J. Dairy Sci. 109:1604–1619
https://doi.org/10.3168/jds.2025-26912
© 2026, The Authors. Published by Elsevier Inc. on behalf of the American Dairy Science Association®.
This is an open access article under the CC BY license (https://creativecommons.org/licenses/by/4.0/).

A survey among students of veterinary medicine and agricultural sciences in Germany, Austria, and Switzerland about perception of digital technologies on dairy farms and students' preparedness for the digital transformation in dairy farming

K. R. Weimar,[1] W. Heuwieser,[2] M. Iwersen,[1,3] and M. Drillich[1,4]*
[1]Centre for Systems Transformation and Sustainability, Department for Farm Animals and Veterinary Public Health, University of Veterinary Medicine, 1210 Vienna, Austria
[2]Department of Population Medicine and Diagnostic Sciences, Quality Milk Production Services, Cornell University College of Veterinary Medicine, Ithaca, NY 14850
[3]Clinic for Ruminants with Ambulatory and Herd Health Services, Ludwig-Maximilians-University, 85764 Munich, Germany
[4]Clinic for Farm Animals, Unit for Reproduction Medicine and Udder Health, Faculty of Veterinary Medicine, Freie Universität Berlin, 14163 Berlin, Germany

ABSTRACT

Digital technologies and the internet determine our professional and private everyday life. This also applies to the dairy industry and veterinary practice. The objective of the presented study was to learn more about the perception of digital technologies by students of veterinary medicine (VetMed) and agricultural sciences (AgriSci) in Germany, Austria, and Switzerland. This next generation of farmers and veterinarians will have to deal with digital technologies in their later professional lives and they will have to face societal demands such as animal welfare and the reduced use of pharmaceuticals. We created an online survey comprising 6 sections: (1) demographic data, (2) questions about the participants' relationship to today's dairy industry, (3) participants' perception of digital technologies in everyday life and in the dairy industry, (4) associations based on the effects of images, (5) visions and expectations of the dairy industry in the future. Finally, the participants were asked whether they felt well prepared for the digital transformation in the dairy industry by their colleges. The survey link was sent to the students through their administration or student body of veterinary medicine and agricultural sciences colleges and faculties in Austria, Germany, and Switzerland. In total, 454 questionnaires were eligible for the final analysis, 318 from veterinary medicine students, and 136 from agricultural science students. In general students of both disciplines have a positive attitude toward the use of digital technologies as all participants of the study showed a high acceptance of cows being equipped with sensors. But the survey shows also areas in which the students are skeptical about the technological progress and especially VetMed students did not agree with some procedures in dairy cattle husbandry such as early cow-calf separation and an automatic feeding of calves. They also associated digital technologies with a reduction or even a loss of human-animal relationship. One reason for this can be seen in the preparation for the digital transformation in the dairy industry. Almost 50% of VetMed students were not "adequately prepared" for this transformation during their studies; among AgriSci students, it was one-third of the respondents. The current survey provides a fundament for discussing various topics against the background of digitalization in the dairy industry. Representative examples are veterinary education and the shortage of livestock veterinarians.
Key words: survey, students, digital technologies, digital transformation, dairy industry

INTRODUCTION

The digital transformation and the use of the internet affect our professional and private everyday life. Information is accessible in real time from almost any location and with a variety of devices (Gysin et al., 2019). According to a recent survey, 8 out of 10 German farms use digital technologies (Rohleder et al., 2020). On dairy farms, these technologies are implemented in different areas of the farm (e.g., at milking, feeding, breeding, housing conditions, and animal health management; Medeiros et al., 2022). They can capture a wide range of data on animal health, welfare, and performance, which have the potential to improve farm management. In addition, a shortage of qualified workers, the need for an increased farm efficiency, and a demand for an improved

Received May 9, 2025.
Accepted November 1, 2025.
*Corresponding author: marc.drillich@fu-berlin.de

The list of standard abbreviations for JDS is available at adsa.org/jds-abbreviations-25. Nonstandard abbreviations are available in the Notes.

quality of life for farmers are some of the driving factors behind this development (Medeiros et al., 2022).

Along with the rapid changes in the dairy industry, an adapted veterinary herd health management (**VHHM**) approach is required. Implementing a VHHM program is mandatory in the European Union (**EU**); it has been incorporated into EU law since April 2021 (Ries et al., 2022). The use of digitalization, sensor technologies, real-time interpretation of data, and decision support (assisted by artificial intelligence) have the potential to improve and intensify the VHHM. They can also improve and intensify the cooperation between farmers and other stakeholders in the dairy sector such as nutrition consultants and hoof trimmers.

Previous studies have shown that animal welfare is the number 1 topic of the general public concerning the dairy industry (e.g., in the United States and Germany; Cardoso et al., 2016; Rovers et al., 2019), often in context with expectations on sustainability (Pfeiffer et al., 2021). In many countries, there is a discrepancy among citizens' expectations, societal values, and current animal husbandry and care practices (von Keyserlingk et al., 2009; Busch et al., 2017; Schuppli et al., 2023). For example, as numerous studies have shown, for citizens, animal welfare issues are closely linked to the desire for naturalness, such as pasture access and rearing calves with their dams (Beaver et al., 2020; Cook and von Keyserlingk, 2024).

Little is known about the societal acceptance of the use of digital technologies in the dairy industry. Recently, a German survey by Pfeiffer et al. (2021) revealed that the general attitude toward digital technologies in agriculture is mostly positive, especially when such technologies contribute to animal welfare and sustainability.

Compared with the current generation of farmers and veterinarians, future generations will have to work even more intensively with sensor technologies and digitalization in their professional lives. At the same time, they will be facing societal demands for improved animal welfare, the reduced use of antibiotics and other pharmaceuticals, as well as consumer expectations and food safety. Therefore, it will be necessary for students of both disciplines to acquire sound expertise about digital technologies.

The objective of the present survey was to gain insights into the perception of students of veterinary medicine (**VetMed**) and agricultural sciences (**AgriSci**) on digital technologies and general use of technologies in the dairy industry. The hypotheses to be tested in this study were (1) VetMed and AgriSci students have a positive attitude toward digital technologies; (2) students' perceptions of technologies differ between the disciplines; and (3) students of both disciplines do not feel well prepared for current and future digital technologies in the dairy industry by their colleges. Hypotheses were based on (1) the findings about public acceptance of digital farm technologies (Pfeiffer et al., 2021), (2) the assumption that veterinary students have a strong interest in animal welfare related topics (Kostelnik, 2010), and (3) the described phenomenon of a lack of confidence in preparedness for practice among university graduates (Gilling and Parkinson, 2009).

MATERIALS AND METHODS

Study Design

A questionnaire was created in Microsoft Word (MS Word 2016, Microsoft Corporation, Redmond, WA) and applied through an online survey tool (SurveyMonkey, American polling company, San Mateo, CA). It consisted of 20 closed (n = 11) or open (n = 9) questions and comprised 6 sections: (1) demographic data, (2) questions about the participants' relationship to today's dairy industry, (3) participants' perception of sensor technologies in everyday life in general and in the dairy industry in particular, (4) associations based on the effect of images, (5) visions and expectations of the future of the dairy industry, and (6) students perceptions of the preparation for the digital transformation in the dairy industry by their colleges.

In the introduction, we explained the aim of the survey and gave some examples for recent digital and sensor-based technologies on dairy farms. The first section of the questionnaire consisted of 4 multiple-choice questions regarding gender, study discipline (VetMed or AgriSci), place of study, and the origin of the participants, as well as an open question about the current semester.

In the second section, we asked about the participants' relationship to dairy farms by presenting 4 answering options: "Dairy industry in the family or among friends," "I come from a rural area," "Vacations on a farm or similar activities," and "No connection." Multiple answers were allowed. Furthermore, the students were asked to give a self-assessment on their knowledge of today's dairy industry. Response options in this multiple-choice question were very good, good, moderate, bad, and no answer.

In section 3, we showed 2 examples of cows equipped with sensors (Figure 1), described as similar to fitness trackers. Five statements were provided:

1. I like it. Technological progress helps humans and animals.
2. I find it acceptable if it improves animal health.
3. I do not like it. There is already too much technology in the barn.
4. It is not necessary. The farmer knows his animals best.
5. Not specified.

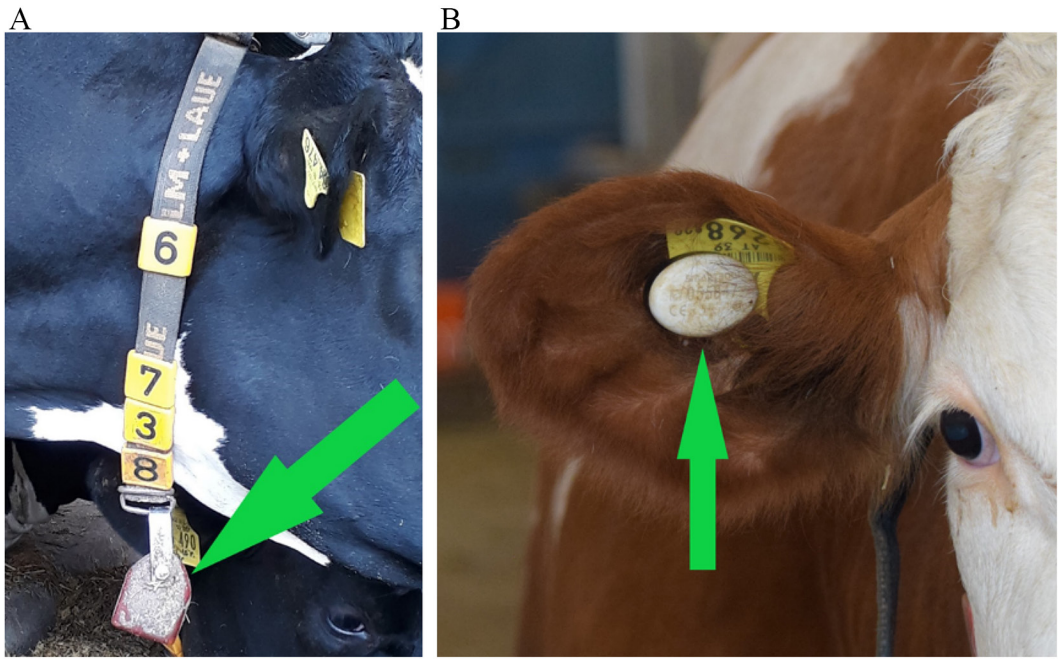

Figure 1. The 2 examples of cows equipped with sensors were shown to illustrate questions: (A) collar-mounted sensor and (B) ear tag.

