten Studie wollten wir herausfinden, ob Mitarbeiter der Milchviehhaltung auf SOP zugreifen, die in Web-basierte Trainingseinheiten eingebettet sind. Weiterhin wollten wir wissen, ob dadurch die selbsteingeschätzte Richtigkeit in der Arbeitsdurchführung gesteigert werden konnte. Unsere Arbeitshypothese war, dass solche Trainingseinheiten ein Gefühl von Selbstvertrauen und Genauigkeit bei der Arbeitsausführung schaffen können. Dafür wurden 3 Web-basierte Kurse mithilfe einer Cloud-basierten Autorensoftware (Gomo Learning, Brighton, UK) entworfen. Diese befassten sich mit dem Kolostrum-Management (Drenchen von Kolostrum, Fütterung von Kolostrum mit der Nuckelflasche, Messung der Kolostrum-Qualität) als fundamentalem Bestandteil der Kälbergesundheit. Die Kurse waren online verfügbar und konnten jederzeit, auch mehrfach, aufgerufen werden. Jeder Kurs beinhaltete zudem einen Fragebogen, der durch 12 Fragen die Wahrnehmung zum jeweiligen Kurs und ein Feedback erfragte. Zwei Fragen bezogen sich darauf, ob der Kurs während der Arbeits- oder Freizeit gemacht wurde. Mithilfe der Cloud-basierten Autorensoftware (Gomo Learning) wurden alle Aktivitäten der Teilnehmer innerhalb der Kurse erfasst. Dazu zählten Zeitpunkt, Anzahl und Dauer der Aufrufe, Details zur Navigation innerhalb der Kurse, sowie zur Quiz-Teilnahme. Die quantitativen Daten wurden anhand von 5-stufigen Likert-Skalen erfasst und als Häufigkeiten und prozentuale Anteile beschrieben. Für alle drei Kurse zusammen (Drenchen von Kolostrum, Fütterung von Kolostrum mit der Nuckelflasche, Messung der Kolostrum-Qualität) wurden Einladungen an 243 Teilnehmer verschickt, von denen 117 (48%) auf die Kurse zugriffen. Die jeweilige SOP stellte einen Teil des Kurses dar und wurde von fast allen Teilnehmern (92, 90 und 96% für den ersten, zweiten und dritten Kurs) aufgerufen. Insgesamt starteten 59% (22/37) den Kurs in ihrer Freizeit und 80% der Teilnehmer gaben an, dass sie nach der Kursdurchführung überzeugt waren, den jeweiligen Arbeitsprozess genauer durchzuführen. Die meisten Mitarbeiter (76%) unterschätzten die Zeit, die sie in den Kursen verbrachten. Die Mehrzahl (89%) schaute sich die bereitgestellten Hintergrundinformationen im Kurs an und mehr als die Hälfte der Teilnehmer gab ein Feedback zum jeweiligen Kurs. Diese Ergebnisse sprechen für eine hohe Motivation und

Engagement. Insgesamt gaben 78% der Teilnehmer an, dass sie sich nach den Kursen sicherer fühlten, die Arbeitsprozesse korrekt durchzuführen. Zu der Aussage, dass die Wiederholung von Wissen wertvoll sei, gaben nach Durchführung des zweiten und dritten Kurses 76, beziehungsweise 83% an, dass sie diese Aussage als sehr zutreffend empfanden. Alle drei Kurse wurden von 89% als sehr gut oder gut bewertet. Die Teilnehmer waren lernbegierig und bereit, die Trainingseinheiten in ihrer Freizeit durchzuführen. Die Tatsache, dass die meisten Teilnehmer ihren Zeitaufwand für die Kurse unterschätzten, zeigt ein hohes Maß an Motivation. Offensichtlich waren die Kurse geeignet, um Selbstvertrauen und ein Gefühl von Sicherheit in der korrekten Arbeitsdurchführung zu schaffen.

Die Ergebnisse der Studie zeigen, dass die Standardisierung von Arbeitsprozessen auf deutschen Betrieben ein zentrales Thema ist. Vielen Landwirten fehlen zumeist das Wissen und die Fähigkeiten für die Erstellung von SOP. Sie sind dankbar für die Bereitstellung von SOP und Hintergrundinformationen. Das eröffnet eine Gelegenheit für Tierärzte und Betriebsberater, die Betriebe im Bereich des Mitarbeitermanagements und der Standardisierung von Arbeitsprozessen mehr und besser zu unterstützen.

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9 PUBLICATIONS

Research articles

Hesse, A., S. Bertulat, and W. Heuwieser. (2017):
Survey of work processes on German dairy farms.
Journal of Dairy Science. 100:1–9.

P. Ospina, D. Nydam, A. Hesse, and W. Heuwieser (2017):
Farms can ensure better milking technique.
Hoard's Dairyman. April 25, 2017.

