THE GLOBAL STANDARD
FOR LIVESTOCK DATA

Section 7- Guidelines for Dairy Cattle Health

Section 7 – Bovine Functional Traits: Dairy Cattle Health

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Network. Guidelines. Certification.

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Change Summary

Date of Change	Nature of Change
August 2017	Reformatted using new template.
August 2017	Table of contents added.
August 2017	Heading numbers and heading text edited for clarity and removal of redundant text.
August 2017	Insert links to ICAR website for Claw Health Atlas and Disease Codes.
August 2017	Insert table and equation captions. Insert Table and Equation index into Table of Contents.
August 2017	Fixed bulleted lists; fixed *et al* as italics and minor changes.
August 2017	Stopped Track changes and accept all previous changes otherwise there was no valid pagination.
August 2017	Added two Sections female fertility in dairy cattle and udder health (Section 7.2 and 7.3). Add index of figures to Table of Contents. V17.05.
August 2017	Added figure and header on page 64.
August 2017	Accepted all changes. V17.06.
August 2017	Stopped Track change sand accepted all previous changes.
August 2017	Moved the file to the new template (v2017_08_29).
August 2017	Correct heading error on page 72 and some other minor edits.
October 2017	Hyperlinks have been corrected.
April 2018	Minor corrections proposed by Dorota Krencik.
April 2018	The "Table of content" for the Figures has been updated as indicated by Dorota Krencik.

January 2018	Claw Health chapter (4) added.
May 2018	Claw Health chapter (4) replaced with new version. Edits marked with track changes. All changes accepted to facilitate final edits and cross referencing.
June 2018	Minor corrections as suggested by Noureddine Charfeddine and Christa Egger-Danner.
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August 2018	File name added to improve version control. Draft finalised for distribution to General Assembly for approval.
October 2018	Accepted all previous changes and stopped tracking; paginated according to the template. Published on ICAR website.
April 2019	Lameness chapter (5) added.
October 2019	Lameness chapter 5 updated by FT-WG.
January 2020	Edits made by the FT-WG. Submitted to ICAR Board for approval.
February 2020	Photos added to table 26.
March 2020	Corrections by Anne-Marie Christen (CA) and by Johann Kofler.
April 2020	Corrections by Dorota Krencik as indicated in her email (31-March 2020).

1 Dairy Cattle Health

1.1 Technical abstract

Improved health of dairy cattle is of increasing economic importance. Poor health results in greater production costs through higher veterinary bills, additional labor costs, and reduced productivity. Animal welfare is also of increasing interest to both consumers and regulatory agencies because healthy animals are needed to provide high-quality food for human consumption. Furthermore, this is consistent with the European Union animal health strategy that emphasizes disease prevention over treatment. Animal health issues may be addressed either directly, by measuring and selecting against liability to disease, or indirectly by selecting against traits correlated with injury and illness. Direct observations of health and disease events, and their inclusion in recording, evaluation and selection schemes, will maximize the efficiency of genetic selection programs. The Scandinavian countries have been routinely collecting and utilizing those data for years, demonstrating the feasibility of such programs. Experience with direct health data in non-Scandinavian countries is still limited. Due to the complexity of health and diseases, programs may differ between countries. This document presents best-practices with respect to data collection practices, trait definition, and use of health data in genetic evaluation programs and can be extended to its use for other farm management purposes.

1.2 Introduction

The improvement of cattle health is of increasing economic importance for several reasons. Impaired health results in increased production costs (veterinary medical care and therapy, additional labor, and reduced performance), while prices for dairy products and meat are decreasing. Consumers also want to see improvements in food safety and better animal welfare. Improvement in the general health of the cattle population is necessary for the production of high-quality food and implies significant progress with regard to animal welfare. Improved welfare also is consistent with the EU animal health strategy, which states that that prevention is better than treatment (European Commission, 2007).

Health issues may be addressed either directly or indirectly. Indirect measures of health and disease have been included in routine performance tests by many countries. However, directly observed measures of health and disease need to be included in recording, evaluation and selection schemes in order to increase the efficiency of genetic improvement programs for animal health.