The next question of this section consisted of 5 statements about technologies and digitalization:

1. I can imagine that with the use of too much technology the bond between farmer and cow gets lost.
2. I would like milk produced without much technology.
3. I can imagine that detecting problems in cows is easier with technical aids.
4. Artificial intelligence increases my confidence in agriculture.
5. Organic farming and digitalization do not go together.

Participants had to assess the statements on a Likert scale with the following options: (1) strongly agree, (2) agree, (3) slightly agree, (4) do not agree, and (5) no statement.

In the last question of this section, we wanted to know what the main objective of using digital technologies in agriculture should be. The following objectives were specified: (1) more animal welfare, (2) reduction of greenhouses gases; (3) conservation of resources, (4) reduction in the use of pharmaceuticals; (5) improvement of the work-life balance for farmers, and (6) maintenance of the international competitiveness of domestic agriculture.The students were asked to rank the items, with 1 being the most important objective. We chose the ordinal ranking with the intention to encourage the participants to make a clear choice, although this does not reflect possible distances between ranks.

In section 4, all questions were open questions. In this section we showed 2 images: a barn office (Figure 2a), and a calf in individual housing drinking milk at an automatic calf feeder (calf rail; Figure 2b). We explained that the farmer uses sensors and digital technologies in his barn to evaluate data and manage his herd. Then we asked for 2 to 3 associations with these images. No limitation on the number of characters or words was specified in the instructions.

With the last question, we wanted to evaluate whether the students feel that they are getting well prepared for the digital transformation in the dairy industry during their education. They were also invited to give a statement by use of 2 to 3 keywords.

A first version of the survey was β-tested with a small group of veterinarians at the department, with a focus on comprehensibility and clarity of the questions. The feedback of this evaluation was integrated into the final version of the survey. The final questionnaire can be found as Supplemental File S1 (see Notes). The survey was submitted to the relevant ethics committee of the Medical University of Vienna. The committee decided that the survey did not require approval.

The next step was to contact the administration or the student body of all 8 veterinary colleges in Germany, Austria, and Switzerland, as well as 11 colleges for agricultural sciences in the 3 countries. They were asked to forward a cover letter with the link to the survey to their students by email. The cover letter stated that answering the questions would take less than 15 min and

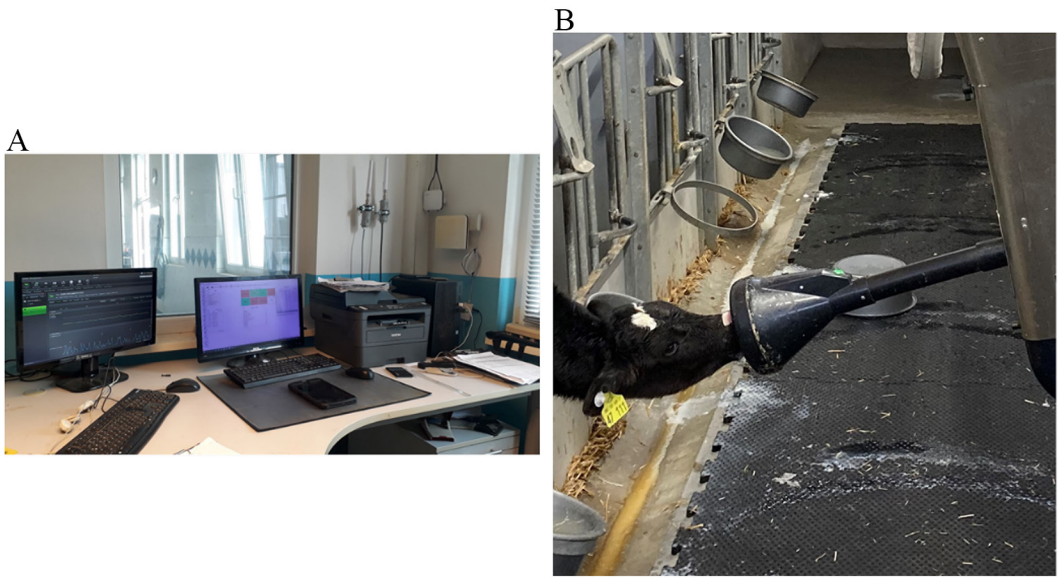

Figure 2. The images of a barn office (A) and an automatic calf feeder (calf rail with individual housing; B) were shown in questions 15 and 16, respectively.

included data protection information in accordance with the standards of the Vetmeduni Vienna. The survey was accessible for 6 wk from November 3 to December 7, 2021. During this time, 2 follow-up emails were sent to the student bodies to increase the number of participants. Participation in the study was voluntary and anonymous. No incentive was offered. The participants were informed that the results would be published. Because our target groups were students at German-speaking colleges, the brief introduction and the questionnaire were in German. The introduction provided relevant information and images for the students of the first semesters to better understand the term sensor and digital technology on dairy farms.

Data Analysis

Questionnaires were eligible for final analysis only if the questions of study discipline, gender, and at least one question from one of the other sections were answered.

The questionnaires were exported in csv format into Excel (MS Excel 2016, Microsoft Cooperation, Redmond, WA) and checked for plausibility and errors. Open questions were analyzed according to Guest et al. (2014) on qualitative data analysis. The first step was to familiarize ourselves with the participants' responses by reading them several times. This made it possible to identify and create main categories for the answers. The next step was to examine how these categories related to each other and which assumptions and interpretations result thereof. Numerical codes were created, and the participants' answers were manually coded by re-reading them (Supplemental File S2, see Notes). After coding the open questions, they were also analyzed quantitatively by calculating frequencies and testing differences (chi-square test) between VetMed and AgriSci students. The comparison of frequencies was conducted to test our second hypothesis that perceptions of digital technologies differ between disciplines. Identifying thematic frequencies allowed us to determine whether specific concerns or expectations were more salient in one academic group, thereby connecting qualitative patterns to our quantitative results. We followed a mixed-methods approach combining inductive category formation and quantitative frequency testing (Mayring, 2019; Kelle, 2022). This triangulation approach enhances interpretive validity by integrating context-sensitive insights with statistical comparisons. Such methods are widely recommended for attitudinal survey research (Guest et al., 2014). The primary objective, however, was to determine the participants' perception about a particular issue. For this purpose, word clouds were created for the spontaneous associations to the 2 images with a software tool (www.wordclouds.com, Zygomatic, Amersfoort, the Netherlands) to visualize the answers. Nonspecific terms (e.g., and, also, for) were removed, and words or phrases with the same meaning (e.g., digital, digitization) were combined into one term.

The complete quantitative data analysis was carried out with SPSS (version 27, IBM Corporation, Armonk, NY). For the descriptive analysis, categorical variables were presented as percentages. For continuous data the mean and SD were calculated. The distribution of the data was statistically tested with the Mann-Whitney-U-test. In the

Table 1. Distribution of students (n = 454) according to discipline and study year

	Year of study, n (%)						
Item[1]	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr ≥6	No answer
VetMed	69 (21.7)	63 (19.8)	68 (21.4)	48 (15.1)	37 (11.6)	29 (9.1)	4 (1.3)
AgriSci	36 (26.5)	34 (25.0)	28 (20.6)	22 (16.2)	10 (7.4)	4 (2.9)	2 (1.5)
Total	105 (23.1)	97 (21.4)	96 (21.1)	70 (15.4)	47 (10.4)	33 (7.3)	6 (1.3)

[1]VetMed = veterinary medicine; AgriSci = agricultural sciences.

case of binary parameters within 2 groups of students (i.e., veterinary medicine and agriculture) a chi-squared test was carried out.

RESULTS

Demographic Data

A total of 496 questionnaires was recorded on SurveyMonkey. After excluding 42 questionnaires, 454 questionnaires were used for the final analyses. Reasons for exclusion were that no answers were given (41/42; 97.6%), or that the answers to the demographic questions did not match (1/42; 2.4%). In the questionnaires used for the final analysis, 318 (70.0%) and 136 (30.0%) participants indicated that they were VetMed and AgriSci students, respectively, from 14 colleges from all 3 included countries (6 VetMed colleges, 8 AgriSci colleges).

The majority of VetMed students were female (84.3%), 14.8% were male, and 0.9% diverse. The participating students of AgriSci were 48.5% male and 51.5% female.

