dairy

MDPI

Article

Economics of Production Diseases at the Individual Animal Level in German Dairy Farms

Adriana Wöckel [1,†], Wolf Wippermann [1,†], Benno Waurich [2], Erik Bannert [3], Julia Wittich [4], Christina Felgentreu [4], Franz Fröhlich [4], Fanny Rachidi [1], Peter Hufe [4], Detlef May [4], Sven Dänicke [3], Hermann H. Swalve [2], Alexander Starke [1] and Melanie Schären-Bannert [1,5,*]

[1] Clinic for Ruminants and Swine, Faculty of Veterinary Medicine, University of Leipzig, 04103 Leipzig, Germany
[2] Institute of Agricultural and Nutritional Sciences, Martin Luther University Halle-Wittenberg, 06120 Halle, Germany
[3] Institute of Animal Nutrition, Friedrich-Loeffler-Institute (FLI), Federal Research Institute for Animal Health, 38116 Brunswick, Germany
[4] LVAT—Institute for Animal Breeding and Husbandry, 14450 Groß Kreutz, Germany
[5] Unit for Herd Health Management in Ruminants, Clinical Centre for Ruminants, Camelids and Herd Health Management, Clinical Department for Farm Animals and Food System Science, University of Veterinary Medicine Vienna (Vetmeduni), 1210 Wien, Austria
* Correspondence: melanie.schaeren@vetmeduni.ac.at
† These authors contributed equally to this work.

Abstract

Production diseases in dairy cattle impose economic and welfare burdens, yet few studies quantify costs using on-farm cases. This study aimed to estimate costs and lost revenues at the individual-animal level in 10 German dairy farms (average of 592 cows; 9694 kg marketed milk/cow/year; 32.9% culling rate). Each farm was visited for three weeks; diseased cows and calves were examined by a trained veterinarian. Diagnoses, treatments, labour times, and outcomes were recorded, and costs calculated for labour, products, veterinary and orthopaedic services, discarded milk, decreased milk yield, culling, book loss, and reduced carcass value. In total, 1272 single-animal cases were included: 68% were stand-alone diseases, 11% involved multiple diagnoses within one organ system, and 21% affected several organ systems. When several diseases occurred in the same animal, total costs and lost revenues were greater than the sum of stand-alone cases, indicating compounding effects. High-impact conditions included mastitis, claw disorders, left displaced abomasum, and multimorbidity; per-case losses ranged from €43 (digital dermatitis) to >€1200 (left displaced abomasum with complications). Labour and culling-related costs were higher than reported, and productivity losses exceeded treatment costs in many cases. Findings support farm-level decision-making, prevention, and parameterization of future dynamic models.

Keywords: cost; revenue; labour; culling

Check for updates

Academic Editor: Erminio Trevisi

Received: 7 January 2026
Revised: 17 March 2026
Accepted: 18 March 2026
Published: 24 March 2026

Copyright: © 2026 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

1. Introduction

Production diseases in dairy cows, such as mastitis, lameness, hypocalcaemia, retained placenta, metritis, left displaced abomasum (LDA), and ketosis, have a high prevalence, negatively impact animal production, and therefore have a substantial economic impact [1–7]. Furthermore, they constitute a considerable welfare issue [6,8]. The economic framework of disease costs and lost revenues comprises multiple levels, including discarded milk,

milk production losses, negative impacts on product quality, veterinary services and drugs, labour, materials and investments, culling, and increased risk of other diseases [7,9–14].

Many studies have investigated the potential economic impact of production diseases in dairy cows, using different approaches. Costs and lost revenues are estimated from a single cow (e.g., in [15–18]) or a herd level (e.g., in [11,19–22]) perspective. As basis either normative (e.g., in [14,16,23–25]) or empirical (e.g., in [11,15,26]) data are used. In normative studies, the costs of drugs and other products, the lost revenues from discarded milk, and labour are estimated; for example, using questionnaires, prices of common products, values from the literature, or expert opinions [7]. The strength of empirical studies lies in the coherence of the data, whereas in normative studies, the data basis may not originate from a similar setting or may be imprecise. However, studies using detailed empirical data at the single-animal level are scarce.

Estimating the economic impact of a disease at the individual-animal level poses distinct challenges [7,11], as disease severity and cause can vary, thereby influencing potential outcomes [27]. Additionally, cows may be affected by multiple diseases [2,28,29], which are interrelated and not readily distinguishable in terms of costs and lost revenues. Data quality for disease identification and documentation is often poor, unreliable, or difficult to compare across farms [20,30].

Diseased animals have a higher risk for euthanasia and bring significantly lower slaughter weights and revenues, and have a higher risk for carcass disposal [10,31]. The culling of a dairy cow entails costs, including transport and administration for slaughter or euthanasia, as well as carcass disposal [32]. Revenue is generated from the sale of the carcass (slaughter revenue), whereas a decreased carcass quality is considered a loss of revenue.

A third aspect to consider when economically evaluating the culling of a cow is its current value in the farm's accounting records. The cow is treated as an asset with a book value; when she is culled, the resulting book loss is recognised. Assets can either be recorded at a fixed amount in the accounting records or depreciated. In the literature, the cost of culling is considered in different ways. Possible approaches include: 1. the subtraction of the current estimated value of a cow (e.g., using the current market value) by the net income received from slaughter [24], 2. subtraction of the current cost of a replacement heifer on the market by half of the lifeloss of a cow (lifeloss defined as: subtraction of the current cost of a replacement heifer on the market by net income received from slaughter [33]), or 3. choosing a more complex retention pay-off model [34]. These approaches, however, do not account for the combined effects of individual rearing costs and the cow's lifetime productivity when the cow is affected by the disease.

Furthermore, several studies have reported high disease prevalence and mortality during the rearing period [35–37]. However, only a few studies describe the economic impact of diseases in calves (e.g., in [38–40]).

The current study aimed to address these relevant challenges and generate validated on-farm data for the aspects of diagnoses, respective costs and lost revenues for treatment, including products, labour, discarded milk, as well as decrease in milk production, book loss and culling for a distinct set of cows and calves by identification and diagnosing diseased animals in real production settings by specialised veterinarians, thereby adding to the current literature and creating empirical data for future studies using complex modelling approaches.

2. Materials and Methods

The study was performed within the scope of a European Innovation Partnership (EIP)-agri project ("Die Entwicklung des KUH-mehr-WERT Navigators") [41] between May 2020 and April 2021.

2.1. Farms

The project involved 12 dairy farms located in the state of Brandenburg, being part of the test herd programme of the breeder association RBB Rinderproduktion Berlin-Brandenburg GmbH, implying a high standard in animal production and health data documentation established on the farms (herd programme described in König and Swalve (2024) [42]). Ten of the twelve farms were identified as suitable for this specific data acquisition. Requirements were: 1. individual daily recording of milk yields and alarm systems for decreased milk yield in place, 2. functioning animal identification in milk parlour 3. possibility to fix groups of cows (e.g., fresh cows, cows in sick cow pens) and single animals for controls and examinations without disturbing daily routines on the farm or influencing animal behaviour due to too long restraints. Of the twelve farms, one was excluded due to a temporary defect in the animal identification system, and another due to the failure to provide adequate facilities for animal fixation.

Farms had an average herd size of 592 (229–1221) German Holstein cows, an average milk production of 9694 kg (8943–10,549 kg) marketed milk per cow and year, and a 32.9% (21.5–38.6%) culling rate. All farms are characterised by a total mixed ration feeding system, a free-stall confinement system for the milking herd with cubicles, and, in most cases, dry cows are housed in deep-bedded straw pack. Exceptions to these conditions were three farms with dry cows (partially) on pasture and partial mixed ration feeding in the case of robot milking (two farms). A more detailed description of the farms has recently been published [43].

2.2. Data Collection

Each farm was visited for 13 days (over three consecutive weeks), during which the data collection was conducted by one project veterinarian (specialised buiatrician with several years of clinical experience), accompanied by two project employees (data collectors).

The veterinarian and one data collector were responsible for diseased animal detection and diagnosis, whereas the second data collector accompanied the herd manager of the farm, recording the animal treatments (if not done by the herd manager himself, the second data collector accompanied the respective employee of the farm for the specific time frame of the task).

For each diagnosed case of a diseased cow or calf (young stock > 100 d of age and before first calvings were excluded) costs and lost revenues were recorded for the following categories: time expenditure, product expenses, veterinary services, orthopaedic services, discarded milk, decreased milk production, culling, book loss, and lost revenues from decreased carcass quality (details see below).

2.2.1. Identification and Examination of Diseased Animals

To detect diseased animals, the project veterinarian implemented systematic, standardised animal control routines. In the cows, these consisted of:

1. The clinical examination of animals appearing on the milk yield alarms lists (at least a decrease of 20% compared to the 7-day average was considered notifiable) and, depending on the farm individual availability, other sensor system alarm lists (e.g., activity sensors).

2. Clinical examination under restraint in the headlock of animals identified by employees and herd manager throughout their daily routines (e.g., during animal controls or pushing of cows).
3. The clinical examination of the cows in the fresh and sick cow pen under restraint in the headlock daily or at least two times per week (depending on farm size and practicability).
4. The clinical examination of the cows in the mastitis pen in the milking parlour and under restraint in the headlock two to three times per week (depending on farm size and practicability), as well as immediately at discovery of the mastitis.
5. The observation and documentation of the diagnoses during claw treatment routines.
6. Pen walk through all pens two to three times per week (depending on farm size and practicability), applying visual control for signs of disease (according to the clinical adspection described in Dirksen et al. (2012) [44]).

The calves until 100 days of age were controlled daily or at least three times per week (depending on farm size and practicability) visually (according to the clinical adspection described in Dirksen et al. (2012) [44], supported by an alarm list made by farm employees as well as their treatment protocols.

Animals that were identified as diseased were clinically examined by the project's veterinarian according to the standards described in Dirksen et al. (2012) [44] and then handed to the herd manager for treatment (no intervention or recommendation by the project team in this regard). The possibilities/tools for diagnosis were limited to the equipment representative for a bovine veterinarian in practice, e.g., tools needed for clinical examination (thermometer, stethoscope, plexor and pleximeter, rubber hammer, flash light, speculum, rectal gloves and lubricant), urine ketone sticks and blood sampling for a set of clinical chemistry variables (analysis only possible after returning from the data acquisition) as well as the glutaraldehyde test [45]. Only diagnoses established by the project veterinarian through clinical examination were considered. Cases with an inconclusive or incomplete disease history were excluded. Each case was followed up after the time of presence on the farm, using herd health data documented by the herd manager in the herd management software.

2.2.2. Documentation and Categorization of Diagnoses

A total of 2250 animals were clinically examined. For the standardised documentation of the diagnoses, the "central animal health code" (Zentraler Tiergesundheitsschlüssel (ZTGS)) according to Staufenbiel (2018) [46] was used. A total of 3724 (mean 2.4, 1–15 per animal) diagnoses were recorded. For each animal, the diagnoses were ranked by the examining veterinarian for clinical relevance. A further categorization was made to condense the dataset and increase the number of cases per category. A complete overview of all categories is given in Appendix A, Table A1.

2.2.3. Time Expenditure

The data collector accompanying the project veterinarian recorded the time required for each animal's clinical examination. A total of 6346 examinations were recorded, divided into fresh cow control, examination cow, examination calf, and examination/treatment in the claw trimming chute (Table 1). The examinations of the cow and calf, as well as the events during claw treatment, were divided into the first exam and the follow-up exam. Furthermore, the time was recorded for a final clinical examination of cows prior to slaughter. This event was recorded in the case of each cow that was culled and slaughtered as a quality-assurance measure by the farm and the veterinarian.

Table 1. Duration (hh:mm:ss) of events recorded for examination and treatment of cows and calves. The duration indicates the time invested per event and animal.

Event [1]	Mean	Min	Max	No. of Events Recorded
Fresh cow control	00:01:34	00:00:10	00:21:00	3032
Cow initial clinical exam	00:03:53	00:00:10	00:36:50	608
Cow follow-up exam	00:02:02	00:00:10	00:21:50	1003
Cow culling exam	00:02:13	00:00:30	00:12:00	61
Calf initial clinical exam	00:02:27	00:00:15	00:07:30	349
Calf follow-up exam	00:01:40	00:00:10	00:06:12	266
Claw treatment initial	00:04:23	00:00:25	00:32:00	758
Claw treatment follow-up	00:03:09	00:00:10	00:40:00	269
Intramuscular/subcutaneous injection	00:03:19	00:00:30	01:01:00	265
Intravenous injection	00:03:12	00:01:00	00:13:00	14
Intrauterine application	00:04:42	00:01:00	00:21:00	41
Intravenous infusion	00:09:09	00:05:00	00:15:00	8
Oral application	00:02:28	00:01:00	00:12:00	86
Drenching of a cow	00:07:43	00:02:00	00:23:00	28
Topical application	00:02:46	00:01:00	00:12:00	54
Blood sample collection	00:04:09	00:01:00	00:07:00	7
Control and treatment in milk parlour [2]	00:01:35	00:00:48	00:03:29	102
Downer cow care [3]	00:20:00	-	-	-
Movement of animal [4]	00:04:15	-	-	282
Documentation of data [5]	00:01:29	-	-	248

[1] In case of treatments, time to catch/fixate animal, preparation of treatments, treatment itself and afterwork is included. [2] Time invested in one animal in mastitis pen at average (including milking, clinical control, treatments, and documentation), 102 groups with 1202 cows recorded. [3] Per day, providing feed and water, change in bedding, turning sides; estimated, no reliable data available. [4] From one location to another (e.g., milk parlour, pen, claw trimming chute, selection area), including selection process (00:50:00, n = 480) and actual movement of animal (00:03:25, n = 282). [5] In herd management software, 248 events of data documentation were recorded, with an average of 10 animals per recording, including time per animal (00:01:23) and general medication information (00:01:04 per 10 animals = 00:00:05 per animal).