In the Scandinavian countries, direct health data have been routinely collected and utilized for years, with recording based on veterinary medical diagnoses (Nielsen, 2000; Philipsson and Linde, 2003; Østerås and Sølverød, 2005; Aamand, 2006; Heringstad *et al.*, 2007). In the non-Scandinavian countries experience with direct health data is still limited, but interest in using recorded diagnoses or observations of disease has increased considerably in recent years (Zwald *et al.*, 2006a,b; Neuenschwander *et al.*, 2008; Neuenschwender, 2010; Appuhamy *et al.*, 2009; Egger-Danner *et al.*, 2010, Egger-Danner *et al.*, 2012, Koeck *et al.*, 2012a,b, Neuschwander *et al.*, 2012).

Due to the complex biology of health and disease, guidelines should mainly address general aspects of working with direct health data. Specific issues for the major disease complexes are discussed, but breed- or population-specific focuses may require amendments to these guidelines.

1.3 Types and sources of data

1.3.1 Types of data

The collection of direct information on health and disease status of individual animals is preferable to collection of indirect information. However, population-wide collection of reliable health information may be easier to implement for indirect rather than direct measures of health. Analyses of health traits will probably benefit from combined use of direct and indirect health data, but clear distinctions must be drawn between these two types of data:

1.3.1.1 Direct health information

a. Diagnoses or observations of diseases

b. Clinical signs or findings indicative of diseases

1.3.1.2 Indirect health information

a. Objectively measurable indicator traits (e.g., somatic cell count, milk urea nitrogen, health biomarkers)

b. Subjectively assessable indicator traits (e.g., body condition score, conformation scores)

Health data may originate from different data sources which differ considerably with respect to information content and specificity. Therefore, the data source must be clearly indicated whenever information on health and disease status is collected and analysed. When data from different sources are combined, the origin of data must be taken into account when defining health traits.

In the following sections, possible sources of health data are discussed, together with information on which types of data may be provided, specific advantages and disadvantages associated with those sources, and issues which need to be addressed when using those sources.

1.3.2 Sources of data

1.3.2.1 Veterinarians

Content

a. Primarily report direct health data.

b. Provide disease diagnoses (documented reasons for application of pharmaceuticals), possibly supplemented by findings indicative of disease, and/or information on indicator traits.

Advantage

a. Information on a broad spectrum of health traits.

b. Specific veterinary medical diagnoses (high-quality data).

c. Legal obligations of documentation in some countries (possible utilization of already established recording practices).

Disadvantages

a. Only severe cases of disease may be reported (need for veterinary intervention and pharmaceutical therapy).

b. Possible delay in reporting (gap between onset of disease and veterinary visit).

c. Extra time and effort for recording (complete and consistent documentation cannot be taken for granted, recording routine and data flow need to be established).

1.3.3 Producers

Content

a. Primarily direct health data.

b. Disease observations ('diagnoses'), possibly supplemented by findings indicative of disease and/or information on indicator traits.

Advantages

a. Information on a broad spectrum of health traits.

b. Minor cases not requiring veterinary intervention may be included.

c. First-hand information on onset of disease.

d. Possible use of already-established data flow (routine performance testing, reporting of calving, documentation of inseminations).

Disadvantages

a. Risk of false diagnoses and misinterpretation of findings indicative of disease (lack of veterinary medical knowledge).

b. Possible need to confine recording to the most relevant diseases (modest risk of misinterpretation, limited extra time and effort for recording).

c. Extra documentation might be needed.

d. Need for expert support and training (veterinarian) to ensure data quality.

e. Completeness of recording may vary, and may be dependent on work peaks on the farm.

Remarks

a. Data logistics depend on technical equipment on the farm (documentation using herd management software (e.g. including tools to record hoof trimming, diseases, vaccinations,..), handheld for online recording, information transfer through personnel from milk recording agencies.

b. Possible producer-specific documentation focuses must be considered in all stages of analyses (checks for completeness of health / disease incident documentation; see Kelton *et al.*, 1998).

c. Preliminary research suggests that epidemiological measures calculated from producer-recorded data are similar to those reported in the veterinary literature (Cole *et al.*, 2006).