Distribution considering discipline and study year is shown in Table 1.

Relationship to Today's Dairy Industry

Students assessed their knowledge, with 16.2% selecting "very good," 42.9% as "good," and 36.1% as "moderate" (Figure 3). Comparing the 2 disciplines, differences were found regarding the self-assessment score "very good" and "moderate" ($P < 0.001$).

We also asked the students about their relationship toward the dairy industry. A connection to the dairy industry through family or friends was stated by 71.3% of AgriSci students. For the VetMed students this proportion was significantly smaller (37.7%, $P < 0.001$). More VetMed students had a connection through vacations on a farm or similar activities or no references ($P = 0.005$; Figure 4).

Cows Equipped with Sensors

A narrow majority of the participants (51.4%) considered sensors (described as similar to fitness trackers) to be good ("I like it") and saw benefits for animal health and for farm employees. This proportion was greater in AgriSci students compared with VetMed students (69.1%

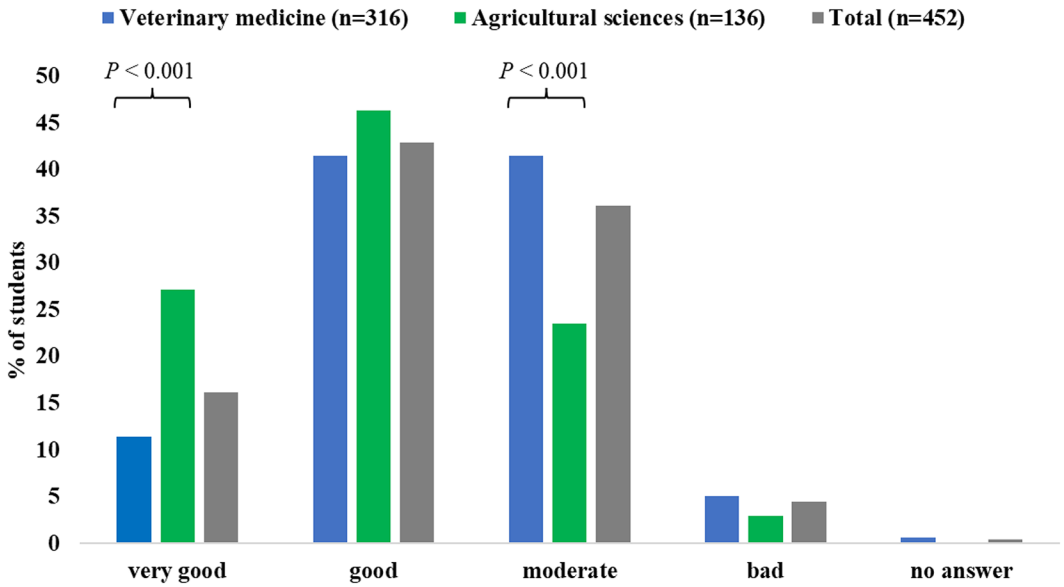

Figure 3. Self-assessment of knowledge about today's dairy industry by students of veterinary medicine and agricultural sciences.

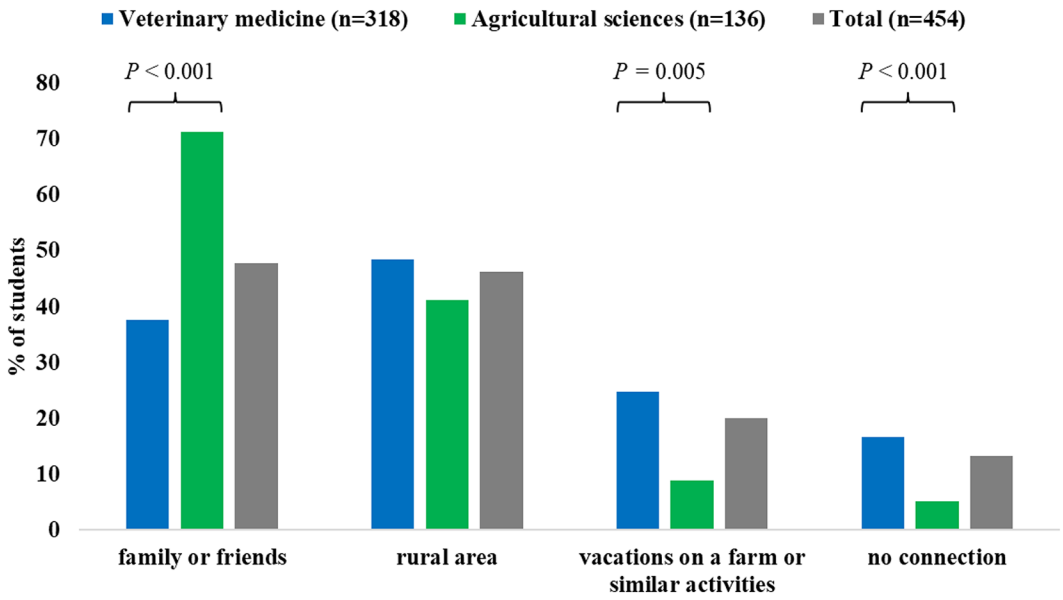

Figure 4. Relationship of veterinary medicine and agricultural sciences students to the dairy industry. Multiple answers were allowed.

vs. 43.8%, $P < 0.001$). Another 44.8% of participants regarded the use of sensors as "acceptable" to improve animal health. A minority (2.9%) rejected the use of sensors in dairy cows (Figure 5).

Assessment of Statements

More than half of the participants agreed (47.3%) or strongly agreed (9.7%) with the statement "I can imagine that with the use of too much technology, the bond between farmer and cow gets lost." Approximately one-third (31.2%) slightly agreed, and 11.3% did not agree. Significant differences existed in the gradation of responses between VetMed and AgriSci students ($P = 0.011$; Table 2).

Opinions on the statement "I would like milk produced without much technology" were similar in both disciplines, with most answers not supporting this statement.

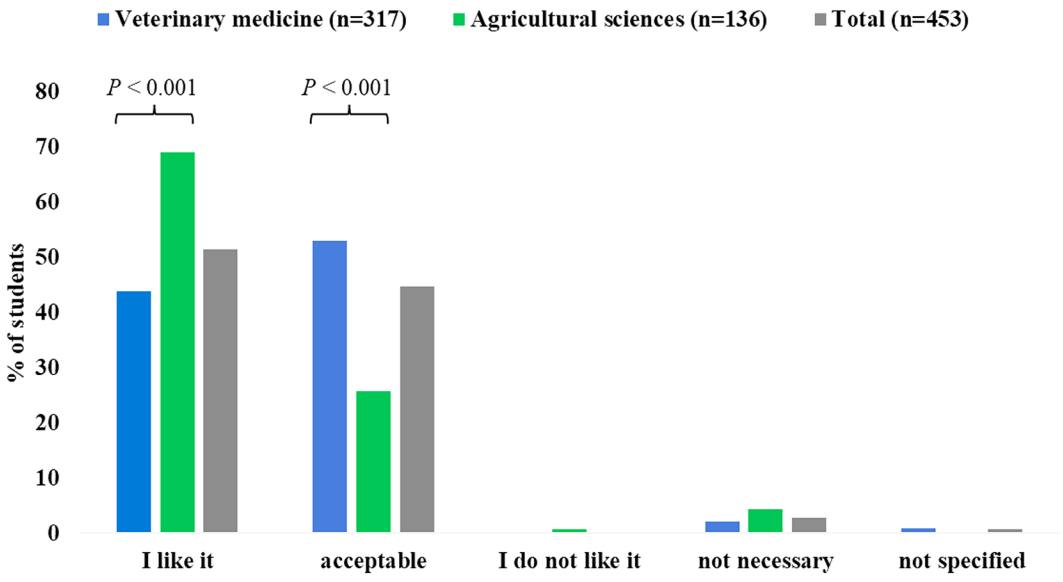

Figure 5. Students' perception of sensors attached to cows.

Table 2. Assessment of the statements on the use of technologies and digitalization in the dairy industry

Statement	Discipline[1] (n)	Answers in each category (%)					Mean for each discipline	SD	*P*-value
		Strongly agree	Agree	Slightly agree	Do not agree	No statement			
I can imagine that with the use of too much technology the bond between farmer and cow gets lost.	VetMed (316)	11.1	48.7	30.7	8.9	0.6	2.36	0.818	0.011
	AgriSci (136)	6.6	44.1	32.4	16.9		2.60	0.847	
I would like milk produced without much technology.	VetMed (317)	0.6	4.7	33.1	54.3	7.3	3.26	1.096	NS[2]
	AgriSci (135)	1.5	8.1	31.9	54.8	3.7	3.33	0.961	
I can imagine that detecting problems in cows is easier with technical aids.	VetMed (317)	36.0	57.4	4.7	0.3	1.6	1.66	0.608	0.003
	AgriSci (136)	53.7	42.6	3.7			1.50	0.571	
Artificial intelligence increases my confidence in agriculture.	VetMed (317)	1.9	14.2	44.8	25.9	13.6	2.67	1.263	NS
	AgriSci (136)	5.1	23.5	27.2	27.2	16.9	2.43	1.386	
Organic farming and digitalization do not go together.	VetMed (317)	0.6	3.8	21.8	71.0	2.8	3.57	0.837	NS
	AgriSci (136)		3.7	19.1	76.5	0.8	3.71	0.610	

[1]VetMed = veterinary medicine; AgriSci = agricultural sciences.