For all cases, the average times for the first and the respective number of necessary follow-up examinations were assigned. The number of necessary follow-up examinations by either the herd manager or the veterinarian was estimated per case based on disease severity and veterinary medicine legislation (Tierärztliche Hausapothekenverordnung [47]) by the project veterinarian. For every intervention (e.g., clinical exam, surgery) by a veterinarian, aside from official fees for the service, the mean time needed was accounted as labour invested by the herd manager, as it was expected that the herd manager would accompany the veterinarian for decision-making.

The data collector accompanying the herd manager recorded the time needed for treatments. The 821 recorded treatment events were assigned to categories. Stand-alone categories are listed in Table 1. To account for combinations of treatments, a factor was applied to reduce the duration of each event based on the nature of the co-occurring event. For example, in the case of two intramuscular injections in one animal with two different products, it can be assumed that the time needed is only slightly more than for one injection, as many of the involved work steps are the same; therefore, a factor of 0.6 is applied to the time needed for each intramuscular injection. Whereas an intravenous infusion and drenching do not involve as many similar work steps, therefore, a factor of 0.8 is applied in each. To validate these factors, the times generated for these treatment combinations were compared with the actual measured treatment-event combinations, and the factors were adjusted to achieve optimal compliance. The final factors selected showed that 78% of combination events exhibited a range of 70–130% of the actual times measured for

comparable event combinations. The following time expenditures were measured and accounted for surgical interventions: surgical or endoscopic fixation of a left displaced abomasum (LDA, 01:00:00, hh:mm:ss, n = 5), toggle-pin or blind-stitch fixation of an LDA (00:55:00, n = 2), and caesarean section (00:01:30, n = 1).

For each category, an executing person was specified: either regular farm staff or a herd manager. The hourly wages for the herd manager and employees were set at 30 € and 20 €, respectively, in accordance with local standards. For actions requiring veterinary expertise, the official veterinary service fees were applied (see Section 2.2.5 below).

2.2.4. Product Expenses

The products and respective amounts applied were documented per case (e.g., medication, bandages, single animal applied feed additives). A total of 513 products were documented. Net retailer prices were assigned for drugs. For all other products, the mean net price of the three obtained offers was used.

2.2.5. Veterinary Services

For each case, the necessary veterinary services were assigned according to disease severity and veterinary medicine drug legislations (Tierärztliche Hausapothekenverordnung [47]), and prices were calculated using the official schedule of fees for veterinarians in Germany (Tierärztegebührenordnung (GOT), Bundestierärztekammer (2020) [48] = a list of fees veterinarians are legally obliged to adhere to in Germany). The veterinary services observed indicated separately in the GOT included initial and follow-up clinical examination, blood sampling, examination of udder, euthanasia, fixation of displaced abomasum either by toggle-pin method, blind-stitch method, endoscopically, or laparotomically, and caesarean section.

2.2.6. Orthopaedic Services

For the orthopaedic services, invoices for claw trimmers active on the project farms were used to estimate the average prices for initial claw treatment (7.80 €), follow-up treatment (3.63 €), placing a bandage (2.49 €), and placing a block (4.35 €). The costs include the labour of the claw trimmer and are exclusive of the materials and time invested by the herd manager, farm manager, or farm employees, which are included in the product expenses. The number of measures and items was assigned to each case based on the herd health records (e.g., the number of visits to the claw trimmer, as these visits mostly exceeded the project team's presence on the farm).

2.2.7. Discarded Milk

The monetary equivalent of the amount of milk not suitable for consumption was estimated by multiplying the daily milk production recorded by the parlour and the withdrawal period of the respective drugs applied for each cow individually, multiplied by the average milk price of January 2021–June 2021 of all project farms (0.34 €/kg milk).

2.2.8. Decreased Milk Production

For each lactating animal, the individual lactation curve was generated from daily milk yields (see Figure 1). Additionally, the lactation curve generated from the rolling 7-day average milk production, the lactation curve generated according to Wilmink (1987) [49], as well as the lactation curve of the cows on the farm with the same lactation number at the moment of observation, were added (=comparable cohort). Several automated approaches, using the latter two compared with the actual lactation curve, were used to estimate the decrease in milk production due to disease. This, however, did not yield results that could be considered valid. This can be attributed to the individual course of diseases. For example,

in a cow that exhibits above-average milk production even after a disease event, comparison with its comparable cohort is not justified (as it would imply an increased production in diseased animals in this case). For a cow with a disease event occurring at the beginning of the lactation, the application of the Wilmink curve for comparison is not appropriate either. Identifying non-diseased cohort animals as a comparison was investigated but dismissed because the reliability of disease documentation by the farms was not considered sufficient across all disease complexes. It was therefore decided to opt for an individual analysis of each lactation curve by a project veterinarian. Information on the disease history was used to identify the time frame on the lactation curve. Then the drop on the actual milk curve was either compared with the curve of the cohort group, the Wilmink curve, or within itself, depending on which approach was deemed most representative for the respective cow and case. The magnitude of the decrease in production was determined graphically on a grid, with the decrease in milk yield multiplied by the respective days (as shown in Figure 1). If this was not possible, the decrease in production was deemed non-identifiable. In cases of stand-alone claw diseases, data on decreased milk production due to the disease were, in many cases, inconsistent and therefore not considered.

Example of costs and lost revenues of an event of a cow with an abscessing mastitis 28 DIM in 2nd lactation

Table A: Cost and lost revenue categories

Category	Cost or lost revenue	Comment
Time expenditure *(details Table B)*	48 €	
Product expenses	62 €	12 treatment days and material for bacterial examination
Veterinary services	31 €	clinical examination, udder exam., 2×medication application
Orthopaedic services	- €	
Discarded milk	211 €	624 kg of milk
Decreased production	844 €	2500 kg of milk
Culling*	- €	
Book loss	- €	
Decreased carcass quality	- €	
Sum	1196 €	

Table B: Components of time expediture

Component	Cost	Time expenditure
Initial clinical exam	1.95 €	3 m 53 s
Follow-up clinical exams (2×)	2.03 €	2 × 2 m 1 s = 4 m 2 s
Control and treatment in mastitis pen (20 d)	25.85 €	2 × 1 m 35 s per day; 62 m 2 s
Collection of milk sample	6.68 €	11 m 0 s**
Pen movements (2×)	2.83 €	2 × 4 m 15 s = 8 m 30 s
Documentation (12 treatment days)	8.90 €	12 ×1 m 29 s = 17 m 48 s
Sum	48.24 €	

* culling costs: pre-slaughter costs (administration and transport) or costs for euthanasia

**components: creating list with cows to sample (56s), preparation of sampling (33s), collecting sample (4m 43 s), afterwork (cleaning, packaging, etc., 3m 20s), documentation (1m 29s)

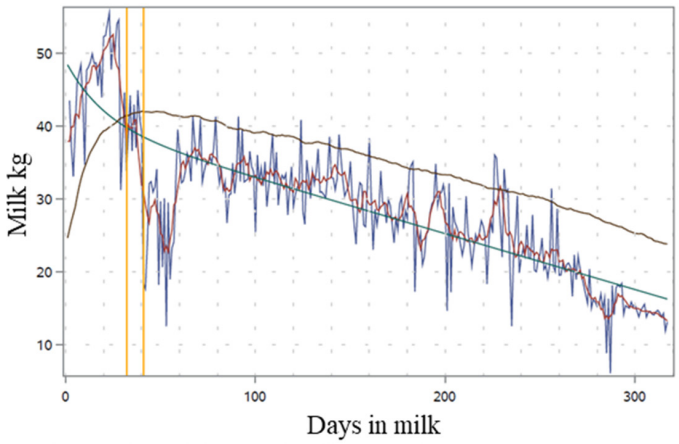


Figure: estimated decrease in milk production: (40 d × 25 kg) + (150 d × 10 kg) = 2500 kg.

Figure 1. Case example of a cow in the second lactation with an abscessing mastitis at 28 days in milk. Above table with the different components of costs and lost revenues (**Table A**), below left table with

details on time expenditure (**Table B**), below right graph used to estimate the decrease in milk production due to the disease (blue = daily milk production, red = rolling 7-day average of milk production, green = milk production curve according to Wilmink (1987) [49], brown = lactation curve of animals on farm in the same lactation at the moment of observation (=comparable cohort), yellow line indicates time point of diagnoses documented. The milk loss was determined by a project veterinarian by comparing the actual milk production curve with the Wilmink curve, as well as with the production curve of the comparable cohort of cows. In this case, 40 days of estimated 25 kg and 150 d of estimated 10 kg were accounted.

To estimate lost revenues, the quantity of milk was then multiplied by the average milk price for January 2021–June 2021 across all project farms (0.34 €/kg).

2.2.9. Culling

If the disease resulted in the culling of an animal, the pre-slaughter costs (administration and transport, individually recorded) or costs of disposal (cow 53.06 €, calf 19.99 €, average across all farms obtained from the invoices) were accounted for. For the cost of euthanasia, the official schedule of fees for veterinarians (Tierärztegebührenordnung (GOT), Bundestierärztekammer (2020) [48]) was applied.

2.2.10. Book Loss

To estimate the book loss, depreciation of the individual animal, based on individual rearing costs and a goal lifetime production, was applied. In an expert round discussion consisting of breeders, economists, veterinarians, agricultural engineers, herd managers, and farm managers, as well as considering the goal communicated by the German Federal Association for Cattle and Pigs (BRS, 2025) for Holstein cows of 40,000 kg, a lifetime production of 50,000 kg of milk was considered feasible [50]. The rearing period was defined as birth to first calving, and the number of days was multiplied by the average rearing costs (2.75 €/day) estimated by Harms (2020) [51] for Mecklenburg-Vorpommern, which shares similar production conditions. The rearing costs were then divided by 50,000 kg, resulting in a per-kg depreciation rate applied to each kg of milk produced by the individual. In the case of slaughter, the slaughter revenue was obtained from the respective invoices. The book loss was then calculated as follows: rearing costs—depreciated rearing costs (=lifetime milk yield × depreciation per kg milk produced)—slaughter revenue. Positive outcomes were set to zero (=zero book loss).

2.2.11. Lost Revenues from Decreased Carcass Quality

To account for a possible decrease in carcass quality due to disease, the farm's average slaughter revenue for that year was used as a reference. If, within a case, a cow was sent to slaughter, its individual slaughter revenue was subtracted from the farm's average slaughter revenue that year. The negative outcome was revenue loss due to reduced carcass quality. If slaughter revenue exceeded the average, no loss was recorded. Mean of all farms: 646 € (518–784 €). Cows refused for slaughter or discarded carcasses were not considered in the average.

2.2.12. Plausibility Checks and Removal of Incomplete Datasets

After plausibility checks, 355 incomplete datasets were removed, leaving a total of 1272 single-animal cases (73–278 per farm).

2.2.13. Calculation of Total Costs and Lost Revenues

The calculated positions were added to a final sum of total costs and lost revenues for each case. Examples are given in Figures 1 and 2.

Two example of costs and lost revenues of an mastitis event in a cow and respective book loss

Cow A: 3rd lactation, acute catarrhal mastitis at 207 DIM, decision for slaughter at 230 DIM, 767 rearing days, 2,109 € rearing costs, depreciation of 4.2 cents/kg milk produced.

Cow B: 5th lactation, acute catarrhal mastitis at 124 DIM, teat injury at 153 DIM, decision for slaughter at 158 DIM, 715 rearing days, 1,966 € rearing costs, depreciation of 3.9 cents/kg milk produced.