1.3.3.1 Expert groups (claw trimmer, nutritionist, etc.)

Content

a. Direct and indirect health data with a spectrum of traits according to area of expertise.

Advantages

a. Specific and detailed information on a range of health traits important for the producer (high-quality data),

b. Possible access to screening data (information on the whole herd at a given point in time),

c. Personal interest in documentation (possible utilization of already-established recording practices)

Disadvantages

a. Limited spectrum of traits,

b. Dependence on the level of expert knowledge (certification/licensure of recording persons may be advisable),

c. Extra time and effort for recording (complete and consistent documentation cannot be taken for granted, recording routine and data flow need to be established)

d. Business interests may interfere with objective documentation

1.3.3.2 Others (laboratories, on-farm technical equipment, etc.)

Content

a. Indirect health data with spectrum of traits according to sampling protocols and testing requests, e.g., microbiological testing, metabolite analyses, hormone tests, virus/bacteria DNA, infrared-based measurements (Soyeurt *et al.,* 2009a,b).

Advantages

a. Specific information on a range of health traits important for the producer (high quality data).

b. Objective measurements.

c. Automated or semi-automated recording systems (possible utilization of already established data logistics).

Disadvantages

a. Interpretation with regard to disease relevance not always clear.

b. Validation and combined use of data may be problematic.

Table 1. Overview of the possible sources of direct and indirect health information.

Source of data	Type of data	
	Direct health information	**Indirect health information**
Veterinarian	Yes	Possibly
Producer	Yes	Possibly
Expert groups	Yes	Possibly
Others	No	Yes

1.4 Data security

Data security is a universally important issue when collecting and using field data. However, the central role of dairy cattle health in the context of animal welfare and consumer protection implies that farmers and veterinarians are obligated to maintain high-quality records, emphasizing the particular sensitivity of health data.

The legal framework for use of health data has to be considered according to national requirements and applicable data privacy standards. The owner of the farm on which the data are recorded is the owner of the data, and must enter into formal agreements before data are collected, transferred, or analysed. The following issues must be addressed with respect to data exchange agreements:

a. Type of information to be stored in the health database, e.g., inclusion of details on therapy with pharmaceuticals, doses and medication intervals).
b. Institutions authorized to administer the health database, and to analyze the data.
c. Access rights of (original) health data and results from analyses of the data.
d. Ownership of the data and authority to permit transfer and use of those data.

Enrolment forms for recording and use of health data (to be signed by the farmers) have been compiled by the institutions responsible for data storage and analysis or governmental authorities (e.g., Austrian Ministry of Health, 2010).

For any health database it must be guaranteed that:

a. The individual farmers can only access detailed information on their own farm, and for animals only pertaining to their presence on that farm.
b. The right to edit health data are limited.
c. Access to any treatment information is confined to the farmer and the veterinarian responsible for the specific treatment, with the option of anonymizing the veterinary data.

Data security is a necessary precondition for farmers to develop enough trust in the system to provide data. The recording of treatment data is much more sensitive than only diagnoses, and the need to collect and store such data should be very carefully considered.

1.5 Documentation

Minimum requirements for documentation:

a. Unique animal ID (ISO number).
b. Place of recording (unique ID of farm/herd).
c. Source of data (veterinarian, producer, expert group, others).
d. Date of health incident.
e. Type of health incident (standardized code for recording).

Useful additional documentation:

a. Individual identification of the recording person.
b. Details on respective health incident (exact location, severity).
c. Type of recording and method of data transfer (software used for on-farm recording, online-transmission).
d. Information on type of diagnosis (first or subsequent).

The systematic use and appropriate interpretation of direct and indirect health data requires that information on health status be combined with other information on the affected animals (basic information such as date of birth, sex, breed, sire and dam, farm/herd; calving dates, and performance records). Therefore, unique identification of the individual animals used for the health data base must be consistent with the animal ID used in existing databases.