[2]NS = not significant.

In contrast, 94.3% of the participants agreed or strongly agreed with the statement "I can imagine that detecting problems in cows is easier with technical aids."

A narrow majority of students slightly agreed (39.3%) or did not agree (26.3%) with the statement "Artificial intelligence increases my confidence in agriculture."

The final statement "Organic farming and digitalization do not go together" was rejected by the majority of participants, with 72.6% who did not agree and 21.0% who slightly agreed.

Use of Digital Technologies in Dairy Farming

Asked about the most important objective for the use of digital technologies in the dairy industry, participants ranked "Animal welfare" as the highest priority, followed by a "reduced usage of pharmaceuticals" and "farmers' work-life balance." Figure 6 displays the ranking of the objectives for all participants, stratified by discipline for the 3 top-rated objectives. Differences ($P < 0.01$) in the mean rank were found between VetMed and AgriSci for "animal welfare" (1.38 vs. 2.27), "farmers' work-life balance" (3.88 vs. 3.27) and "competitiveness of domestic agriculture" (4.98 vs. 4.29).

Associations with Presented Images

Associations with Image "Barn Office." We identified 7 categories in the answers of VetMed and AgriSci students: positive and neutral connotations, characteristics of the workplace, type of workplace, negative connotations, benefits, terms of digital transformation, and others. No differences were found between the disciplines ($P > 0.05$), except for the answers categorized as benefits (VetMed 11.9% vs. AgriSci 16.8%; $P = 0.038$). Most associations (21.4%) could be categorized as positive or neutral connotations indicated with the dark blue terms in the word cloud (Figure 7). The most frequently mentioned term in this category was "modern" (n = 54). In the category negative connotations (red term in Figure 7) only the term "reduced animal contact" (n = 37) was used frequently.

Associations with the Image "Automatic Calf Feeder." We identified 5 categories of student's answers: negative connotations, positive connotations, disadvantages for calves, terms of digital transformation, and others. Similar to the image of the barn office, there were no differences between the disciplines ($P > 0.05$), except that more answers of VetMed students were categorized as disadvantage for calves (22.2% vs. 15.3%; $P = 0.024$). Frequent terms were presented in a word cloud (Figure 8). The most associations could be found in the category of negative connotations (red term in Figure 8). A closer look at this category revealed that "unnatural" (n = 44) and "impersonal" (n = 37) were the most frequently mentioned terms. In the category of disadvantages for calves (orange term, Figure 8), the participants saw a lack of contact to dam (n = 21) and a lack of human contact (n = 30) as the main disadvantages. The most frequently mentioned association was "adequate feeding, good supply" (n = 62; category of positive connotations, green term in the word cloud, Figure 8).

Preparing Students for the Digital Transformation in the Dairy Industry

Although 36.8% of AgriSci students answered that they were "well prepared by their colleges for the digital transformation in the dairy industry," this proportion was only 20.8% in VetMed students ($P < 0.001$; Table 3). In contrast, 47.2% and 31.6% of the VetMed and the AgriSci students ($P = 0.002$) did not "feel adequately prepared for the digital transformation," respectively.

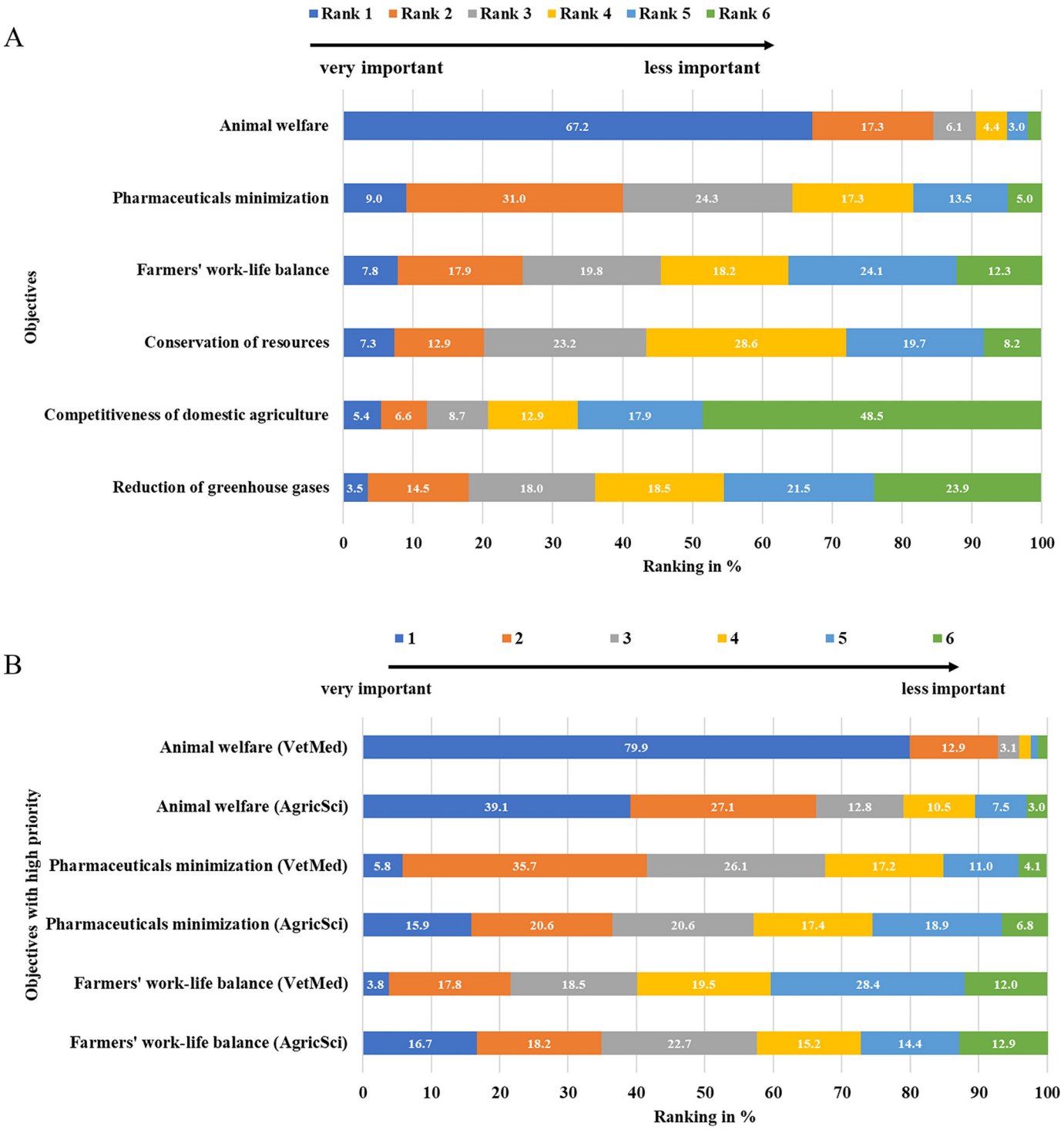

Figure 6. Rank of 6 objectives for the use of digital technologies in the dairy industry (rank 1 = very important, rank 6 = less important) presented for all participants (panel A) and rank of the 3 top objectives stratified by veterinary medicine (VetMed) and agricultural sciences (AgriSci) students (panel B).

Students in the first 2 yr of their studies answered more often that they felt "adequately prepared for the digital transformation" than in the last years (Table 3).

Individual statements by the students included comments regarding the curriculum and teaching in general (e.g., "less practice oriented," "course content is outdat-

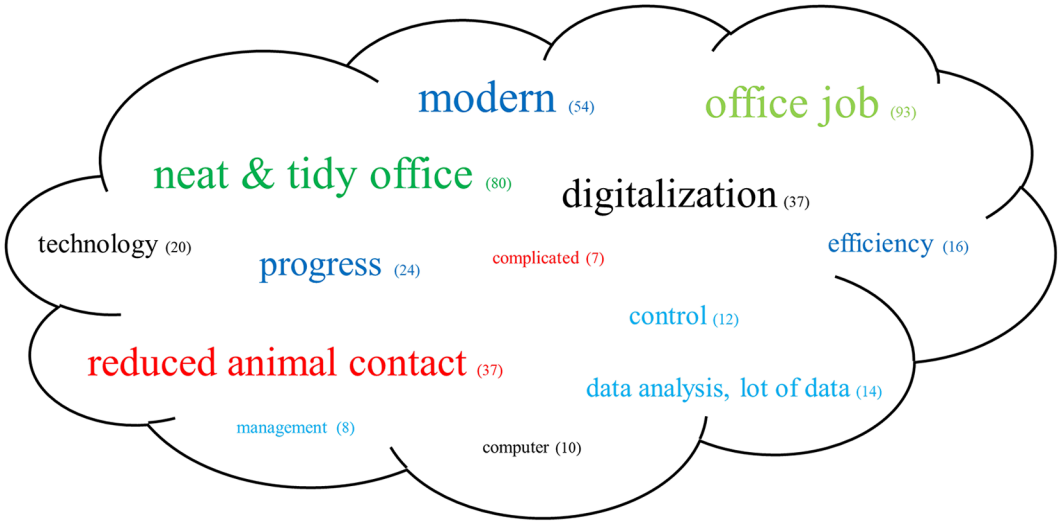

Figure 7. The word cloud shows the most frequent associations with the image of the barn office (number of mentions in parentheses). Positive or neutral connotations were presented in dark blue, characteristics of the workplace in dark green, type of workplace in light green, negative connotations in red, benefits light blue, and terms of digital transformation black. Terms appearing in larger font were used more frequently.

ed," "the college does not even manage to teach digitally, so how can they teach digital technologies," "missing training in the use of technology").