* culling costs: pre-slaughter costs (administration and transport) or costs for euthanasia

Table A: Cost and lost revenue categories

Category	Cost or lost revenue	
	Cow A	Cow B
Time expenditure	42 €	47 €
Product expenses	142 €	85 €
Veterinary services	56 €	28 €
Orthopaedic services	- €	- €
Discarded milk	148 €	88 €
Decreased production	135 €	135 €
Culling*	32 €	47 €
Book loss	278 €	0 €
Decreased carcass quality	224 €	0 €
Sum	1057 €	430 €

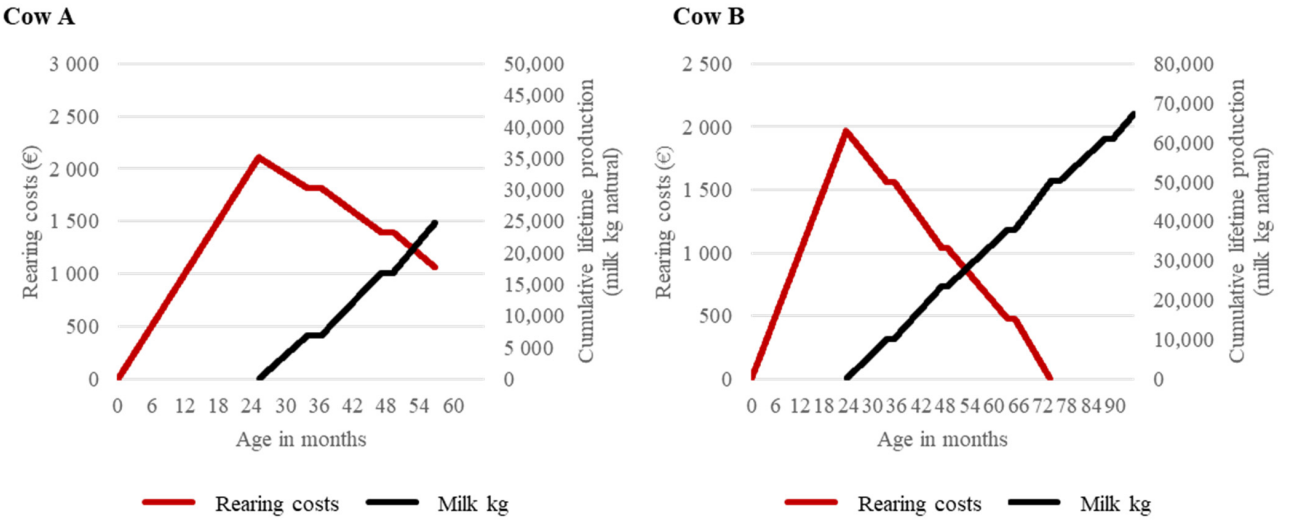


Figure 2. Two cases of cows that were culled due to observed disease. Cow B showed a complete depreciation of rearing costs, whereas Cow A was culled before the goal of 50,000 kg with a decreased carcass quality, causing substantial economic losses due to early culling.

3. Results and Discussion

Of the 1272 cases, 68% of animals were diagnosed with a stand-alone disease. Eleven % of cases were diagnosed with several diseases within one organ system (e.g., claw diseases). In 21%, several diseases were diagnosed across different organ systems, underscoring the difficulty of separating costs and lost revenues by disease. Comparable data in the literature is scarce. Wisnieski et al. (2019) [52] describe 23 of 93 (24.7%) diseased transition cows as being affected by two to four diseases, comparable to our study.

For each case, the costs and lost revenues for treatment, including products, labour, discarded milk, decreased milk production, book loss, and culling, were compiled. In Figures 1 and 2, two examples of mastitis cases are given, illustrating the depth of time expenditure documentation and the book loss model, respectively. In Table 1, a selection of diseases is given of stand-alone diagnoses as well as cases affected by several diseases. A complete overview of all cases is given in Appendix A, Table A1.

3.1. Mastitis

Mastitis cases were defined according to Dirksen et al. 2012 [44] into acute catarrhal (mammary gland secretion is altered with fine to large flakes, udder soft to acutely swollen, no or only little disturbance of the general health), phlegmonous (the mammary gland secretion lost milk resemblance with large flakes, serum or fibrine, udder is acutely swollen, general health is disturbed) and abscessing (the mammary gland secretion consists of pus, the udder tissue with lumpy patches of diffuse hardening or is hardened throughout, no to medium disturbance of the general health). On average the cows were 156 (31–326), 169 (0–518) and 177 (7–538) DIM and regarding the costs and lost revenues, a sum of 403, 594, and 673 € for an acute catarrhal, phlegmonous, and abscessing mastitis, respectively, was calculated, showing an increase in costs and lost revenues with the severity of the disease, mainly attributable to discarded milk and decreased production, as well as increased culling costs.

This was also confirmed by a recent study of Fadillah et al. (2025) [53] and Bonestroo et al. (2023) [54] investigating the cost-efficiency of mastitis control on smallholder dairy farms and the costs of chronic mastitis, respectively. The range of costs of disease for mastitis found in the literature varies wildly due to several aspects: year of study, region and production system, method (e.g., real cases vs. modelling), data source (e.g., milk price), depreciation model applied, disease severity, age of cow if considered, etc. [15,20]. Studies from Liang et al. (2017) [16], Rollin et al. (2015) [24] and Hagnestam-Nielsen and Østergaard (2009) [55] using a stochastic simulation model and an economic modelling tool, respectively, show similar dimensions with 326 $/427 $ (primi-/multiparous cows), 444 $ and 428 € per case, respectively.

A recent study of de Campos et al. (2023) [56], not including costs for culling, shows a mean of 192 $ per case in 37 dairy farms in Wisconsin (USA), with 209 $ for cases treated with antibiotics and 87 $ for cases only treated with supportive therapy. The costs for culling are substantially higher compared to Liang et al. (2017) [16] with 10 $ for primi- and multiparous cows and similar to higher (depending on the nature of the mastitis) compared to Rollin et al. (2015) [24] with 182 $. In a dynamic optimisation model in Finnish production settings Heikkilä et al. (2012) [57] showed an average cost of 485 € and 458 € in Ayrshire and Holstein-Friesian cows, respectively, rising to 596 € and 623 € when the risk of culling was included.

3.2. Lameness

Lameness was defined as a score of two or higher according to Rachidi et al. 2021 [58]. A score of two is characterised by occasional unloading of the affected limb or cautious tripping, slightly asymmetric step length and duration, a straight back (topline), a stable head held slightly below the topline, and mildly stiff limb angulation. A representative number of cases was collected for digital dermatitis (41 €, 211 (1–527) DIM), sole ulcer (107 €, 203 (3–386) DIM), white line abscess (340 €, 243 (2–795) DIM), and toe ulcer (490 €, 237 (56–435) DIM), showing a substantial increase in economic loss due to culling in case of the latter two diseases, i.e., culling costs, book loss and lost revenues from decreased carcass quality. Dolecheck and Bewley (2018) [31] report that the cost per case of non-specific lameness ranges from 76 to 533 $, depending on the study location, the calculation method used, and the expenditures and losses selected for inclusion. A review of Ózsvári (2017) [10] concludes similar ranges with 55 to 320 € per case depending on the study, whereas Alvergnas et al. (2019) [59] summarise costs between 51.5 and 1517 $ across the literature. Furthermore, Liang et al. (2017) [16] show general costs per case of 185 $/333 $ (primi-/multiparous cows), Dolecheck et al. (2019) [14] and Cha et al. (2010) [25] differentiate between at least three named orthopaedic diseases. In both

studies, the lowest economic impact was estimated for digital dermatitis (64 and 132 $), whereas the highest was for sole ulcers (178 and 216 $). Because the decrease in milk yield could not be reliably assessed in our study, comparability between stand-alone claw diseases and the literature is hampered. The cumulative impact of lameness on milk production was illustrated in a study by Puerto et al. (2021) [13], estimating losses between 811 and 1289 kg in primiparous cows depending on the stage of lactation. These ranges are in line with or higher than in other publications [60–64] and emphasise that, also in the case of orthopaedic diseases, reduced performance and early culling are the major cost drivers, compared to the costs arising from treatment (also summarised in Ózsvári (2017) [10]).

Practical experience shows that the treatment success in certain claw diseases is lower compared to others (e.g., Alawneh et al. (2012) [65] and Booth et al. (2004) [66]) as different survival rates have been found according to the grade of lameness or causal disease. This is reflected in our data, which shows a substantial economic impact of culling due to toe ulcers and white line abscesses. The costs and lost revenues arising from culling in these cases are considerably higher than those reported in the literature [10,14,16]. The unsuccessful treatment of many of these cases is furthermore reflected in the average number of visits to the claw trimmer: digital dermatitis (1.6, 1–8; mean, min-max), sole ulcer (3.2, 1–16), white line abscess (5.6, 1–13), and toe ulcer (6.3, 1–14). Complicated claw diseases often require specialised veterinary and orthopaedic knowledge of anaesthesia, surgical approaches, and postoperative care. The treatment is therefore often time-consuming. The average time spent in the claw-trimming chute (Table 1) indicates very short treatment durations. Taken together, the presented data, supported by personal observations, point towards the lack of qualified personnel present as well as adequate treatment areas (e.g., tilt table) as reasons for unsuccessful treatment of these cases.

3.3. Hypocalcaemia

Clinical hypocalcaemia was defined as a downer cow in the peripartal period showing characteristic clinical signs (e.g., cold extremities, muscle weakness) either responsive to hypocalcaemia treatment and/or confirmed decreased serum calcium concentrations. In total, only 12 cases of clinical milk fever were observed during this study (Appendix A Table A1), of which nine were stand-alone cases. The cases were diagnosed by the project veterinarians at an average of 2 (0–5) DIM, with one animal affected already pre-partum at 465 DIM. Of the six cases, a decrease in milk production could be considered; the total costs amount to 262 € (Table 1). The stochastic simulation model of Liang et al. (2017) [16] estimated the total costs for a case of hypocalcaemia in multiparous cows to 246 $. A figure similarly estimated by Caixeta and Omontese (2021) [67].

Hypocalcaemia is considered a gateway disease in transition dairy cows [68,69]. In our dataset, three cases were complicated with mastitis, metritis, and dystocia, respectively. The latter case is a good example of how cost-intensive severe diseases, with the culling of the animal, consequently are. The cow calved during her 6th lactation, developed milk fever, and subsequently experienced dystocia. Despite intensive therapy (labour, veterinarian, and product costs: 545 €), she needed to be euthanized due to her inability to rise after several days. Considering the book loss (20 €), the costs for carcass disposal (136 €), and the lost revenue from not being able to slaughter the animal (618 €), the total economic frame of the case amounted to 1223 €. This highlights the importance and economic potential of prevention and sound decision-making grounded in sound clinical experience.

3.4. Retained Placenta and Metritis

For reproductive disorders, a representative number of cases were collected for retained placenta and metritis (Appendix A Table A1). For diagnosis the definition of Kelton et al. 1998 [70] and Sheldon et al. 2006 [71] were applied: retained placenta: failure to expel foetal membranes within 24 h, metritis: enlarged uterus, foetid watery red-brown or purulent discharge, with or without systemic illness (decreased milk yield, dullness or other signs of toxaemia), and with or without fever greater than 39.5 °C within 21 days postpartum. In isolation, the total costs and lost revenues amounted to 135 € and 195 € for retained placenta and metritis, respectively, including lost revenues attributable to decreases in milk production. The average DIM at diagnosis was 2 (0–12) and 6 (0–17, and one animal with 295 DIM after abortion) for retained placenta and metritis, respectively. None of these cows was culled. In six cases, cows were affected by both diseases, and economic damage from culling amounted to 614 €. In a study including 16 study farms in the United States, Pérez-Báez et al. (2021) [17] estimated the cost of disease to be 513 $ (240–884 $), estimating it a bit higher than the earlier studies of Lima et al. (2019) [72] (267–410 $) and similar to Drillich et al. (2001) [73] (420–523 $, inflation adjusted by Pérez-Báez et al. (2021) [17]). Whereas, the study by Liang et al. (2017) [16] estimates the total costs of metritis and retained placenta at 172/263 $ and 150/313 $ for primiparous/multiparous cows, respectively. A very recent publication estimated the costs for metritis and retained placenta to be 257 and 123 €, respectively, using an individual cow-based and a stochastic bio-economic simulation model to study the interrelations between seven reproductive disorders [29]. A position that was not considered in the current study is costs and lost revenues, arising from decreased reproductive performance (e.g., extended days open, increased number of inseminations per conception, abortus). The literature shows heterogenous results in this regard with for example no costs (metritis, Pérez-Báez et al. (2021) [17]), 73 $ (retained placenta, Gohary and LeBlanc (2018) [74]) or 11/85 $ and 150/313 $ (primi-/multiparous cows, metritis and retained placenta respectively, Liang et al. (2017) [16]).

3.5. Left Displaced Abomasum

A displaced abomasum was diagnosed by a positive swing and percussion auscultation with a steelband sound over a defined area on the left side of the abdomen, with other differential diagnoses excluded by clinical examination [27,44,75]. It is, in many cases, a sequelae of other transition cow diseases [76]. This is also underlined by the current dataset with 36 cows diagnosed with a left displaced abomasum (LDA), of which 19 animals exhibited the LDA as a stand-alone disease (mean: 929 € in 13 animals with data on decreased milk production, DIM: 63 (1–272)), 12 animals showed a second disease (mean: 1051 € in nine animals with data on decreased milk production), whereas five cows were considered multimorbid (three and more diagnoses, mean: 908 € in four animals with data on decreased milk production). These estimations are much higher compared with the estimations of Liang et al. (2017) [16] with 432/640 $ in primi-/multiparous cows and of Caixeta et al. (2018) [77] with 700 $. It should be noted, however, that a considerable number of animals left the herd due to disease in our dataset (n = 21), increasing culling costs and lost revenue. Furthermore, depending on the methods chosen for LDA treatment, especially the costs for veterinary service, may vary considerably. The cows in our dataset were either only treated symptomatically (n = 24), using the toggle-pin or blind-stitch methods (n = 8), or in a few cases surgically (endoscopic (n = 3) or laparatomic (n = 1)). As this is from own experience, not the general distribution of treatment methods seen in practice in comparable production settings, the data should be seen critically. No surgical treatment and the blind-stitch and toggle-pin methods have high recurrence and

complication rates, respectively [78]. Personal communication with herd managers and veterinarians of the study farms revealed that mainly the lack of surgical skills, of an adequate workspace for surgical interventions, as well as time, were the main drivers for the choice of these procedures.