Widespread collection of health data may benefit from legal frameworks for documentation and use of diagnostic data. European legislation requests documentation of health incidents which involved application of pharmaceuticals to animals in the food chain. Veterinary medical diagnoses may, therefore, be available through the treatment records kept by veterinarians and farmers. However, it must be ensured that minimum requirements for data recording are followed; in particular, it must be noted that animal identification schemes are not uniform within or across countries. Furthermore, it must be a clear distinction made between prophylactic and therapeutic use of pharmaceuticals, with the former being excluded from disease statistics. Information on prophylaxis measures may be relevant for interpretation of health data (e.g., dry cow therapy), but should not be misinterpreted as indicators of disease. While recording of the use of pharmaceuticals is encouraged it is not uniformly required internationally, and health data should be collected regardless of the availability of treatment information.

1.6 Standardization of recording

In order to avoid misinterpretation of health information and facilitate analysis, a unique code should be used for recording each type of health incident. This code must fulfil the following conditions:

a. Clear definitions of the health incidents to be recorded, without opportunities for different interpretations.
b. Includes a broad spectrum of diseases and health incidents, covering all organ systems, and address infectious and non-infectious diseases.
c. Understandable by all parties likely to be involved in data recording.
d. Permit the recording of different levels of detail, ranging from very specific diagnoses of veterinarian compared to very general diagnoses or observations by producers.

Starting from a very detailed code of diagnoses, recording systems may be developed that use only a subset of the more extensive code. However, the identical event identifiers submitted to the health database must always have the same meaning. Therefore, data must be coded using a uniform national, or preferably international, scheme before entering information into the central health database. In the case of electronic recording of health data, it is the responsibility of the software providers to ensure that the standard interface for direct and/or indirect health data is properly implemented in their products. When farmers are permitted to define their own codes the mapping of those custom codes to standard codes is a substantial challenge, and careful consideration should be paid to that problem (see, e.g., Zwald *et al.*, 2004a).

A comprehensive code of diagnoses with about 1,000 individual input options (diagnoses) is provided as an appendix to these guidelines. It is based on the code of diagnoses developed in Germany by the veterinarian Staufenbiel ('zentraler Diagnoseschlüssel') (Annex). The structure of this code is hierarchical, and it may represent a 'gold standard' for the recording of direct health data. It includes very specific diagnoses which may be valuable for making management decisions on farms, as well as broad diagnoses with little specificity for analyses which require information on large numbers of animals (e.g. genetic evaluation). Furthermore, it allows the recording of selected prophylactic and biotechnological measures which may be relevant for interpretation of recorded health data.

In the Scandinavian countries and in Austria codes with 60 to 100 diagnoses are used, allowing documentation of the most important health problems of cattle. Diagnoses are grouped by disease complexes and are used for documentation by treating veterinarians (Osteras *et al.*, 2007; Austrian Ministry of Health, 2010; Osteras, 2012).

For documentation of direct health data by expert groups, special subsets of the comprehensive code may be used. Examples for claw trimmers can be found in the literature (e.g. Capion *et al.,* 2008; Thomsen *et al.,*2008; Maier, 2009a, b; Buch *et al.,* 2011).

When working with producer-recorded data, a simplified code of diagnoses should be provided which includes only a subset of the extensive code (Neuenschwander *et al.*, 2008; USDA, 2010). Diagnoses included must be clearly defined and observable without veterinary medical expertise. Such a reduced code may, for example, consider mastitis, lameness, cystic ovarian disease, displaced abomasum, ketosis, metritis/uterine disease, milk fever and retained placenta (Neuenschwander *et al.*, 2008). The United States model (USDA, 2010) is event-based, and permits very general reports (e.g., This cow had ketosis on this day."), as well as very specific ones (e.g., "This cow had Staph. aureus mastitis in the right, rear quarter on this day.").