Hesse, A., P. Ospina, M. Wieland, F. A. Leal Yepes, B. Nguyen, W. Heuwieser. (2019): Short communication: Microlearning courses are effective at increasing the feelings of confidence and accuracy in the work of dairy personnel.
Journal of Dairy Science. 102:9505–9511.

Oral presentations

Hesse, A. (2016): Qualität von Arbeitsabläufen auf landwirtschaftlichen Betrieben. Rinderversammlung bei der ForFarmers GmbH, Beelitz. 13.10.2016.

Poster presentations

Hesse, A., S. Borchardt, J. Lehman, W. Heuwieser. (2016):

Operating procedures for dairy farms and their servicing veterinary practices- an analysis and optimization of the organization of work processes. 29th World Buiatrics Congress. In: The 29th World Buiatrics Congress, Dublin 2016 - Congress Proceedings - Michael Doherty (Hrsg) S. 409 Dublin, Irland: 03.07.-08-07.2016.

Hesse, A., S. Bertulat, and W. Heuwieser (2017): Standard Operating Procedures for Dairy Farms- Optimizing the organization of work processes. ADSA Meeting Pittsburgh, PA, USA. Pittsburgh, 25.06.-28.06.2017.

10 ACKNOWLEDGEMENTS

Ich bedanke mich herzlich bei Herrn Professor Wolfgang Heuwieser für die Möglichkeit, diese spannende und neue Thematik bearbeiten zu dürfen. Sie sind stets mit Motivation und Engagement für mich dagewesen und ich habe mich immer sehr gut betreut gefühlt. Besonderer Dank gilt Ihnen auch für die einzigartige Möglichkeit, einen Teil meiner Zeit an der Cornell University in New York zu verbringen. Die Erfahrungen dort haben nicht nur die Forschungsarbeiten bedeutend vorangebracht, sondern auch meine Zeit als Doktorandin sehr bereichert. Ich danke dem Verein Tiergyn e.V. für die finanzielle Unterstützung.

Meinen Bürokollegen Dr. Carola Fischer-Tenhagen und Dr. Peter Lennart Venjakob danke ich von Herzen für die Unterstützung, Aufmunterung und Ablenkung. Ihr habt mir stets mit Rat und Tat zur Seite gestanden und mir durch schwere Phasen hindurch geholfen. Ohne die täglichen Kaffeepausen mit Euch wäre ich nicht halb so produktiv gewesen!

Ein besonderer Dank gilt Dr. Stefan Borchardt, der mich während der gesamten 4 Jahre maßgeblich unterstützt hat. Du hattest immer ein offenes Ohr und warst für mich da.

Mein Dank gilt auch dem Team der Tierklinik für Fortpflanzung und den vielen Helfern, die für die Fotos der SOPs geduldig Modell gestanden haben. Dr. Stefan Borchardt, Dr. Julia Ruoff, Dr. Katrin Lange, Dr. Anne Rees, Anna-Lisa Voß, Dr. Franziska Sutter und Anna Kossatz, ohne euch wären die SOPs nicht machbar gewesen. Besonderer Dank gilt hier auch den Kollaboratoren der Cornell University Dr. Matthias Wieland, Dr. Franco Leal-Yepes, Dr. Paula Ospina und Dr. Blake Ngyuen. Matthias, du hast dir während meines Aufenthaltes in Cornell viel Zeit genommen und mich super unterstützt. Vielen Dank!

Der größte Dank gilt meinen Eltern Matthias und Gabriele. Ihr habt immer an mich geglaubt und unterstützt alle meine Vorhaben und Träume. Ich danke meinen Eltern und Geschwistern Georg, Susanne und Armin für euer unendliches Verständnis über all die Jahre. Ohne Eure Hilfe wäre diese Arbeit nicht möglich gewesen! Ich bin sehr dankbar, dass es euch gibt!

11 DECLARATION OF INDEPENDENCE

Hiermit bestätige ich, Anne Hesse, dass ich die vorliegende Arbeit selbständig angefertigt habe. Ich versichere, dass ich ausschließlich die angegebenen Quellen und Hilfen in Anspruch genommen habe.

Tabelle 3. Eigener Anteil[1] an den Forschungsprojekten der vorliegenden Dissertation.

	Studie 1[a]	Studie 2[b]	SOP[c,d]
Studienplanung	+++	+++	+++
Datenerhebung	+++	+++	+++
Datenanalyse	+++	+++	+++
Verfassen des Manuskripts	+++	+++	+++
Editieren des Manuskripts	+++	+++	+++

[1]Legende: +++: > 70 %
++: 50-70 %
+: < 50 %

[a] Survey of work processes on German dairy farms

[b] Short communication: Microlearning courses are effective at increasing the feelings of confidence and accuracy in the work of dairy personnel

[c] Tube feeding colostrum

[d] Cornell University Teaching Dairy milking routine

Anne Hesse

Berlin, den 01.07.2020

Druck und Layout: Mensch und Buch Verlag