A considerable number of cows were diagnosed with indigestion (n = 60; 57 cows with a stand-alone diagnosis; 55 cows for which the decrease in milk production was estimated; mean: 183 €; Appendix A Table A1), defined as a disorder affecting the forestomach system [27,44]. In the respective cases, the cause of the digestive problem could not be identified using the available diagnostic tools. More than half of the cases occurred on one farm (n = 35, whereas the others occurred on 8 farms).

As this was noticeable, an in-depth analysis including clinical examination, blood sampling, and ultrasound of a representative number of cases was conducted on this farm and thoroughly elaborated in a case report [79]. The analysis showed that of 15 cows examined, eight were affected by traumatic-reticuloperitonitis (TRP), and in 13 cows, a LDA with varying degrees of displacement from the physiological position and adhesions between the abomasum and reticulum caused by reticuloperitonitis was diagnosed. These observations underline the practical experience that untreated LDA tend to stay dislocated, causing chronic digestive problems. The data in the current study suggest that these cases are more frequent than previously known and warrant further investigation.

3.6. Diseases in Calves

The commonly observed diseases in calves were diarrhoea (53 €), pneumonia (77 €), the combination of the two (73 €), and omphalitis (57 €) (Table 1, Appendix A Table A1); defined according to Dirksen et al. 2006 and Smith and Bradford 2014 [27,80]. As in cows, a considerable number of calves were affected by more than one disease, and the economic impact increased with the number of diagnoses (multimorbidity, mean: 251 €). The elaborated economic impact is similar to Dubrovsky et al. (2020) [39], showing total costs for a bovine respiratory disease (BRD) case in dairy calves of 42 $, and higher than Esslemont and Kossaibati (1999) [38] with 26 $ and Küçükoflaz and Sariözkan (2023) [40] with 6.2–7.5 $. It has, however, to be considered that in the latter, the mortality costs were considered separately.

In recent decades, awareness that diseases acquired during the rearing period can contribute to future production has increased [81]. It should be noted that the costs in our calculation comprise only the short-term economic impact.

3.7. General Considerations

3.7.1. Economic Framework and Study Type

All economic models are based on approximations, as they involve assumptions (Fetrow and Mansfeld, in de Kruif et al. (2014) [33], Hogeveen et al. (2019) [7]). Using real on-farm cases and data, we aimed to have a very close approximation of the aspects of the costs and lost revenues for treatment (labour and products), discarded milk, as well as decrease in milk production, book loss and culling. Unlike normative approaches that rely on assumed or averaged inputs, our on-farm dataset links each clinical diagnosis to actual events: recorded treatments, time-stamped labour, product use and prices, drug-specific withdrawal periods, individualised milk curves, and culling outcomes documented by invoice. This linkage limits recall and expert-elicitation bias and preserves the true joint distribution of cost components. It also allows multimorbidity and non-additive effects to emerge from the data, making visible compounding losses that single-disease normative averages can obscure. Accordingly, the dataset provides em-

pirically grounded priors and validation targets for bioeconomic and dynamic models, and sets realistic parameter bounds for sensitivity analyses under different price and management scenarios.

But also in our approach, certain aspects were/could not be considered. We initially also aimed to differentiate disease severity (e.g., minor, medium, severe) in our calculations. The respective number of cases per disease only allowed for this to a certain degree (e.g., forms of mastitis). As mentioned above, the costs associated with decreased fertility and developmental delays in calves and their impact on later performance potential were not considered. Furthermore, diseases may also have a more widespread effect on the single animal level, potentially leading to a reduced performance in the next lactation [3], influencing the likelihood of disease and culling in the future (Peeler, et al. (1994) [82] e.g., considered by Robcis et al. (2023) [21]) and may also affect the herd/other cows (e.g., in the case of infectious diseases such as digital dermatitis [83]). Such aspects have been modelled using various statistical approaches at the single-animal and herd levels [15,16,19,25,84]. The advantage of these methods is that they allow the testing of scenarios, e.g., milk prices and replacement models [15]. We encourage the use of our data in future studies applying different model approaches.

3.7.2. Book Loss Approach

We deliberately opted for a case-based approach to assessing the replacement of animals, including the individual rearing period and lifetime milk production, to calculate the book loss. With this approach, we considered the time required to bring the animal into production, as well as its individual productivity, thereby not solely accounting for factors such as age and parity. As described in Section 2, a target lifetime production of 50,000 kg was chosen, considering the goal communicated by the German Federal Association for Cattle and Pigs (BRS, 2025) of 40,000 kg, as well as expert experience on economic efficiency at the individual and herd levels in this context. Additionally, it lays the focus on the longevity of cows, an aspect that has been emphasised in recent years due to its relevance regarding animal health, welfare, and sustainability [85]. Another possible approach would have been the application of a retention pay-off model [15,34]. It allows the inclusion of the lactation number, stage of lactation, as well as the reproductive status of the animal in determining the current economic value. A comparison of the different approaches should be considered in future studies.

3.7.3. Labour Costs

In our dataset, substantial differences exist among cases in the hours of labour invested. Dolecheck and Bewley (2018) [31] report in a review that 1.7–17.3% of the total costs of a lameness case are attributable to increased labour. Liang et al. (2017) [16] estimate the costs for labour to be 10–15 $ per case for different production diseases (lowest metritis, highest LDA). Pérez-Báez et al. (2021) [17] accounted for 0.72 $ per metritis case and Bar et al. (2008) [15] and Rollin et al. (2015) [24] accounted for 10 $ and 21 $ for a mastitis case, respectively, in similar economic production settings regarding hourly wages. Our estimates based on detailed measurements were higher in all named disease categories. However, it should be considered that regional differences in wages and market prices may decrease or increase this cost component.

3.7.4. Sensitivity Analysis

As illustrated in the chapters above, current economic conditions have a significant influence on the costs and lost revenue arising from a disease. The division of our data into the different positions of the economic framework (Table 2 and Appendix A Table A1) allows the reader to estimate the influence of changes in labour costs, veterinary costs, milk, and slaughter prices on the respective position and case. For illustrational purposes, we calculated five different scenarios for the acute catarrhal mastitis cases (Table 1, $n = 98$), summarising the cost and lost revenue positions into three subgroups (total; (treatment/milk loss/culling)):

1. Original, market prices of 2021: 403 € (129/204/69 €).
2. Doubling of wages and costs for veterinary services: 464 € (191/204/69 €).
3. Doubling of the milk price (to 0.67 €/100 kg ECM): 525 € (129/326/69 €).
4. Increase of 50% in slaughter revenue: 412 € (129/204/79 €).
5. Doubling the rearing costs: 495 € (129/204/161 €).
6. Decreasing the goal lifetime production for depreciation to 30,000 kg: 384 € (129/204/50 €).

The different scenarios confirm that milk price and culling are the most intensive cost drivers. The increase in slaughter revenue causes a decrease in the average book loss (from 45 to 24 €); however, it also causes an increase in lost revenues (from 19 to 50 €), as many of the culled cows exhibited a decreased carcass quality.

3.7.5. Practical Implications

Our data shows that if an animal is affected by several diseases, the costs and lost revenues do not, in many cases, simply add up but rather potentiate (e.g., mastitis and non-infectious claw disease, sole ulcer and infectious claw disease, left displaced abomasum and mastitis; Table 2). It, furthermore, clearly affirms the literature by showing that the highest costs and lost revenues arise from the influences of the disease on the productivity of the animal (milk production and culling) and not from the expenses for treatment (labour, products, veterinary and orthopaedic service; Halasa et al. (2007) [9], Ózsvári (2017) [10]). A prerequisite, however, is the availability of skilled personnel and treatment facilities that ensure accurate diagnosis and early treatment of the disease. This will largely influence its economic impact. Our dataset, with regard to lameness cases and LDA, clearly illustrates that the qualifications of those involved and workplace design are crucial factors in dairy health management [78,79].

Quantifying disease costs is important for farmers and veterinarians in decision-making. Aside from the possible costs and revenues when culling an animal, the costs for a potential treatment and the predicted future productivity of the individual must be accounted for. This dataset, in line with other studies, provides a comprehensive overview of the economic framework of diseases, assisting not only in factual decision-making but also in highlighting the economic potential of preventative measures.

Table 2. Costs and lost revenues in a selection of diseases in cows and calves [Mean (Min-Max)] in Euros.

Diagnosis	*n*-Number	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production *	Culling **	Book Loss	Decreased Carcass Quality	Sum
Mastitis—acute catarrhal	98	36 (12–104)	60 (4–268)	33 (0–80)	-	122 (0–537)	82 (0–304)	5 (0–75)	45 (0–1321)	19 (0–687)	403 (88–2045)
Mastitis—phlegmonous	19	43 (10–90)	78 (22–183)	44 (19–80)	-	123 (4–413)	162 (34–540)	12 (0–125)	84 (0–878)	49 (0–657)	594 (124–1429)
Mastitis—abscessing	9	32 (6–48)	64 (0–93)	33 (0–65)	-	58 (0–211)	310 (67–844)	17 (0–53)	11 (0–99)	147 (0–657)	673 (262–1195)
Digital dermatitis	121	13 (3–46)	4 (0–25)	0 (0–17)	19 (8–86)	0 (0–0)	-	0 (0–34)	4 (0–544)	0 (0–0)	41 (11–647)
Sole ulcer	42	21 (6–89)	11 (1–93)	1 (0–21)	37 (8–168)	2 (0–88)	-	5 (0–136)	10 (0–429)	19 (0–618)	107 (14–1207)
White line abscess	26	32 (4–68)	17 (0–83)	1 (0–31)	60 (8–137)	0 (0–0)	-	11 (0–119)	183 (0–1406)	38 (0–618)	340 (32–1663)
Toe ulcer	10	40 (10–90)	23 (5–133)	2 (0–17)	69 (18–145)	6 (0–64)	-	11 (0–41)	292 (0–1035)	46 (0–307)	490 (33–1393)
Hypocalcaemia	6	22 (5–35)	50 (17–81)	39 (17–81)	-	13 (0–39)	22 (8–59)	23 (0–136)	0 (0–0)	94 (0–565)	262 (48–833)
Metritis	32	12 (2–46)	26 (0–151)	19 (0–73)	-	19 (0–131)	60 (8–270)	0 (0–0)	0 (0–0)	0 (0–0)	135 (10–411)
Indigestion	55	4 (2–23)	2 (0–35)	3 (0–51)	-	2 (0–117)	86 (8–844)	4 (0–88)	44 (0–1409)	28 (0–758)	172 (10–1629)
Left displaced abomasum	13	26 (3–74)	24 (0–87)	72 (0–232)	-	8 (0–64)	495 (17–1316)	17 (0–47)	221 (0–1523)	67 (0–387)	929 (220–1820)
Mastitis and non-infectious claw disease	13	40 (26–83)	53 (11–211)	28 (19–69)	17 (8–41)	105 (19–442)	80 (25–202)	14 (0–38)	182 (0–1393)	43 (0–273)	563 (182–2032)
Sole ulcer and infectious claw disease	28	22 (10–67)	13 (1–89)	2 (0–35)	37 (14–137)	2 (0–48)	-	6 (0–38)	30 (0–730)	22 (0–239)	134 (27–833)
Multimorbidity cow ***	21	39 (14–83)	81 (7–286)	34 (0–81)	18 (0–101)	78 (0–239)	152 (8–649)	8 (0–136)	68 (0–951)	37 (0–784)	516 (113–1642)
Left displaced abomasum and mastitis	4	76 (28–150)	174 (16–475)	116 (39–165)	-	81 (13–243)	-	37 (0–84)	257 (0–703)	276 (0–618)	1018 (204–1383)

https://doi.org/10.3390/dairy7020026

Table 2. *Cont.*

Diagnosis	*n*-Number	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production *	Culling **	Book Loss	Decreased Carcass Quality	Sum
Calf diarrhoea	62	17 (2–44)	9 (0–34)	22 (0–77)	-	-	-	1 (0–20)	5 (0–239)	-	53 (3–263)
Calf pneumonia	88	18 (1–60)	15 (0–73)	28 (0–74)	-	-	-	2 (0–73)	15 (0–522)	-	77 (22–575)
Calf pneumonia and diarrhoea	42	21 (7–44)	13 (2–37)	27 (0–64)	-	-	-	2 (0–20)	10 (0–113)	-	73 (9–216)
Omphalitis calf	8	15 (8–30)	6 (3–10)	23 (17–35)	-	-	-	7 (0–55)	7 (0–54)	-	57 (27–148)
Multimorbidity calf ***	7	37 (15–70)	17 (5–26)	47 (24–63)	-	-	-	19 (0–55)	131 (0–572)	-	251 (44–734)

* Cows where the decrease in milk production was not clearly determinable were not considered (for differentiation, see Appendix A, Table A1). In the case of solitary claw diseases, the determination of the decrease in milk production was not possible. ** culling costs: pre-slaughter costs (administration and transport) or costs for euthanasia, *** multimorbidity was defined as ≥3 diseases at different organ systems.