Some VetMed students (n = 8) did not see a need for getting prepared for the digital transformation in the dairy industry. They stated, for example, "You already learn this later on agricultural business" or "It would go too much into detail, and ultimately it only affects a few students."

DISCUSSION

Limitations of This Study

The link to the online survey was distributed to students at universities in Germany, Austria, and Switzerland. Therefore, it is important to note that the results of this study cannot be extrapolated to other countries or regions, especially in regions where curricula differ.

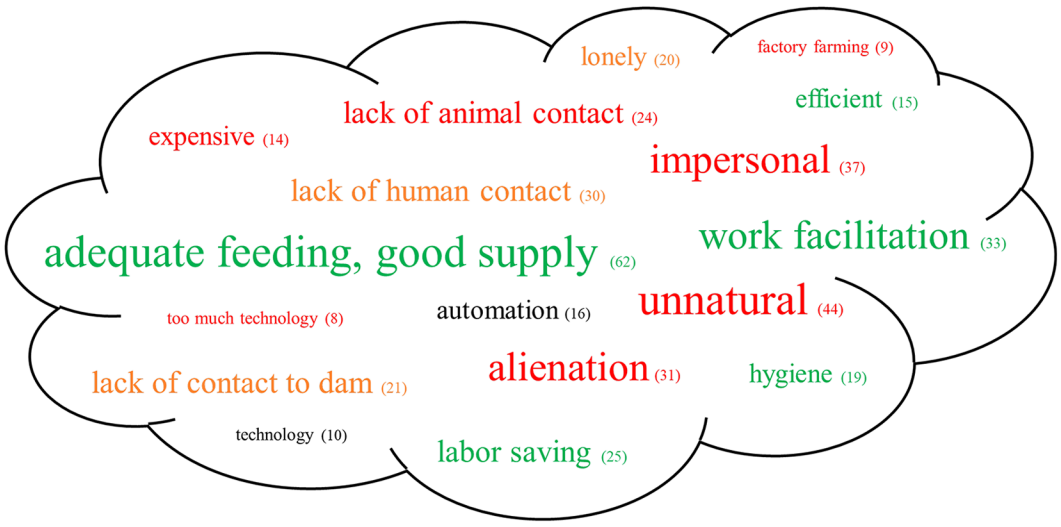

Figure 8. The word cloud shows the most frequent associations with the image of the automatic calf feeder (number of mentions in parentheses). Negative connotations were presented in red, positive connotations in green, disadvantages for calves in orange, and terms of digital transformation black. Terms appearing in larger font were used more frequently.

Table 3. Answers (in %) to the question: "Do you feel adequately prepared for the digital transformation in the dairy industry?"

	% of answers					
Cohort[1]	No	Yes	Partially	Do not know	Probably not	No answer
VetMed	47.2[a]	20.8[c]	11.9	7.9	3.5	8.8
AgriSci	31.6[b]	36.8[d]	13.2	5.9	0.7	11.8
Total	42.5	25.6	12.3	7.3	2.6	9.7
Students in first 2 yr	26.2[c]	34.2[c]	9.9	12.4	4.5	12.9
Last years' students	55.5[d]	19.0[d]	14.6	3.2	1.2	6.5

[a,b]Values in the same column differ significantly between cohorts; $P = 0.002$.

[c,d]Values in the same column differ significantly between cohorts; $P < 0.001$.

[1]VetMed = veterinary medicine; AgriSci = agricultural sciences.

The study does not claim to be representative of the student population. The survey link was distributed through university administrations or student bodies; however, we did not receive confirmation as to whether it was disseminated to all students, or only to specific semesters or subgroups within agricultural sciences. Consequently, the overall response rate cannot be determined. Moreover, it is plausible that students with a particular interest in digital technologies or dairy farming were more inclined to participate, potentially introducing self-selection bias.

Our analysis did not control for potential clustering by institution or country. Given that curricula and exposure to agricultural practice differ across universities and regions, it is plausible that such factors influenced students' preparedness and attitudes. Consequently, our findings should be interpreted as reflecting general tendencies across German-speaking universities rather than institutional effects. Future research should consider multilevel or hierarchical modeling approaches to account for clustering by institution or region. This would enable a more precise evaluation of how curricular design and local agricultural context shape students' digital competence and confidence.

The examples and pictures given in the survey do not represent the full range of digital or sensor technologies that are used on dairy farms. Thus, associations and responses to statements may be biased by the selected examples.

Demographic Data

The gender distribution in the survey was comparable to the gender distribution in both study disciplines at colleges in the EU, United Kingdom, Canada, and the United States in recent years (Kersebohm et al., 2017; Emmett et al., 2019; Hanson, 2024) referred to as the "feminization of veterinary profession" (Kersebohm et al., 2017; Scholz and Trede, 2023). Salary perspectives, for example, play an important role for men, whereas women have a high intrinsic motivation to help. These gender-specific priorities in career choice have often been discussed in the past (Kostelnik, 2010; Usko, 2023).

Relationship to Today's Dairy Industry

Students rated their knowledge of today's dairy industry consistently positive. For AgriSci students, we assume that this assessment was due to their formal education and their family background. Responding to the question about the connection to the dairy industry outside of the curriculum, 71.3% stated a connection to the dairy industry due family and friends (Figure 4). However, we did not ask how many students actually did come from a dairy farm. The VetMed students also rated their knowledge relatively high, with 11.4% and 41.5% choosing "very good" and "good," respectively. Previous studies, however, indicated that VetMed students have inadequate knowledge about agriculture. Farmers described veterinary skills in areas such as husbandry, feeding, milking systems, practical farm routines, and farm economy as insufficient (Kronenberger et al., 2020; Svensson et al., 2022).

Cows Equipped with Sensors

Students from both disciplines had a positive attitude toward sensors attached to cows. One reason could be that the students surveyed had a good basic knowledge about the benefits of these sensors. Another reason could be that the description of the images and the comparison with fitness trackers had an effect toward a positive assessment. The use of fitness trackers for self-monitoring and tracking of activities has increased exponentially in the global population over the last decade (Tricás-Vidal et al., 2022). According to Statista (2017), 33% of the global population aged 15 or more used mobile apps and fitness trackers to track their health in 2016.

Another aspect was the mounting of sensors. Collars and ear tags are common in the dairy industry. As part of the curriculum, students should learn about the EU regu-

lations (European Parliament, 2000, 2019) and the incorporation into national regulations for the identification of bovine animals via ear tags. Therefore, students could have been familiar with ear tags attached to cows. Collars are considered as noninvasive (Mancuso et al., 2023) and are also used for animal identification. As 71.3% of AgriSci students stated a connection to the dairy industry in family or friends, it was likely that they were familiar with sensors and digital technologies. Obviously, limitations to express normal behavior were not associated with sensors and negative emotions did not arise.

Interestingly, the benefits for humans (as stated in one answer option) played a more important role for AgriSci students than for VetMed students (69.1% vs. 43.8%). One possible explanation could be a higher awareness of farmers' work-life balance for AgriSci students. The results from the question about the priority objectives for the use of digital technologies reinforced this assumption. For VetMed students, animal health was the primary concern (53.0% vs. 25.7%) in our study. Previous studies (Kostelnik, 2010; Baumgärtel, 2016) indicated that the desire to help animals, and thus to improve animal health, is the main motivation to study veterinary medicine.

Assessment of Statements

The results of the statements showed that students saw a benefit in technologies, but not without concerns. Concerns were expressed with regard to the statement "I can imagine that with the use of too much technology the bond between farmer and cow gets lost," as the support for this statement was 50/50. Hostiou et al. (2017) described that the integration of technologies into work procedures does not necessarily lead to more disconnection between humans and animals. The authors highlighted risks for the reduction of human-animal relationship, such as the loss of interaction during milking in automatic milking systems (**AMS**). They also gave examples for improving the human-animal relationship after transition. Interactions include the presence of the farmer in the herd to bring individual cows to the AMS or to regularly check the technologies. Wildridge et al. (2020) found in their study that the human-animal relationship had improved after implementing an AMS. In our survey, we did not assess whether students considered the human-animal bond to be important. Consequently, it remains possible that respondents agreed with the statement but regarded the loss of this bond as unimportant or acceptable.

Based on the results of the statements "I would like milk produced without too much technology," "I can imagine that detecting problems in cows is easier with technical aids," and "organic farming and digitalization do not go together," it was evident that students saw benefits of technology in general. A majority agreed that "detecting problems in cows is easier with technical aids." The assessment differed between the 2 disciplines ($P = 0.003$). We assumed that the relationship to today's dairy industry played a role, especially for the AgriSci students. In addition, the term "technical aids" was very broadly defined. In medicine, for example, it also includes blood testing devices and X-ray equipment. For VetMed students, it can therefore be speculated that they had good experiences with aids themselves in the event of health problems or during an internship in a veterinary practice. Students also recognized a benefit for organic agriculture. An example of a benefit is early mastitis detection with generated data of technologies and associated reduction of antibiotics (details described below), an important aspect of the organic dairy industry. Organic farms in particular must adhere to a strict regulation regarding the use of antibiotics (Barkema et al., 2015).