4. Conclusions

This study quantified the economic impact of production diseases at the single-animal level using 1272 validated on-farm cases in German dairy herds. Decreased milk production and culling-related positions (pre-slaughter/disposal, book loss, reduced carcass value) dominated total losses: in mastitis, roughly two-thirds of the case loss stemmed from milk loss and culling, and across all diseases, the average damage per removed animal was €512. Severe claw lesions (white line abscess, toe ulcer) frequently ended in removal with substantial book loss and carcass penalties, and many LDA cases were culled, yielding mean losses near €900–€1050 when milk loss was included. Multimorbidity consistently amplifies losses beyond the sum of the costs of individual diseases. These findings point to clear priorities: earlier, accurate diagnosis and timely, skilled intervention (especially for mastitis, LDA, and severe claw lesions); appropriate surgical capacity for LDA; and investment in effective treatment infrastructure (e.g., safe restraint, dedicated claw-treatment areas). Empirical, case-level costing should inform treat-versus-cull decisions, particularly in multimorbid animals. Our dataset provides grounded inputs and validation targets for dynamic and bioeconomic models; future work should capture longer-term consequences (reproduction, next-lactation effects, calfhood carryover) and be powered to test associations with herd size, milk yield, and milking method.

Author Contributions: Conceptualization, A.W., W.W., B.W., P.H., J.W., F.R., A.S. and M.S.-B.; methodology, A.W., W.W., B.W., F.R., P.H., A.S. and M.S.-B.; software, B.W. and E.B.; validation, A.W., W.W., B.W., E.B., C.F., F.F., J.W., P.H. and M.S.-B.; formal analysis, A.W., W.W., B.W., E.B., C.F., F.F., J.W., P.H. and M.S.-B.; investigation, A.W., W.W., J.W., C.F., F.F., E.B. and M.S.-B.; resources, D.M. and A.S.; data curation, B.W., E.B. and M.S.-B.; writing—original draft preparation, A.W., W.W. and M.S.-B.; writing—review and editing, M.S.-B., F.R., S.D., H.H.S. and A.S.; visualisation, B.W. and M.S.-B.; supervision, S.D., H.H.S., A.S., P.H., D.M. and M.S.-B.; project administration, P.H. and D.M.; funding acquisition, F.R., M.S.-B., A.S., P.H. and D.M. All authors have read and agreed to the published version of the manuscript.

Funding: The study was conducted in the scope of a European Innovation Partnership (EIP)-agri project ("Die Entwicklung des KUH-mehr-WERT Navigators").

Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Acknowledgments: Open Access Funding by the University of Veterinary Medicine Vienna. We thank the farmers involved in this study for their trust and engagement. During the preparation of this manuscript, the authors used Academic AI and ChatGPT (GPT-4 and GPT-5) and Grammarly for language editing, summarization, and wording suggestions. The authors have reviewed and edited all AI-generated content and take full responsibility for the content of this publication.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Costs and lost revenues in a selection of diseases in cows and calves [Mean (Min-Max)] in Euros in alphabetical order. CA = calves; LA = locomotion apparatus; MD = metabolic and digestive; OT = other; RE = reproduction; and UD = udder health.

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
CA—Arthritis	1		33	13	35	0	0	0	0	0			80
CA—Diarrhoea	62		17 (2–44)	9 (0–34)	22 (0–77)	0 (0–0)	0 (0–0)	0 (0–0)	1 (0–20)	5 (0–239)			53 (3–263)
CA—Diarrhoea and inflammation of the dehorning wound	2		17 (6–28)	7 (1–13)	22 (0–44)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)			46 (7–85)
CA—Diarrhoea and pneumonia	42		21 (7–44)	13 (2–37)	27 (0–64)	0 (0–0)	0 (0–0)	0 (0–0)	2 (0–20)	10 (0–113)			73 (9–216)
CA—Disease of the small intestines	1		15	16	28	0	0	0	0	0			59
CA—Flexor tendon contraction	1		12	7	31	0	0	0	0	0			50
CA—Indigestion	1		11	9	23	0	0	0	0	0			43
CA—Inflammation of the dehorning wound	4		21 (13–30)	10 (3–19)	36 (26–62)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)			68 (47–103)
CA—Multimorbidity **	7		37 (15–70)	17 (5–26)	47 (24–63)	0 (0–0)	0 (0–0)	0 (0–0)	19 (0–55)	131 (0–572)			251 (44–734)
CA—Omphalitis	8		15 (8–30)	6 (3–10)	23 (17–35)	0 (0–0)	0 (0–0)	0 (0–0)	7 (0–55)	7 (0–54)			57 (27–148)
CA—Omphalitis and diarrhoea	16		16 (3–29)	9 (1–22)	26 (0–44)	0 (0–0)	0 (0–0)	0 (0–0)	1 (0–20)	3 (0–45)			55 (5–102)
CA—Omphalitis and pneumonia	5		30 (8–83)	21 (11–52)	35 (0–91)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)			87 (21–226)

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
CA—Other	2		8 (4–13)	15 (1–29)	24 (15–32)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)			47 (20–74)
CA—Otitis	2		15 (14–16)	5 (5–5)	24 (21–27)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)			44 (42–46)
CA—Pneumonia	88		18 (1–60)	15 (0–73)	28 (0–74)	0 (0–0)	0 (0–5)	0 (0–0)	2 (0–73)	15 (0–522)			77 (22–575)
CA—Pneumonia and conjunctivitis	1		7	14	17	0	0	0	0	0			37
CA—Pneumonia and disease of the digestive tract	2		32 (11–53)	33 (15–51)	37 (17–58)	0 (0–0)	0 (0–0)	0 (0–0)	10 (0–20)	151 (0–302)			263 (43–483)
CA—Pneumonia and flexor tendon contraction	2		32 (25–38)	26 (22–29)	47 (35–59)	0 (0–0)	0 (0–0)	0 (0–0)	28 (0–55)	81 (0–162)			213 (82–343)
CA—Pneumonia and inflammation of the dehorning wound	4		15 (4–34)	6 (1–12)	22 (17–35)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)			44 (26–80)
CA—Pneumonia and otitis	3		22 (6–33)	25 (14–37)	35 (21–49)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)			81 (41–103)
LA—Arthritis	3	3	10 (3–19)	20 (0–50)	7 (0–21)	14 (0–42)	0 (0–0)	98 (40–213)	0 (0–0)	0 (0–0)	163 (0–490)	312 (112–706)	214 (70–493)
LA—Asymmetric claws and non-infectious claw disease	1		35	20	0	70	0	0	72	124	323		644

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
LA—Axial horn fissure and non-infectious claw disease	2		34 (34–34)	14 (11–18)	0 (0–0)	65 (65–65)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		114 (110–117)
LA—Claw injury	2		13 (12–14)	11 (4–18)	8 (0–17)	11 (8–14)	8 (0–16)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		51 (25–78)
LA—Digital dermatitis	121		13 (3–46)	4 (0–25)	0 (0–17)	19 (8–86)	0 (0–0)	0 (0–0)	0 (0–34)	4 (0–544)	0 (0–0)		41 (11–647)
LA—Digital dermatitis and infectious claw disease	34		13 (6–29)	7 (0–25)	0 (0–0)	21 (8–58)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		42 (14–100)
LA—Digital dermatitis and non-infectious claw disease	35		13 (6–28)	9 (1–83)	1 (0–31)	20 (8–42)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		43 (14–166)
LA—Dermatitis interdigitalis	13		11 (6–19)	4 (0–11)	0 (0–0)	17 (8–34)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		31 (14–59)
LA—Double sole	4		19 (10–27)	4 (1–6)	0 (0–0)	31 (11–45)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		54 (22–75)
LA—Double sole and other claw disease	2		15 (10–19)	5 (2–7)	0 (0–0)	24 (14–34)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		43 (26–61)
LA—Heel abscess	8		23 (5–37)	7 (0–11)	0 (0–0)	38 (11–65)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		67 (17–113)
LA—Heel abscess and claw disease	2		17 (14–19)	19 (6–32)	0 (0–0)	33 (24–42)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		68 (44–93)

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
LA—Heel horn erosions	3		9 (6–10)	2 (0–3)	0 (0–0)	12 (8–14)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		22 (14–27)
LA—Injury at the locomotion apparatus	1		20	29	17	14	55	0	0	0	0		135
LA—Injury at the locomotion apparatus and claw disease	2		10 (10–10)	4 (3–5)	0 (0–0)	14 (14–14)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		28 (27–29)
LA—Interdigital hyperplasia	12		11 (5–19)	3 (1–8)	0 (0–0)	17 (8–34)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		32 (13–62)
LA—Interdigital hyperplasia and Digital dermatitis and infectious claw disease	4		17 (11–24)	12 (5–19)	0 (0–0)	30 (14–45)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		60 (30–88)
LA—Interdigital hyperplasia and Digital dermatitis and non-infectious claw disease	2		12 (10–15)	8 (5–11)	0 (0–0)	19 (14–24)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		39 (29–49)
LA—Interdigital hyperplasia and Digital dermatitis	5		16 (10–23)	6 (1–8)	0 (0–0)	26 (14–42)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		47 (25–74)
LA—Interdigital hyperplasia and infectious claw-disease	5		10 (5–15)	2 (1–4)	0 (0–0)	13 (8–24)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		25 (13–42)

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
LA—Interdigital hyperplasia and non-infectious claw-disease	3		10 (6–15)	6 (0–14)	0 (0–0)	16 (8–27)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		32 (14–55)
LA—Interdigital phlegmone	3	3	12 (10–14)	21 (10–30)	25 (21–27)	0 (0–0)	54 (31–79)	90 (67–118)	0 (0–0)	0 (0–0)	0 (0–0)	202 (139–261)	112 (71–143)
LA—Interdigital phlegmone and claw disease	2	1	15 (10–21)	30 (2–58)	10 (0–21)	20 (14–27)	0 (0–0)	101 (101–101)	0 (0–0)	0 (0–0)	0 (0–0)	227	76 (25–126)
LA—Interdigital phlegmone and metritis	8	8	28 (5–46)	43 (3–101)	16 (0–31)	38 (0–55)	18 (0–111)	100 (17–270)	21 (0–136)	181 (0–1450)	65 (0–518)	510 (63–2365)	410 (29–2264)
LA—Nervus radialis paresis and non-infectious claw disease	1		27	24	13	47	0	0	53	16	618		798
LA—Nervus tibialis paresis	1		10	3	0	14	0	0	0	0	0		27
LA—Nervus tibialis paresis and rectum-bladder-tail-paresis	2		18 (3–33)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	62 (35–88)	709 (560–858)	309 (100–518)		1098 (727–1468)
LA—Other diseases of the locomotion apparatus	2		17 (4–30)	74 (0–149)	53 (0–105)	0 (0–0)	0 (0–0)	0 (0–0)	19 (0–38)	491 (0–982)	128 (0–256)		782 (284–1280)
LA—Periarthritis	5		15 (4–36)	49 (0–166)	15 (0–39)	2 (0–8)	49 (0–164)	0 (0–0)	6 (0–30)	44 (0–220)	0 (0–0)		180 (21–404)

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
LA—Periarthritis and other claw diseases	3		33 (20–46)	46 (18–77)	14 (0–21)	43 (0–95)	10 (0–30)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		145 (130–159)
LA—Sole haemorrhage	2		10 (10–10)	5 (4–6)	0 (0–0)	15 (14–16)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		30 (27–33)
LA—Sole ulcer	3	2	33 (15–61)	57 (6–160)	14 (0–41)	47 (29–69)	0 (0–0)	19 (13–25)	11 (0–33)	0 (0–0)	0 (0–0)	226 (74–378)	163 (49–365)
LA—Sole ulcer (Rusterholz)	42	19	21 (6–89)	11 (1–93)	1 (0–21)	37 (8–168)	2 (0–88)	40 (17–94)	5 (0–136)	10 (0–429)	19 (0–618)	110 (48–297)	107 (14–1207)
LA—Sole ulcer (Rusterholz) and infectious claw disease	28	9	22 (10–67)	13 (1–89)	2 (0–35)	37 (14–137)	2 (0–48)	42 (0–51)	6 (0–38)	30 (0–730)	22 (0–239)	192 (69–833)	134 (27–833)
LA—Sole ulcer (Rusterholz) and non-infectious claw disease	22	8	28 (10–88)	18 (2–86)	2 (0–21)	51 (14–174)	0 (0–0)	45 (17–76)	3 (0–36)	3 (0–67)	20 (0–282)	177 (70–350)	125 (25–629)
LA—Sole ulcer and infectious claw disease	5	4	21 (10–29)	13 (1–37)	3 (0–17)	37 (11–50)	0 (0–0)	32 (17–59)	0 (0–0)	0 (0–0)	0 (0–0)	120 (83–158)	75 (22–124)
LA—Sole ulcer and non-infectious claw disease	8	5	34 (19–48)	27 (6–73)	4 (0–17)	66 (34–116)	0 (0–0)	36 (17–67)	13 (0–72)	0 (0–0)	30 (0–240)	171 (80–265)	174 (63–531)
LA—Swelling of coronet and non-infectious claw disease	2		13 (10–17)	27 (2–53)	10 (0–21)	14 (14–14)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		65 (26–104)