The statement "artificial intelligence increases my confidence in agriculture" was included, to explore whether digital technologies are perceived as enhancing trust in modern agricultural systems. Specifically, we aimed to assess whether AI was associated with increased transparency, reliability, and credibility of agricultural practices. We expected that veterinary students, due to their familiarity with data-driven decision-making and diagnostic tools, would show higher agreement, reflecting an assumption that technological precision fosters confidence. For agricultural science students, who may already possess high baseline trust in their profession, we anticipated less additional confidence attributed to AI. The low level of agreement and high proportion of "no statement" responses (Table 2) indicate uncertainty or limited familiarity with AI applications in agriculture. Moreover, the item may have been interpreted ambiguously, either as trust in agriculture as a sector or in information about agriculture. A clearer baseline assessment of pre-existing trust would have been required for stronger interpretive conclusions and should be incorporated in future surveys. Given the rapid increase in AI awareness and use since 2022, driven by the public uptake of generative artificial intelligence tools such as ChatGPT, it is likely that responses collected today would differ substantially from those obtained in 2021.

Use of Digital Technologies in the Dairy Industry

For the students of both disciplines, the improvement of animal welfare was the most important reason for using digital technologies on farms, underscoring shared ethical values. Nevertheless, a difference was found when comparing the 2 disciplines. The animal welfare objective was even more important for VetMed than for AgriSci students. This is probably related to the inten-

tion with which female VetMed students especially begin their studies (Baumgärtel, 2016). A survey among farmers in Germany (Rohleder et al., 2020) showed that 8 out of 10 farmers saw a potential in digital technologies for improving animal welfare. In a survey among cattle practitioners in Austria, one-third of respondents saw a positive contribution of digitalization to animal welfare (Pospischil et al., 2023).

"Reducing the use of pharmaceuticals" was ranked second place in the current survey. This is not surprising because veterinarians and farmers have been confronted with this issue for years (Barkema et al., 2015; McAloon et al., 2021). Comparing the disciplines, VetMed students ranked animal health and reduction of pharmaceuticals higher, aligning with their clinical and welfare focus.

Above all, reducing the use of antibiotics is a great concern and occupies regulators, professional associations, and the general public. Knowlton and von Keyserlingk (2023) reported a growing public debate regarding antibiotic use in livestock farming in the United States. For example, sensors used in milking equipment and parlors and especially AMS record a wide range of parameters for udder health (Lundström and Lindblom, 2021). Changes in the parameters provide farmers with indicators of health disorders (Bausewein et al., 2022), enabling them to react earlier. This can prevent severe illness and the use of antibiotics (Pakrashi et al., 2023).

Improving work-life balance ranked third among students of AgriSci and fourth among students of VetMed. The importance of work-life balance for students of both disciplines and young professionals has also been identified in other studies (Contzen and Häberli, 2021; Sonneveld et al., 2023; Weltzien, 2023). Especially AgriSci students and farmers saw an improvement in their quality of life by using digital technologies (Häberli et al., 2021). Automatic milking systems are one example, increasing work flexibility, improving work efficiency and satisfaction, and reducing physical workloads (Lundström and Lindblom, 2021). The automatic feed pusher is a second example (Supplemental Material S1). It is a physical relief, reducing working hours and contributing to an improved work-life balance (Romano et al., 2023). For students of both disciplines, the use of data from technologies should also be mentioned as an example of improving work-life balance. Objective data can serve as a decision-support tool and could help to minimize the work pressure that for both professions is often reported in literature (Dürnberger, 2020; Sonneveld et al., 2023). Compared with VetMed students, AgriSci students placed greater emphasis on work-life balance and also on competitiveness, suggesting a stronger management- and efficiency-oriented view.

The objectives "conservation of resources" and "reduction of greenhouse gases" showed a wider distribution of rankings, indicating less consensus or lower perceived personal relevance.

Associations Based on the Effects of Images—Qualitative Analysis

The effect of images on people should not be underestimated. Images or various associations with images do not provide conclusions from empirically obtained data. Associations based on the effects of images are shaped by participants' impressions, feelings, and communication experience (Busch and Hamm, 2015). The authors described that there is a stronger effect of the image as the alienation from the represented object increases. This should be considered when evaluating associations with the images of the barn office and the automatic calf feeder.

Barn Office. The students were predominantly neutral or positive toward the image of the barn office showing a computer with 2 monitors and described it with words such as modern, progress, efficiency. As Figure 7 showed, the most frequent associations were categorized as office job, without giving the terms a connotation. This is not surprising, as the image shows equipment that can be found in an ordinary office. Due to the increased use of technology on dairy farms, the farmer's work is also increasingly shifting to the office to evaluate data generated by various technologies and use it for farm management (Butler et al., 2012).

The word cloud shown in Figure 7, however, also visualized a negative connotation with the comment "reduced animal contact." Students had expressed such concerns also in the statement "I can imagine that with the use of too much technology the bond between farmer and cow gets lost"; details can be found in Figure 7.

The benefits of such an equipped office were especially mentioned by AgriSci students, who more often used terms such as control, management, and data analysis, categorized as benefits. One reason could be that working with data is more common for AgriSci than for VetMed students, whether they work on the family farm or during their internships. Furthermore, at least in German-speaking countries, AgriSci studies are often more focused on economic aspects compared with VetMed studies and include lectures on business and economics, for example.

In contrast, other studies showed that veterinary medicine still has some catching-up to do in the area of data analysis and management (Stumpp et al., 2020). Some veterinarians are not interested in dealing with data and new technologies. Other veterinarians complain that they are interested, but it is not possible to implement it, due to practice structures (Pospischil et al., 2023). Due to the legal situation created in 2021, cattle practitioners have to deal with data and data analysis more intensively in

the future. The EU Animal Health Law (European Parliament, 2016) requires regular herd visits to maintain or even improve the health of the herd. For this purpose, the current health status of a herd must be known (Ritter et al., 2017; Svensson et al., 2022). Dairy industry technologies provide large amounts of data for analysis and enable continuous recording of the herd's health status (Medeiros et al., 2022).

Automatic Calf Feeder. Regarding to the image of the automatic calf feeder, 38.3% of participants expressed negative connotations and 20.2% perceived disadvantages for the calves. In the word cloud in Figure 8, the term "unnatural" stood out. Looking at the other negative connotations mentioned, it became clearer what was meant by "unnatural." Given terms were "impersonal," "alienation," "lack of animal contact," and, from the calf's perspective (category disadvantages for calves), lack of contact with humans and the dam. Similar results were also obtained in surveys, interviews, and discussions with citizens. As Beaver et al. (2020) reported naturalness in the dairy industry has a high priority for citizens. Citizens consider the current widespread practice of calf rearing (e.g., individual housing of calves and early cow-calf separation after birth) to be unnatural (Busch et al., 2017; Sirovica et al., 2022). The AgriSci and VetMed students in our study expressed the same attitude. We assumed that the negative connotations related to the undesirable way of housing did not necessarily represent a rejection of the technology. This is supported by Beaver et al. (2020) who suggested that the younger generation has a different understanding of naturalness that does not exclude technologies. Pair housing for preweaning calves could be a compromise in the first days of life. Several researchers described the benefits for calves in this housing systems (Bučková et al., 2021; Suchon et al., 2023). The automatic calf feeder can also be used in this system. Interestingly in this context, an earlier study that compared automatic milk feeding with manual milk feeding considered automatic milk feeding as more natural as larger amounts of milk could be fed several times a day and thus, implemented a more natural behavior and improved animal welfare (Medrano-Galarza et al., 2017). The farmer can monitor drinking behavior (e.g., milk quantity, number of visits, sucking speed per calf). This should not go unmentioned, because 28.8% of participants saw the benefits of the automatic calf feeder, and given answers were "adequate feeding, good supply," "work facilitation," and "labor saving."

Preparing for the Digital Transformation in Dairy Farming

This study showed that most VetMed students critically reflect their education with regard to new technologies. This was particularly evident when students were surveyed at the end of their education, which has been shown previously (Baumgärtel, 2016). Gilling and Parkinson (2009) spoke of a widespread phenomenon of a lack of confidence in preparation for practice among university graduates. One explanation for the results among veterinary students could be that veterinary curricula are less flexible in accommodating new topics. For example, the nationwide degree program for veterinary medicine in Germany has remained unchanged since 2006. Although new topics may be integrated into lectures and electives, they are not established as independent subjects, are not compulsory for instructors, and are not a mandatory component of examinations.

There were VetMed students who "did not feel adequately prepared" for their professional life but were not distressed and expected to "learn this later on farm." It would be desirable, however, if students did not simply postpone things until later, but also dealt with sensor technologies and digitalization during their studies.

Some VetMed students did not see a need to prepare for the digital transformation. "Too much detail," "only affects a few students," and "already decided against cattle practice" were some of their comments. Such arguments raise the question of whether it would make sense to specialize in a veterinary field during VetMed studies (Kronenberger and Doll, 2019; Kronenberger et al., 2020; Losansky et al., 2022). In view of the global shortage of food animal veterinarians it might make sense to reconsider the issue of early specialization (Dürnberger, 2020). Specific topics such as communication skills (Dürnberger, 2020; Svensson et al., 2020), the use of technologies and digitalization and VHHM in the livestock sector could thus be better integrated into the curriculum. In agricultural education, on the contrary, students have to decide early on which field of specialization (e.g., plant production, animal production, agricultural economics, and agricultural technology) they will pursue. It can be assumed that specific topics, such as the use of technologies and digitalization, can be adapted to the field of specialization and communicated more efficiently. This in turn could be a reason why a greater proportion of AgriSci students compared with VetMed students felt well prepared for the digital transformation (36.8% vs. 20.8%).