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
LA—Toe ulcer	10		40 (10–90)	23 (5–133)	2 (0–17)	69 (18–145)	6 (0–64)	0 (0–0)	11 (0–41)	292 (0–1035)	46 (0–307)		490 (33–1393)
LA—Toe ulcer and other claw diseases	9		43 (20–87)	32 (7–57)	8 (0–35)	79 (34–178)	7 (0–59)	0 (0–0)	26 (0–96)	400 (0–1483)	161 (0–618)		754 (99–1955)
LA—Vertical horn fissure and non-infectious claw disease	1		29	12	0	55	0	0	0	0	0		96
LA—White line abscess	26		32 (4–68)	17 (0–83)	1 (0–31)	60 (8–137)	0 (0–0)	0 (0–0)	11 (0–119)	183 (0–1406)	38 (0–618)		340 (32–1663)
LA—White line abscess and infectious claw disease	11		15 (6–24)	8 (1–26)	0 (0–0)	27 (8–47)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		50 (14–98)
LA—White line abscess and non-infectious claw disease	30		27 (10–73)	13 (0–80)	1 (0–21)	51 (11–149)	1 (0–41)	0 (0–0)	6 (0–47)	0 (0–0)	9 (0–256)		108 (26–401)
LA—White line fissure	6		30 (15–58)	13 (4–26)	0 (0–0)	63 (24–125)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		107 (43–209)
LA—White line fissure and chronic catarrhal mastitis	1		48	89	58	24	116	0	0	0	0		336
LA—White line fissure and infectious claw disease	7		19 (10–30)	10 (1–30)	0 (0–0)	34 (11–58)	0 (0–0)	0 (0–0)	5 (0–35)	0 (0–0)	20 (0–141)		88 (22–294)

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
LA—White line fissure and ketosis	1		54	73	31	27	6	0	0	0	0		189
LA—White line fissure and non-infectious claw disease	14		27 (10–93)	11 (1–34)	0 (0–0)	53 (14–183)	0 (0–0)	0 (0–0)	3 (0–39)	44 (0–614)	14 (0–197)		153 (25–1031)
MD—Hypocalcaemia	9	6	23 (5–47)	45 (17–95)	35 (17–81)	0 (0–0)	9 (0–39)	22 (8–59)	30 (0–136)	0 (0–0)	125 (0–565)	262 (48–833)	268 (39–821)
MD—Hypocalcaemia and acute catarrhal mastitis	1	1	46	93	44	0	126	8	0	0	0	317	308
MD—Hypocalcaemia and dystocia	1		97	183	169	0	0	0	136	20	618		1223
MD—Hypocalcaemia and metritis	1	1	20	79	63	0	37	84	0	0	0	284	199
MD—Indigestion	57	55	4 (2–23)	2 (0–35)	3 (0–51)	0 (0–0)	2 (0–117)	86 (8–844)	5 (0–88)	56 (0–1409)	36 (0–758)	172 (10–1629)	108 (2–1561)
MD—Indigestion and acute catarrhal mastitis	1	1	24	46	20	0	38	182	0	0	0	311	129
MD—Indigestion and infectious claw disease	1		21	30	17	14	36	0	0	0	0		117

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
MD—Indigestion and non-infectious claw disease	1	1	12	2	0	14	7	127	0	0	0	162	35
MD—Intestinal disease	5		30 (13–66)	38 (0–122)	26 (0–76)	0 (0–0)	9 (0–45)	0 (0–0)	75 (30–136)	0 (0–0)	426 (0–784)		604 (43–1172)
MD—Ketosis	13	12	15 (2–31)	20 (0–78)	21 (0–57)	0 (0–0)	11 (0–84)	28 (0–84)	0 (0–0)	0 (0–0)	0 (0–0)	95 (25–224)	67 (2–170)
MD—Ketosis and udder haematoma	1	1	26	55	19	0	87	84	0	0	0	271	187
MD—LDA and claw disease	2	2	33 (22–44)	18 (12–23)	74 (31–118)	16 (14–18)	0 (0–0)	51 (51–51)	27 (0–53)	0 (0–0)	379 (0–758)	597 (140–1053)	546 (89–1003)
MD—LDA and hypocalcaemia	1	1	15	38	27	0	0	202	36	0	217	536	333
MD—LDA and lower limb phlegmone	1		48	56	31	45	44	0	0	0	0		224
MD—LDA and intestinal disease	1	1	13	16	15	0	17	152	36	500	434	1183	1031
MD—LDA and mastitis	4	2	76 (28–150)	174 (16–475)	116 (39–165)	0 (0–0)	81 (13–243)	557 (101–1012)	37 (0–84)	257 (0–703)	276 (0–618)	1231 (1216–1246)	1018 (204–1383)
MD—LDA and metritis	1	1	3	0	0	0	0	137	47	1368	0	1555	1418
MD—LDA and periarthritis	1	1	46	13	142	0	17	101	53	1022	758	2152	2050

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
MD—LDA and retained placenta	1	1	55	38	229	0	54	0	0	0	0	376	376
MD—Left displaced abomasum (LDA)	19	13	28 (3–81)	34 (0–166)	74 (0–279)	0 (0–0)	10 (0–66)	495 (17–1316)	26 (0–136)	151 (0–1523)	110 (0–784)	929 (220–1820)	432 (17–1795)
MD—Other digestive tract diseases	1		9	10	0	0	0	0	0	0	0		19
MD—Subclinical hypocalcaemia	2		9 (7–11)	20 (15–24)	14 (0–28)	0 (0–0)	0 (0–0)	0 (0–0)	15 (0–30)	0 (0–0)	0 (0–0)		58 (22–94)
MD—Traumatic reticuloperitonitis	15	12	10 (2–23)	21 (0–56)	13 (0–21)	0 (0–0)	16 (0–64)	157 (49–304)	11 (0–88)	116 (0–901)	35 (0–518)	296 (90–1154)	222 (2–1586)
OT—Abduction of hind legs and downer cow syndrome	3	3	25 (9–54)	15 (0–46)	9 (0–28)	0 (0–0)	0 (0–0)	143 (101–211)	45 (0–136)	654 (0–1169)	416 (0–758)	1389 (224–2235)	1165 (13–2117)
OT—Bronchopneumonia	7	6	14 (3–29)	48 (0–193)	15 (0–53)	0 (0–0)	18 (0–123)	47 (27–67)	12 (0–83)	0 (0–0)	74 (0–518)	252 (65–638)	181 (20–604)
OT—Bronchopneumonia and indigestion	1	1	8	11	17	0	72	101	0	0	0	208	107
OT—Bronchopneumonia and ketosis	1	1	24	83	44	0	90	34	0	0	0	275	241
OT—Bronchopneumonia and metritis	2	2	23 (16–30)	59 (38–80)	17 (13–21)	0 (0–0)	6 (0–13)	119 (27–211)	0 (0–0)	0 (0–0)	0 (0–0)	224 (101–347)	105 (74–136)

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
OT—Cutaneous abscess or skin laceration	10		15 (4–48)	27 (0–224)	6 (0–44)	4 (0–22)	0 (0–0)	0 (0–0)	3 (0–34)	63 (0–628)	29 (0–294)		147 (10–960)
OT—Disease of unknown origin	3		19 (11–31)	58 (23–114)	25 (19–35)	0 (0–0)	32 (0–95)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)		134 (53–275)
OT—Keratoconjunctivitis	1		10	3	13	0	0	0	0	0	0		27
OT—Multimorbidity **	30	21	39 (14–83)	81 (7–286)	35 (0–90)	18 (0–101)	70 (0–248)	152 (8–649)	13 (0–136)	87 (0–951)	80 (0–784)	516 (113–1642)	423 (63–1686)
OT—Rib and sternum fracture and pneumonia	1	1	16	28	31	0	42	211	136	0	518	982	771
RE—Abortus	3	1	18 (12–28)	48 (16–90)	27 (17–33)	3 (0–8)	23 (0–64)	101 (101–101)	0 (0–0)	0 (0–0)	0 (0–0)	186	118 (85–151)
RE—Dystocia and subcutaneous emphysema	1		46	274	383	0	96	0	34	1282	222		2337
RE—Dystocia and vaginal laceration	1	1	20	21	55	0	0	253	0	0	0	349	96
RE—Endometritis	1		6	1	19	0	0	0	0	0	0		26
RE—Metritis	37	32	13 (2–46)	27 (0–151)	20 (0–73)	0 (0–0)	17 (0–131)	60 (8–270)	0 (0–0)	0 (0–0)	0 (0–0)	135 (10–411)	77 (2–394)
RE—Metritis and claw disease	5	4	26 (2–54)	35 (0–80)	24 (0–40)	22 (0–53)	35 (0–94)	38 (0–67)	0 (0–0)	0 (0–0)	0 (0–0)	163 (44–269)	143 (2–227)

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
RE—Retained placenta	16	14	19 (5–78)	47 (2–226)	45 (17–140)	0 (0–0)	28 (0–93)	64 (8–135)	0 (0–0)	0 (0–0)	0 (0–0)	195 (50–528)	139 (24–444)
RE—Retained placenta and metritis	6	6	11 (2–25)	19 (0–42)	23 (0–47)	0 (0–0)	28 (0–76)	91 (34–278)	17 (0–53)	311 (0–1100)	115 (0–687)	614 (177–1544)	524 (41–1509)
RE—Retained placenta and non-infectious claw disease	2	1	48 (47–48)	105 (33–177)	81 (72–90)	42 (37–48)	16 (4–29)	51 (51–51)	0 (0–0)	0 (0–0)	0 (0–0)	406	293 (230–355)
RE—Uterine torsion	1	1	13	0	0	0	0	354	0	291	472	1130	776
RE—Vaginal disease	1		2	0	0	0	0	0	0	0	0		2
RE—Vaginal laceration	5		13 (3–22)	18 (0–38)	35 (0–67)	0 (0–0)	0 (0–0)	0 (0–0)	18 (0–88)	0 (0–0)	104 (0–518)		187 (43–609)
RE—Vaginal laceration and udder edoema	2		11 (2–20)	8 (0–15)	33 (0–66)	0 (0–0)	0 (0–0)	0 (0–0)	27 (0–53)	674 (0–1347)	259 (0–518)		1011 (101–1921)
UD—Abscessing mastitis	11	9	33 (6–55)	62 (0–93)	35 (0–71)	0 (0–0)	72 (0–243)	310 (67–844)	18 (0–53)	144 (0–1486)	153 (0–657)	673 (262–1195)	517 (124–1972)
UD—Abscessing mastitis and milk fever	1		17	39	43	0	0	0	0	0	0	99	99
UD—Abscessing mastitis and non-infectious claw disease	3	2	43 (35–56)	54 (16–110)	24 (19–35)	30 (26–34)	85 (73–97)	118 (101–135)	11 (0–34)	0 (0–0)	0 (0–0)	399 (337–461)	247 (177–360)

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
UD—Abscessing mastitis and retained placenta	1		76	237	59	0	57	0	34	216	0		1077
UD—Acute catarrhal mastitis	110	98	35 (2–104)	59 (0–268)	32 (0–80)	0 (0–11)	123 (0–561)	82 (0–304)	6 (0–75)	44 (0–1321)	25 (0–687)	403 (88–2045)	324 (44–1894)
UD—Acute catarrhal mastitis and indigestion	1	1	52	68	52	0	155	127	72	0	297	822	695
UD—Acute catarrhal mastitis and infectious claw disease	7	6	52 (41–68)	72 (25–147)	33 (19–55)	32 (14–55)	112 (57–190)	142 (42–304)	0 (0–0)	0 (0–0)	0 (0–0)	456 (364–601)	302 (187–493)
UD—Acute catarrhal mastitis and metritis	1		42	119	50	0	88	0	0	0	0		299
UD—Acute catarrhal mastitis and non-infectious claw disease	15	13	42 (26–83)	75 (11–302)	30 (19–69)	18 (8–41)	103 (0–442)	80 (25–202)	14 (0–38)	158 (0–1393)	43 (0–273)	563 (182–2032)	484 (123–1947)
UD—Acute catarrhal mastitis and retained placenta	2	2	37 (35–40)	64 (53–75)	48 (36–60)	0 (0–0)	53 (38–69)	38 (34–42)	0 (0–0)	0 (0–0)	0 (0–0)	240 (217–263)	202 (183–221)
UD—Acute catarrhal mastitis and teat injury	3	1	34 (22–47)	63 (31–85)	23 (19–28)	0 (0–0)	88 (63–112)	135 (135–135)	16 (0–47)	0 (0–0)	0 (0–0)	430	223 (134–295)

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
UD—Acute catarrhal mastitis and vaginal laceration	1		26	56	31	0	81	0	0	0	0		193
UD—Chronic catarrhal mastitis	12	10	42 (13–70)	60 (10–185)	45 (19–71)	1 (0–8)	174 (73–452)	79 (17–270)	9 (0–38)	215 (0–1625)	81 (0–565)	399 (181–912)	626 (114–2509)
UD—Chronic catarrhal mastitis and claw disease	1	1	50	53	46	8	125	42	0	0	0	324	281
UD—Injury of the teat canal	2	2	22 (21–23)	69 (50–89)	50 (31–70)	0 (0–0)	160 (69–251)	162 (121–202)	17 (0–34)	208 (0–416)	0 (0–0)	689 (292–1086)	527 (170–883)
UD—Phlegmonous mastitis	25	19	39 (3–90)	67 (0–183)	40 (0–80)	0 (0–0)	117 (0–413)	162 (34–540)	15 (0–125)	173 (0–1040)	65 (0–657)	594 (124–1429)	516 (90–1341)
UD—Phlegmonous mastitis and claw disease	6	4	50 (32–65)	104 (28–215)	32 (19–51)	13 (8–19)	62 (8–85)	152 (94–192)	11 (0–34)	125 (0–571)	86 (0–351)	711 (249–1296)	484 (155–1144)
UD—Phlegmonous mastitis and metritis	1	1	37	134	87	0	63	17	0	0	0	338	322
UD—Phlegmonous mastitis and pelvic phlegmone	1		35	42	31	0	9	0	39	1062	349		1566
UD—Phlegmonous mastitis and teat injury	1	1	30	77	0	0	120	211	0	0	0	438	227

Table A1. *Cont.*

Diagnosis [1]	*n* [2]	*n* dp [3]	Time Expediture	Product Expenses	Veterinary Services	Orthopaedic Services	Discarded Milk	Decreased Production	Culling *	Book Loss	Decreased Carcass Quality	Sum with Decreased Production [4]	Sum Without Decreased Production [5]
UD—Subclinical mastitis	3	2	19 (15–23)	28 (27–31)	19 (19–19)	0 (0–0)	46 (38–54)	59 (51–67)	11 (0–34)	408 (0–1223)	35 (0–106)	171 (159–183)	566 (108–1473)
UD—Teat injury	6	4	13 (3–25)	16 (0–38)	15 (0–33)	0 (0–0)	69 (0–150)	108 (27–270)	26 (0–47)	298 (0–1353)	61 (0–208)	459 (184–735)	497 (123–1403)
UD—Udder haematoma	5		19 (10–31)	13 (1–26)	13 (0–28)	0 (0–0)	35 (0–91)	0 (0–0)	7 (0–36)	32 (0–162)	22 (0–109)		142 (15–445)

[1] All diagnoses in cows, except for category CA = Calves. [2] *n*-number all animals. [3] *n*-number of animals where a decrease in milk production could be estimated. [4] Sum of costs and lost revenues, only animals where the decrease in milk production could be estimated. [5] Sum of costs and lost revenues in all animals, without a decrease in milk production. ** multimorbidity was defined as $\geq$ 3 diseases at different organ systems. * culling costs: pre-slaughter costs (administration and transport) or costs for euthanasia.

References

1. Garvey, M. Lameness in dairy cow herds: Disease aetiology, prevention and management. *Dairy* **2022**, *3*, 199–210. [CrossRef]
2. Mulligan, F.J.; Doherty, M.L. Production diseases of the transition cow. *Vet. J.* **2008**, *176*, 3–9. [CrossRef]
3. Seegers, H.; Fourichon, C.; Beaudeau, F. Production effects related to mastitis and mastitis economics in dairy cattle herds. *Vet. Res.* **2003**, *34*, 475–491. [CrossRef]
4. Hoischen-Taubner, S.; Habel, J.; Uhlig, V.; Schwabenbauer, E.-M.; Rumphorst, T.; Ebert, L.; Möller, D.; Sundrum, A. The whole and the parts—A new perspective on production diseases and economic sustainability in dairy farming. *Sustainability* **2021**, *13*, 9044. [CrossRef]
5. Kappes, A.; Tozooneyi, T.; Shakil, G.; Railey, A.F.; McIntyre, K.M.; Mayberry, D.E.; Rushton, J.; Pendell, D.L.; Marsh, T.L. Livestock health and disease economics: A scoping review of selected literature. *Front. Vet. Sci.* **2023**, *10*, 1168649. [CrossRef]
6. Steeneveld, W.; van den Borne, B.; Kok, A.; Rodenburg, T.; Hogeveen, H. Invited review: Quantifying multiple burdens of dairy cattle production diseases and reproductive inefficiency—Current knowledge and proposed metrics. *J. Dairy Sci.* **2024**, *107*, 8765–8795. [CrossRef]
7. Hogeveen, H.; Steeneveld, W.; Wolf, C.A. Production diseases reduce the efficiency of dairy production: A review of the results, methods, and approaches regarding the economics of mastitis. *Annu. Rev. Resour. Econ.* **2019**, *11*, 289–312. [CrossRef]
8. von Keyserlingk, M.A.G.; Rushen, J.; de Passille, A.M.; Weary, D.M. The welfare of dairy cattle-Key concepts and the role of science. *J. Dairy Sci.* **2009**, *92*, 4101–4111. [CrossRef]
9. Halasa, T.; Huijps, K.; Østerås, O.; Hogeveen, H. Economic effects of bovine mastitis and mastitis management: A review. *Vet. Q.* **2007**, *29*, 18–31. [CrossRef] [PubMed]
10. Ózsvári, L. Economic cost of lameness in dairy cattle herds. *J. Dairy Vet. Anim. Res.* **2017**, *6*, 00176. [CrossRef]
11. Van Soest, F.; Mourits, M.; Blanco-Penedo, I.; Duval, J.; Fall, N.; Krieger, M.; Sjöstrom, K.; Hogeveen, H. Farm-specific failure costs of production disorders in European organic dairy herds. *Prev. Vet. Med.* **2019**, *168*, 19–29. [CrossRef]
12. Puerto, M.; Shepley, E.; Cue, R.; Warner, D.; Dubuc, J.; Vasseur, E. The hidden cost of disease: I. Impact of the first incidence of mastitis on production and economic indicators of primiparous dairy cows. *J. Dairy Sci.* **2021**, *104*, 7932–7943. [CrossRef]
13. Puerto, M.; Shepley, E.; Cue, R.; Warner, D.; Dubuc, J.; Vasseur, E. The hidden cost of disease: II. Impact of the first incidence of lameness on production and economic indicators of primiparous dairy cows. *J. Dairy Sci.* **2021**, *104*, 7944–7955. [CrossRef]
14. Dolecheck, K.; Overton, M.; Mark, T.; Bewley, J. Use of a stochastic simulation model to estimate the cost per case of digital dermatitis, sole ulcer, and white line disease by parity group and incidence timing. *J. Dairy Sci.* **2019**, *102*, 715–730. [CrossRef]
15. Bar, D.; Tauer, L.; Bennett, G.; Gonzalez, R.; Hertl, J.; Schukken, Y.; Schulte, H.; Welcome, F.; Gröhn, Y. The cost of generic clinical mastitis in dairy cows as estimated by using dynamic programming. *J. Dairy Sci.* **2008**, *91*, 2205–2214. [CrossRef]
16. Liang, D.; Arnold, L.; Stowe, C.; Harmon, R.; Bewley, J. Estimating US dairy clinical disease costs with a stochastic simulation model. *J. Dairy Sci.* **2017**, *100*, 1472–1486. [CrossRef] [PubMed]
17. Pérez-Báez, J.; Silva, T.V.; Risco, C.A.; Chebel, R.C.; Cunha, F.; De Vries, A.; Santos, J.E.P.; Lima, F.S.; Pinedo, P.; Schuenemann, G.M. The economic cost of metritis in dairy herds. *J. Dairy Sci.* **2021**, *104*, 3158–3168. [CrossRef] [PubMed]
18. Charfeddine, N.; Pérez-Cabal, M. Effect of claw disorders on milk production, fertility, and longevity, and their economic impact in Spanish Holstein cows. *J. Dairy Sci.* **2017**, *100*, 653–665. [CrossRef] [PubMed]
19. Bruijnis, M.; Hogeveen, H.; Stassen, E. Assessing economic consequences of foot disorders in dairy cattle using a dynamic stochastic simulation model. *J. Dairy Sci.* **2010**, *93*, 2419–2432. [CrossRef]
20. Doehring, C.; Sundrum, A. The informative value of an overview on antibiotic consumption, treatment efficacy and cost of clinical mastitis at farm level. *Prev. Vet. Med.* **2019**, *165*, 63–70. [CrossRef]
21. Robcis, R.; Ferchiou, A.; Berrada, M.; Ndiaye, Y.; Herman, N.; Lhermie, G.; Raboisson, D. Cost of lameness in dairy herds: An integrated bioeconomic modeling approach. *J. Dairy Sci.* **2023**, *106*, 2519–2534. [CrossRef] [PubMed]
22. Kerslake, J.; Amer, P.; O'neill, P.; Wong, S.; Roche, J.; Phyn, C. Economic costs of recorded reasons for cow mortality and culling in a pasture-based dairy industry. *J. Dairy Sci.* **2018**, *101*, 1795–1803. [CrossRef] [PubMed]
23. Gohary, K.; Overton, M.W.; Von Massow, M.; LeBlanc, S.J.; Lissemore, K.D.; Duffield, T.F. The cost of a case of subclinical ketosis in Canadian dairy herds. *Can. Vet. J.* **2016**, *57*, 728.
24. Rollin, E.; Dhuyvetter, K.C.; Overton, M.W. The cost of clinical mastitis in the first 30 days of lactation: An economic modeling tool. *Prev. Vet. Med.* **2015**, *122*, 257–264. [CrossRef]
25. Cha, E.; Hertl, J.; Bar, D.; Gröhn, Y. The cost of different types of lameness in dairy cows calculated by dynamic programming. *Prev. Vet. Med.* **2010**, *97*, 1–8. [CrossRef]
26. Donnelly, M.R.; Hazel, A.R.; Hansen, L.B.; Heins, B.J. Health treatment cost of Holsteins in eight high-performance herds. *Animals* **2023**, *13*, 2061. [CrossRef] [PubMed]
27. Dirksen, G. *Innere Medizin und Chirurgie des Rindes*, 5th ed.; Georg Thieme Verlag: Stuttgart, Germany, 2006.