The authors recommend that those responsible for teaching herd health management discuss the results with the relevant university committees. In the authors' opinion, it is necessary to incorporate lectures and courses on digital technologies in livestock farming into the curricula, especially for veterinary students. Further activities, preferably with veterinary and agricultural students together, such as farm visits with the focus on digital farming or rounds with farmers, veterinarians, and

manufacturers of sensor technologies, could improve the understanding of current and future livestock farming.

CONCLUSIONS

AgriSci and VetMed students in Germany, Austria, and Switzerland showed positive attitudes toward the use of digital technologies in the dairy industry. They saw benefits to digital technologies, such as improved animal welfare and better work-life balance. In some areas, students of both disciplines were skeptical about technological progress (e.g., automatic calf feeder). It will be necessary to discuss how to implement the transfer of knowledge about digital technologies and digital transformation into the universities' curricula. Both VetMed and AgriSci students could benefit from a more intensive exchange (e.g., by discussions about digital technologies, farm economics, and husbandry methods). This could contribute to better preparation for digital transformation and to promoting VetMed students' interest in working in cattle practice.

NOTES

This study was funded by FFoQSI, the Austrian Competence Centre for Feed and Food Quality, Safety and Innovation (Tulln, Austria). The COMET-K1 competence centre FFoQSI is funded by the Austrian Federal Ministry of Innovation, Mobility and Infrastructure, the Federal Ministry of Economy, Energy and Tourism, and the Austrian provinces of Lower Austria, Upper Austria, and Vienna, within the scope of Competence Centers for Excellent Technologies (COMET). The COMET program is handled by the Austrian Research Promotion Agency (FFG; Vienna, Austria). Zoetis (Dublin, Ireland) is a member of the FFoQSI consortium and provided financial and in-kind support for the study. Furthermore, this study was funded by D4Dairy (Digitalisation, Data integration, Detection and Decision support in Dairying; FFG-Project). Special thanks to all participating students, as well as the administration or the student body of the universities for making this study possible. Preliminary results of this project were presented at the 10th European Conference on Precision Livestock Farming in 2022 in Vienna, Austria, and at the 31st World Buiatrics Congress in 2022 in Madrid, Spain. Supplemental material for this article is available at https://doi.org/10.5281/zenodo.17777493. The survey was submitted to and approved by the Ethics Committee of Vienna Medical University, Austria, prior to implementation. The authors have not stated any conflicts of interest.

Nonstandard abbreviations used: AgriSci = agricultural sciences; AMS = automatic milking systems; EU = European Union; VetMed = veterinary medicine; VHHM = veterinary herd health management.

REFERENCES

Barkema, H. W., M. A. G. von Keyserlingk, J. P. Kastelic, T. J. G. M. Lam, C. Luby, J. P. Roy, S. J. LeBlanc, G. P. Keefe, and D. F. Kelton. 2015. Invited review: Changes in the dairy industry affecting dairy cattle health and welfare. J. Dairy Sci. 98:7426–7445. https://doi.org/10.3168/jds.2015-9377.

Baumgärtel, O. A. 2016. Berufswunsch Tierärztin/Tierarzt. Anspruch der heutigen Studierenden versus Praxisanforderungen. DTBL 1:12–17.

Bausewein, M., R. Mansfeld, M. G. Doherr, J. Harms, and U. S. Sorge. 2022. Sensitivity and specificity for the detection of clinical mastitis by automatic milking systems in Bavarian dairy herds. Animals (Basel) 12:2131. https://doi.org/10.3390/ani12162131.

Beaver, A., K. L. Proudfoot, and M. A. G. von Keyserlingk. 2020. Symposium review: Considerations for the future of dairy cattle housing: An animal welfare perspective. J. Dairy Sci. 103:5746–5758. https://doi.org/10.3168/jds.2019-17804.

Bučková, K., R. Šárová, Á. Moravcsíková, and M. Špinka. 2021. The effect of pair housing on dairy calf health, performance, and behavior. J. Dairy Sci. 104:10282–10290. https://doi.org/10.3168/jds.2020-19968.

Busch, C., and U. Hamm. 2015. Trägt das Image der Landwirtschaft zu einer steigenden Zahl von Veganern bei? Pages 37–65 in Die Landwirtschaft im Spiegel von Verbrauchern und Gesellschaft. Vol. 31. L. Rentenbank, ed. Edmund-Rehwinkel-Stiftung der landwirtschaftlichen Rentenbank, Frankfurt a. Main, Germany.

Busch, G., D. M. Weary, A. Spiller, and M. A. von Keyserlingk. 2017. American and German attitudes towards cow-calf separation on dairy farms. PLoS One 12:e0174013. https://doi.org/10.1371/journal.pone.0174013.

Butler, D., L. Holloway, and C. Bear. 2012. The impact of technological change in dairy farming: Robotic milking systems and the changing role of the stockperson. J. R. Agric. Soc. Engl. 173:1–6.

Cardoso, C. S., M. J. Hötzel, D. M. Weary, J. A. Robbins, and M. A. G. von Keyserlingk. 2016. Imagining the ideal dairy farm. J. Dairy Sci. 99:1663–1671. https://doi.org/10.3168/jds.2015-9925.

Contzen, S., and I. Häberli. 2021. Exploring dairy farmers' quality of life perceptions—A Swiss case study. J. Rural Stud. 88:227–238. https://doi.org/10.1016/j.jrurstud.2021.11.007.

Cook, N. B., and M. A. G. von Keyserlingk. 2024. Perspective: Prolonged cow calf contact—A dilemma or simply another step in the evolution of the dairy industry? J. Dairy Sci. 107:4–8. https://doi.org/10.3168/jds.2023-23840.

Dürnberger, C. 2020. Am I actually a veterinarian or an economist? Understanding the moral challenges for farm veterinarians in Germany on the basis of a qualitative online survey. Res. Vet. Sci. 133:246–250. https://doi.org/10.1016/j.rvsc.2020.09.029.

Emmett, L., J. Aden, A. Bunina, A. Klaps, and B. U. Stetina. 2019. Feminization and stress in the veterinary profession: A systematic diagnostic approach and associated management. Behav. Sci. (Basel) 9:114. https://doi.org/10.3390/bs9110114.

European Parliament. 2000. Regulation (EC) No 1760/2000 of the European Parliament and of the Council of 17 July 2000 establishing a system for the identification and registration of bovine animals and regarding the labelling of beef and beef products and repealing Council Regulation (EC) No 820/97. Accessed Aug. 11, 2024. http://data.europa.eu/eli/reg/2000/1760/oj.

European Parliament. 2016. Regulation (EU) 2016/429 of the European Parliament and of the Council of 9 March 2016 on transmissible animal diseases and amending and repealing certain acts in the area of animal health ('Animal Health Law'). Accessed Aug. 11, 2024. http://data.europa.eu/eli/reg/2016/429/2019-12-14.

European Parliament. 2019. Commission Delegated Regulation (EU) 2019/2035 of 28 June 2019 supplementing Regulation (EU) 2016/429 of the European Parliament and of the Council as regards rules for establishments keeping terrestrial animals and hatcheries, and the traceability of certain kept terrestrial animals and hatching eggs. Accessed Aug. 11, 2024. http://data.europa.eu/eli/reg_del/2019/2035/oj.

Gilling, M. L., and T. J. Parkinson. 2009. The transition from veterinary student to practitioner: A "make or break" period. J. Vet. Med. Educ. 36:209–215. https://doi.org/10.3138/jvme.36.2.209.

Guest, G., K. MacQueen, and E. Namey. 2014. Chapter 2: Planning and preparing the analysis. Pages 21–49 in Applied Thematic Analysis. SAGE Publications Inc. https://doi.org/10.4135/9781483384436.

Gysin, M., F. Tschuor, D. E. Schweizer, C. Nett, and U. Geissbühler. 2019. Digitization in Swiss veterinary practices. Schweiz. Arch. Tierheilkd. 161:307–317. https://doi.org/10.17236/sat00207.

Häberli, I., S. Contzen, and U. Straub. 2021. Wie Milchproduzentinnen und Milchproduzenten ihre Lebensqualität verbessern. Agrarforsch. Schweiz 12:121–127. https://doi.org/10.34776/afs12-121.

Hanson, E. 2024. Women in agriculture. PhD thesis. Department of Agricultural and Applied Economics, University of Wyoming.

Hostiou, N., J. Fagon, S. Chauvat, A. Turlot, F. Kling-Eveillard, X. Boivin, and C. Allain. 2017. Impact of precision livestock farming on work and human-animal interactions on dairy farms. A review. Biotechnol. Agron. Soc. Environ. 21:268–275. https://doi.org/10.25518/1780-4507.13706.

Kelle, U. 2022. Mixed methods. Pages 163–177 in Handbuch Methoden der empirischen Sozialforschung. N. Baur and J. Blasius, ed. Springer VS, Wiesbaden, Germany.

Kersebohm, J. C., T. Lorenz, A. Becher, and M. G. Doherr. 2017. Factors related to work and life satisfaction of veterinary practitioners in Germany. Vet. Rec. Open 4:e000229. https://doi.org/10.1136/vetreco-2017-000229.

Knowlton, K. F., and M. A. G. von Keyserlingk. 2023. To treat or not to treat: Public attitudes on the therapeutic use of antibiotics in the dairy industry—A qualitative study. Animals (Basel) 13:2913. https://doi.org/10.3390/ani13182913.