28. Rasmussen, P.; Barkema, H.W.; Osei, P.P.; Taylor, J.; Shaw, A.P.; Conrady, B.; Chaters, G.; Muñoz, V.; Hall, D.C.; Apenteng, O.O. Global losses due to dairy cattle diseases: A comorbidity-adjusted economic analysis. *J. Dairy Sci.* **2024**, *107*, 6945–6970. [CrossRef] [PubMed]
29. Wicaksono, A.; van den Borne, B.; Aardema, H.; van Werven, T.; Hogeveen, H.; Steeneveld, W. Estimating the costs of interrelated reproductive disorders in dairy farms. *J. Dairy Sci.* **2025**, *108*, 8508–8528. [CrossRef]
30. Nordlund, K.V.; Cook, N.B. Using herd records to monitor transition cow survival, productivity, and health. *Vet. Clin. Food Anim. Pract.* **2004**, *20*, 627–649. [CrossRef] [PubMed]
31. Dolecheck, K.; Bewley, J. Animal board invited review: Dairy cow lameness expenditures, losses and total cost. *Animal* **2018**, *12*, 1462–1474. [CrossRef]
32. Fetrow, J.; Nordlund, K.; Norman, H. Invited review: Culling: Nomenclature, definitions, and recommendations. *J. Dairy Sci.* **2006**, *89*, 1896–1905. [CrossRef]
33. de Kruif, A.; Mansfeld, R.; Hoedemaker, M. *Tierärztliche Bestandsbetreuung beim Milchrind*, 3rd ed.; Georg Thieme Verlag: Stuttgart, Germany, 2014.
34. Groenendaal, H.; Galligan, D.; Mulder, H. An economic spreadsheet model to determine optimal breeding and replacement decisions for dairy cattle. *J. Dairy Sci.* **2004**, *87*, 2146–2157. [CrossRef]
35. Mee, J.F. Why do so many calves die on modern dairy farms and what can we do about calf welfare in the future? *Animals* **2013**, *3*, 1036–1057. [CrossRef]
36. Mee, J. Invited review: Bovine neonatal morbidity and mortality—Causes, risk factors, incidences, sequelae and prevention. *Reprod. Domest. Anim.* **2023**, *58*, 15–22. [CrossRef]
37. Waurich, B.; Schären, M.; Hufe, P.; May, D. Extended view on young stock losses in Holstein dairy cattle-First results from the EIP-project "Die Entwicklung des KUH-mehr-WERT Navigators". In Proceedings of the International Symposium on Ruminant Physiology (ISRP), Leipzig, Germany, 3–6 September 2019.
38. Esslemont, R.; Kossaibati, M. The cost of respiratory diseases in dairy heifer calves. *Bov. Pract.* **1999**, *33*, 174–178. [CrossRef]
39. Dubrovsky, S.; Van Eenennaam, A.; Aly, S.; Karle, B.; Rossitto, P.V.; Overton, M.; Lehenbauer, T.; Fadel, J. Preweaning cost of bovine respiratory disease (BRD) and cost-benefit of implementation of preventative measures in calves on California dairies: The BRD 10K study. *J. Dairy Sci.* **2020**, *103*, 1583–1597. [CrossRef] [PubMed]
40. Küçükoflaz, M.; Sariözkan, S. Determination of economic losses related to calf diseases and mortalities in intensive dairy cattle. *Erciyes Üniversitesi Vet. Fakültesi Derg.* **2023**, *20*, 94–103. [CrossRef]
41. Schären-Bannert, M.; Hufe, P.; Waurich, B.; Wöckel, A.; Wippermann, W.; Bannert, E.; Hilke, S.; Hermenau, G.; Wittich, J.; Felgentreu, C.; et al. *Abschlussbericht des EIP-Projektes "Die Entwicklung des KUH-mehr-WERT Navigators"*; Landesregierung Brandenburg: Potsdam, Germany, 2023.
42. König, S.; Swalve, H.H. Breeding for Metabolic Robustness and Longevity in Dairy Cows. In *Production Diseases in Farm Animals: Pathophysiology, Prophylaxis and Health Management*; Springer: Berlin/Heidelberg, Germany, 2024; pp. 531–553.
43. Schären-Bannert, M.; Waurich, B.; Wöckel, A.; Wippermann, W.; Felgentreu, C.; Fröhlich, F.; Wittich, J.; Rachidi, F.; May, D.; Dänicke, S.; et al. Analysis of herd manager daily routines and interrelations with production and health and economic key figures of dairy farms—A case study. *J. Dairy Sci.* **2025**, *109*, 437–451. [CrossRef] [PubMed]
44. Dirksen, G.; Gründer, H.-D.; Stöber, M. *Die klinische Untersuchung des Rindes*; Enke: Stuttgart, Germany, 2012.
45. Doll, K.; Schillinger, D.; Klee, W. Der Glutaraldehyd-Test beim Rind—Seine Brauchbarkeit für Diagnose und Prognose innerer Entzündungen. *Zentralbl. Veterinaermed.* **1985**, *32*, 581–593. [CrossRef]
46. Staufenbiel, R. *Zentraler Tiergesundheitsschlüssel (ZTGS)*; Freie Universität Berlin: Berlin, Germany, 2018.
47. TÄHAV. *Tierärztliche-Hausapothekenverordnung vom 1. November 2024 (BGBl. 2024 I Nr. 343), Ersetzt V 2121-50-1-15 v. 8.7.2009 I 1760 (TÄHAV)*; Bundesanzeiger Verlag: Bonn, Germany, 2024.
48. Bundestierärztekammer. Gebührenverordnung für Tierärzte (GOT), Gültig ab 14 Februar 2020. Available online: https://www.bundestieraerztekammer.de/tieraerzte/beruf/got/ (accessed on 1 January 2022).
49. Wilmink, J.B.N. Studies on Test-Day and Lactation Milk, Fat and Protein Yield of Dairy Cows. Ph.D. Thesis, Wageningen University and Research, Wageningen, The Netherlands, 1987.
50. Bundesverband Rind und Schwein e.V. Zuchtziel Deutsche Holsteins. Available online: https://www.rind-schwein.de/brs-rind/population-2.html (accessed on 1 January 2022).
51. Harms, J. *Ökonomische und Produktionstechnische Analyse der Milcherzeugung und Färsenaufzucht 2020*; Landesforschungsanstalt für Landwirtschaft und Fischerei Mecklenburg-Vorpommern Institut für Pflanzenproduktion und Betriebswirtschaft, SG Agrarökonomie: Gülzow-Prüzen, Germany, 2020.
52. Wisnieski, L.; Norby, B.; Pierce, S.; Becker, T.; Gandy, J.; Sordillo, L. Predictive models for early lactation diseases in transition dairy cattle at dry-off. *Prev. Vet. Med.* **2019**, *163*, 68–78. [CrossRef]
53. Fadillah, A.; van den Borne, B.; Schukken, Y.; Poetri, O.; Hogeveen, H. Cost-efficiency of mastitis control strategies on smallholder dairy farms. *J. Dairy Sci.* **2025**, *108*, 8726–8741. [CrossRef]

54. Bonestroo, J.; Fall, N.; Hogeveen, H.; Emanuelson, U.; Klaas, I.C.; van der Voort, M. The costs of chronic mastitis: A simulation study of an automatic milking system farm. *Prev. Vet. Med.* **2023**, *210*, 105799. [CrossRef]
55. Hagnestam-Nielsen, C.; Østergaard, S. Economic impact of clinical mastitis in a dairy herd assessed by stochastic simulation using different methods to model yield losses. *Animal* **2009**, *3*, 315–328. [CrossRef] [PubMed]
56. de Campos, J.L.; Gonçalves, J.; Kates, A.; Steinberger, A.; Sethi, A.; Suen, G.; Shutske, J.; Safdar, N.; Goldberg, T.; Ruegg, P. Variation in partial direct costs of treating clinical mastitis among 37 Wisconsin dairy farms. *J. Dairy Sci.* **2023**, *106*, 9276–9286. [CrossRef]
57. Heikkilä, A.-M.; Nousiainen, J.; Pyörälä, S. Costs of clinical mastitis with special reference to premature culling. *J. Dairy Sci.* **2012**, *95*, 139–150. [CrossRef]
58. Rachidi, F.; Černá, A.; Zenker, M.; Ullrich, E.; Starke, A. *Untersuchung und Bewertung der Haupteinflussfaktoren auf die Entstehung von Infektiösen Klauenerkrankungen des Dermatitis-Digitalis-Komplexes*; Landesamt für Umwelt, Landwirtschaft und Geologie, Freistaat Sachsen: Dresden, Germany, 2021.
59. Alvergnas, M.; Strabel, T.; Rzewuska, K.; Sell-Kubiak, E. Claw disorders in dairy cattle: Effects on production, welfare and farm economics with possible prevention methods. *Livest. Sci.* **2019**, *222*, 54–64. [CrossRef]
60. Green, L.; Hedges, V.; Schukken, Y.; Blowey, R.; Packington, A. The impact of clinical lameness on the milk yield of dairy cows. *J. Dairy Sci.* **2002**, *85*, 2250–2256. [CrossRef] [PubMed]
61. Warnick, L.; Janssen, D.; Guard, C.; Gröhn, Y. The effect of lameness on milk production in dairy cows. *J. Dairy Sci.* **2001**, *84*, 1988–1997. [CrossRef]
62. Penev, T.; Stankov, K. Effect of lameness on milk production traits in holstein-friesian dairy cows. *Vet. Zootech.* **2015**, *70*, 53–59.
63. Van Den Borne, B.H.; Villalobos, A.M.D.G.; Hogeveen, H. Disentangling the relationships between lameness, milking frequency and milk production in Dutch dairy herds using an automatic milking system. *Prev. Vet. Med.* **2022**, *208*, 105733. [CrossRef]
64. Rajala-Schultz, P.; Gröhn, Y.; McCulloch, C. Effects of milk fever, ketosis, and lameness on milk yield in dairy cows. *J. Dairy Sci.* **1999**, *82*, 288–294. [CrossRef] [PubMed]
65. Alawneh, J.; Laven, R.; Stevenson, M. Interval between detection of lameness by locomotion scoring and treatment for lameness: A survival analysis. *Vet. J.* **2012**, *193*, 622–625. [CrossRef] [PubMed]
66. Booth, C.; Warnick, L.; Gröhn, Y.; Maizon, D.; Guard, C.; Janssen, D. Effect of lameness on culling in dairy cows. *J. Dairy Sci.* **2004**, *87*, 4115–4122. [CrossRef] [PubMed]
67. Caixeta, L.S.; Omontese, B.O. Monitoring and Improving the Metabolic Health of Dairy Cows during the Transition Period. *Animals* **2021**, *11*, 352. [CrossRef]
68. Mulligan, F.; O Grady, L.; Rice, D.; Doherty, M. Production diseases of the transition cow: Milk fever and subclinical hypocalcaemia. *Ir. Vet. J.* **2006**, *59*, 697.
69. Fikadu, W.; Tegegne, D.; Abdela, N.; Ahmed, W.M. Milk fever and its economic consequences in dairy cows: A review. *Glob. Vet.* **2016**, *16*, 441–452.
70. Kelton, D.F.; Lissemore, K.D.; Martin, R.E. Recommendations for recording and calculating the incidence of selected clinical diseases of dairy cattle. *J. Dairy Sci.* **1998**, *81*, 2502–2509. [CrossRef]
71. Sheldon, I.M.; Lewis, G.S.; LeBlanc, S.; Gilbert, R.O. Defining postpartum uterine disease in cattle. *Theriogenology* **2006**, *65*, 1516–1530. [CrossRef]
72. Lima, F.; Vieira-Neto, A.; Snodgrass, J.; De Vries, A.; Santos, J. Economic comparison of systemic antimicrobial therapies for metritis in dairy cows. *J. Dairy Sci.* **2019**, *102*, 7345–7358. [CrossRef]
73. Drillich, M.; Beetz, O.; Pfützner, A.; Sabin, M.; Sabin, H.-J.; Kutzer, P.; Nattermann, H.; Heuwieser, W. Evaluation of a systemic antibiotic treatment of toxic puerperal metritis in dairy cows. *J. Dairy Sci.* **2001**, *84*, 2010–2017. [CrossRef]
74. Gohary, K.; LeBlanc, S.J. Cost of retained fetal membranes for dairy herds in the United States. *J. Am. Vet. Med. Assoc.* **2018**, *252*, 1485–1489. [CrossRef] [PubMed]
75. Dirksen, G. Gegenwärtiger Stand der Diagnostik, Therapie und Prophylaxe der Dislocatio abomasi sinistra des Rindes. *Dtsch. Tier-ärztl. Wochenschr.* **1967**, *74*, 625–628.
76. Van Winden, S.; Kuiper, R. Left displacement of the abomasum in dairy cattle: Recent developments in epidemiological and etiological aspects. *Vet. Res.* **2003**, *34*, 47–56. [CrossRef] [PubMed]
77. Caixeta, L.S.; Herman, J.A.; Johnson, G.W.; McArt, J.A.A. Herd-level monitoring and prevention of displaced abomasum in dairy cattle. *Vet. Clin. N. Am. Food Anim. Pract.* **2018**, *34*, 83–99. [CrossRef]
78. Schären-Bannert, M.; Bittner-Schwerda, L.; Rachidi, F.; Starke, A. Case report: Complications after using the "blind-stitch" method in a dairy cow with a left displaced abomasum: Treatment, outcome, and economic evaluation. *Front. Vet. Sci.* **2024**, *11*, 1470190. [CrossRef]
79. Schären-Bannert, M.; Wippermann, W.; Wöckel, A.; Vogel, L.; Waurich, B.; Rachidi, F.; Fröhlich, F.; Felgentreu, C.; Wittich, J.; Bannert, E.; et al. Evaluation of multifactorial digestive disorders in a dairy herd at different stages of lactation. *Tierarztl. Prax. Ausg. G. Grosstiere Nutztiere* **2023**, *51*, 237–247. [CrossRef]

80. Smith, B.P. *Large Animal Internal Medicine*; Elsevier Health Sciences: Amsterdam, The Netherlands, 2014.
81. Buczinski, S.; Achard, D.; Timsit, E. Effects of calfhood respiratory disease on health and performance of dairy cattle: A systematic review and meta-analysis. *J. Dairy Sci.* **2021**, *104*, 8214–8227. [CrossRef]
82. Peeler, E.J.; Otte, M.J.; Esslemont, R.J. Recurrence odds ratios for periparturient diseases and reproductive traits of dairy cows. *Br. Vet. J.* **1994**, *150*, 481–488. [CrossRef]
83. Palmer, M.A.; O'Connell, N.E. Digital dermatitis in dairy cows: A review of risk factors and potential sources of between-animal variation in susceptibility. *Animals* **2015**, *5*, 512–535. [CrossRef]
84. Rollin, E.; Berghaus, R.D.; Rapnicki, P.; Godden, S.M.; Overton, M.W. The effect of injectable butaphosphan and cyanocobalamin on postpartum serum β-hydroxybutyrate, calcium, and phosphorus concentrations in dairy cattle. *J. Dairy Sci.* **2010**, *93*, 978–987. [CrossRef]
85. Dallago, G.M.; Wade, K.M.; Cue, R.I.; McClure, J.T.; Lacroix, R.; Pellerin, D.; Vasseur, E. Keeping dairy cows for longer: A critical literature review on dairy cow longevity in high milk-producing countries. *Animals* **2021**, *11*, 808. [CrossRef] [PubMed]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.