Kostelnik, K. 2010. Der Mangel an tierärztlichem Nachwuchs in der Nutztiermedizin. PhD thesis. Faculty of Veterinary Medicine, Freie Universität Berlin, Germany.

Kronenberger, M., and K. Doll. 2019. Does buiatric education meet the needs of the modern bovine practice? Part 1: Assessment of the situation by university professors for cattle diseases. Prakt. Tierarzt 100:370–379. https://doi.org/10.2376/0032-681x-1907.

Kronenberger, M., M. Sparenberg, F. Klaus, and K. Doll. 2020. Does buiatric education meet the needs of the modern bovine practice? Part 2: Assessment of the situation through farm animal practitioners and dairy farmers. Prakt. Tierarzt 101:168–179. https://doi.org/10.2376/0032-681X-1944.

Losansky, V. A., S. Arnhold, J. R. Aschenbach, T. Göbel, K. Fey, C. Kleinsorgen, C. Mülling, E. Schaper, J. Seeger, A. Tipold, and M. G. Doherr. 2022. Survey on the relevance of subjects in the current and future veterinary curriculum among veterinarians and veterinary students in Germany. Berl. Munch. Tierarztl. Wochenschr. 135:1–16. https://doi.org/10.2376/1439-0299-2021-13.

Lundström, C., and J. Lindblom. 2021. Care in dairy farming with automatic milking systems, identified using an Activity Theory lens. J. Rural Stud. 87:386–403. https://doi.org/10.1016/j.jrurstud.2021.09.006.

Mancuso, D., G. Castagnolo, and S. M. C. Porto. 2023. Cow behavioural activities in extensive farms: Challenges of adopting automatic monitoring systems. Sensors (Basel) 23:3828. https://doi.org/10.3390/s23083828.

Mayring, P. 2019. Qualitative content analysis: Demarcation, varieties, developments. FQS 20:16. https://doi.org/10.17169/fqs-20.3.3343.

McAloon, C. I., F. McCoy, and S. J. More. 2021. Trends in estimated intramammary antimicrobial usage in the Irish dairy industry from 2003 to 2019. JDS Commun. 2:271–276. https://doi.org/10.3168/jdsc.2021-0081.

Medeiros, I., A. Fernandez-Novo, S. Astiz, and J. Simões. 2022. Historical evolution of cattle management and herd health of dairy farms in OECD countries. Vet. Sci. 9:125. https://doi.org/10.3390/vetsci9030125.

Medrano-Galarza, C., S. J. LeBlanc, T. J. DeVries, A. Jones-Bitton, J. Rushen, A. Marie de Passillé, and D. B. Haley. 2017. A survey of dairy calf management practices among farms using manual and automated milk feeding systems in Canada. J. Dairy Sci. 100:6872–6884. https://doi.org/10.3168/jds.2016-12273.

Pakrashi, A., C. Ryan, C. Guéret, D. P. Berry, M. Corcoran, M. T. Keane, and B. Mac Namee. 2023. Early detection of subclinical mastitis in lactating dairy cows using cow-level features. J. Dairy Sci. 106:4978–4990. https://doi.org/10.3168/jds.2022-22803.

Pfeiffer, J., A. Gabriel, and M. Gandorfer. 2021. Understanding the public attitudinal acceptance of digital farming technologies: A nationwide survey in Germany. Agric. Human Values 38:107–128. https://doi.org/10.1007/s10460-020-10145-2.

Pospischil, C., A. Palluch, M. Iwersen, and M. Drillich. 2023. Digitalisation in cattle practice—Results of an online-survey in Austria. Tierarztl. Prax. Ausg. G Grosstiere Nutztiere 51:70–76. https://doi.org/10.1055/a-2050-4123.

Ries, J., K. C. Jensen, K. E. Müller, C. Thöne-Reineke, and R. Merle. 2022. Impact of veterinary herd health management on German dairy farms: Effect of participation on farm performance. Front. Vet. Sci. 9:841405. https://doi.org/10.3389/fvets.2022.841405.

Ritter, C., J. Jansen, S. Roche, D. F. Kelton, C. L. Adams, K. Orsel, R. J. Erskine, G. Benedictus, T. J. G. M. Lam, and H. W. Barkema. 2017. Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. J. Dairy Sci. 100:3329–3347. https://doi.org/10.3168/jds.2016-11977.

Rohleder, B., B. Krüsken, and H. Reinhardt. 2020. Digitalisierung in der Landwirtschaft 2020. Accessed Aug. 15, 2024. https://www.bitkom.org/sites/main/files/2022-01/27.04.20_digitalisierung-in-der-landwirtschaft-2020.pdf.

Romano, E., M. Brambilla, M. Cutini, S. Giovinazzo, A. Lazzari, A. Calcante, F. M. Tangorra, P. Rossi, A. Motta, C. Bisaglia, and A. Bragaglio. 2023. Increased cattle feeding precision from automatic feeding systems: Considerations on technology spread and farm level perceived advantages in Italy. Animals (Basel) 13:3382. https://doi.org/10.3390/ani13213382.

Rovers, A., I. Christoph-Schulz, and N. Brümmer. 2019. Citizens' perception of different aspects regarding German livestock production. Int. J. Food Syst. Dyn. 10:361–374. https://doi.org/10.18461/ijfsd.v10i4.24.

Scholz, E., and F. Trede. 2023. Veterinary professional identity: Conceptual analysis and location in a practice theory framework. Front. Vet. Sci. 10:1041475. https://doi.org/10.3389/fvets.2023.1041475.

Schuppli, C. A., J. M. Spooner, and M. A. G. von Keyserlingk. 2023. Canadian dairy farmer views about animal welfare. Anim. Welf. 32:e38. https://doi.org/10.1017/awf.2023.32.

Sirovica, L. V., C. Ritter, J. Hendricks, D. M. Weary, S. Gulati, and M. A. G. von Keyserlingk. 2022. Public attitude toward and perceptions of dairy cattle welfare in cow-calf management systems differing in type of social and maternal contact. J. Dairy Sci. 105:3248–3268. https://doi.org/10.3168/jds.2021-21344.

Sonneveld, D., Y. Goverts, C. Duijn, G. Camps, R. Bougie, and N. Mastenbroek. 2023. Dutch veterinary graduates leaving practice: A mixed-methods analysis of frequency and underlying reasons. Vet. Rec. 192:e2178. https://doi.org/10.1002/vetr.2178.

Statista. 2017. Percentage of the global population that used a mobile app or fitness tracking device to track their health as of 2016, by age. Accessed Aug. 11, 2024. https://www.statista.com/statistics/742448/global-fitness-tracking-and-technology-by-age/.

Stumpp, S., T. Knopf, H. Krüger, H. Keimer, and J. Henning. 2020. Wer die Zukunft gestalten will, muss heute agieren–ein Aufruf. DTBL 68:1238–1244.

Suchon, M., T. Ede, B. Vandresen, and M. A. G. von Keyserlingk. 2023. Social housing improves dairy calves' performance in a competition test. JDS Commun. 4:479–483. https://doi.org/10.3168/jdsc.2023-0378.

Svensson, C., H. Lomander, and S. Kokko. 2022. Veterinary herd health management—Experiences and perceptions among Swedish dairy cattle veterinarians. J. Dairy Sci. 105:6820–6832. https://doi.org/10.3168/jds.2021-21184.

Svensson, C., H. Wickström, U. Emanuelson, A. M. Bard, K. K. Reyher, and L. Forsberg. 2020. Training in motivational interviewing improves cattle veterinarians' communication skills for herd health management. Vet. Rec. 187:191. https://doi.org/10.1136/vr.105646.

Tricás-Vidal, H. J., M. O. Lucha-López, C. Hidalgo-García, M. C. Vidal-Peracho, S. Monti-Ballano, and J. M. Tricás-Moreno. 2022.

Health habits and wearable activity tracker devices: Analytical cross-sectional study. Sensors (Basel) 22:2960. https://doi.org/10.3390/s22082960.

Usko, K. 2023. Die nutztierärztliche Versorgung von Rindern und Schweinen in Bayern: Ermittlung des aktuellen tierärztlichen Bedarfs und Prognose der Situation 2025. PhD thesis. Faculty of Veterinary Medicine, Ludwig-Maximilians-Universität München, Munich, Germany.

von Keyserlingk, M. A. G., J. Rushen, A. M. de Passillé, and D. M. Weary. 2009. Invited review: The welfare of dairy cattle—Key concepts and the role of science. J. Dairy Sci. 92:4101–4111. https://doi.org/10.3168/jds.2009-2326.

Weltzien, L. M. 2023. The livestock veterinarian shortage. Accessed Aug. 15, 2024. https://clf.jhsph.edu/sites/default/files/2023-06/the-livestock-veterinarian-shortage.pdf.

Wildridge, A. M., P. C. Thomson, S. C. Garcia, E. C. Jongman, and K. L. Kerrisk. 2020. Transitioning from conventional to automatic milking: Effects on the human-animal relationship. J. Dairy Sci. 103:1608–1619. https://doi.org/10.3168/jds.2019-16658.

ORCIDS

K. R. Weimar, https://orcid.org/0000-0003-1962-1731
W. Heuwieser, https://orcid.org/0000-0003-1434-7083
M. Iwersen, https://orcid.org/0000-0001-7893-6050
M. Drillich https://orcid.org/0000-0002-2824-8185