1.7 Data quality

1.7.1 General quality checks

Mandatory information will be used for basic plausibility checks. Additional information can be used for more sophisticated and refined validation of health data when those data are available.

a. The recording farm must be registered to record and transmit health data.

b. If information on the person recording the data are provided, that individual must be authorized to submit data for this specific farm.

c. The animal for which health information is submitted must be registered to the respective farm at the time of the reported health incident.

d. The date of the health incident must refer to a living animal (must occur between the birth and culling dates), and may not be in the future.

e. A particular health event can only be recorded once per animal per day.

f. The contents of the transmitted health record must include a valid disease code. In the case of known selective recording of health events (e.g., only claw diseases, only mastitis, no calf diseases), the health record must fit the specified disease category for which health data are supposed to be submitted.

g. For sources of data with limited authorization to submit health data, the health record must fit the specified disease category (e.g., locomotory diseases for claw trimmers, metabolic disorders for nutritionists).

1.7.2 Specific quality checks

In order to produce reliable and meaningful statistics on the health status in the cattle population, recording of health events should be as complete as possible on all farms participating in the health improvement program. Ideally, the intensity of observation and completeness of documentation should be the same for all animals regardless of sex, age, and individual performance. Only then will a complete picture of the overall health status in the population emerge. However, this ideal situation of uniform, complete, and continuous recording may rarely be achieved, so methods must be developed to distinguish between farms with desirably good health status of animals and farms with poor recording practices.

Countries with on-going programs of recording and evaluation of health data require a minimum number of diagnoses per cow and year (e.g., Denmark: 0.3 diagnoses; Austria: 0.1 first diagnoses); continuity of data registration needs to be considered. Farms that fail to achieve these values are automatically excluded from further analyses until their recording has improved. However, herd sizes need to be considered when defining minimum reporting frequencies to avoid possible biases in favor of larger or smaller farms. Any fixed procedure involves the risk of excluding farms with extraordinary good herd health, but to avoid biased statistics there seems to be no alternative to criteria for inclusion, and setting minimum lower limits for reporting. Different criteria will be needed for diseases that occur with low frequency versus those with high frequency, particularly when the cost of a rare illness is very high compared to a common one.

Because recording practices and completeness on farms may not be uniform across disease categories (e.g., no documentation of claw diseases by the producer), data should be periodically checked by disease category to determine what data should be included. Use of the most-thoroughly documented group of health traits to make decisions about inclusion or exclusion of a specific farm may lead to considerable misinterpretation of health data.

There are limited options to routinely check health data for consistency on a per animal basis. Some diagnoses may only be possible in animals of specific sex, age, or physiological state. Examples can be found in the literature (Kelton *et al.*, 1998; Austrian Ministry of Health, 2010). Criteria for plausibility checks will be discussed in the trait-specific part of these guidelines.

1.8 Keys to long-term success

Regardless of the sources of health data included, long-term acceptance of the health recording system and success of the health improvement program will rely on the sustained motivation of all parties involved. To achieve this, frequent, honest, and open communications between the institutions responsible for storage and analysis of health data and people in the field is necessary. Producers, veterinarians and experts will only adopt and endorse new approaches and technologies when convinced that they will have positive impacts on their own businesses. Mutual benefits from information exchange and favorable cost-benefit ratios need to be communicated clearly.

When a key objective of data collection is the development a of genetic improvement program for health, producers must be presented with a reasonable timeline for events. When working with low-heritability traits that are differentially recorded much more data will be necessary for the calculation of accurate breeding values than for typical production traits. It is very important that everyone is aware of the need to accumulate a sufficient dataset to support those calculations, which may take several years. This will help ensure that participants remain motivated, rather than become discouraged when new products are not immediately provided. The development of intermediate products, such as reports of national incidence rates and changes over time, could provide tools useful to producers between the start of data collection and the introduction of genetic evaluations.

Health reports, produced for each of the participating farms and distributed to authorized persons, will help to provide early rewards to those participating in health data recording. To assist with management decisions on individual farms, health reports should contain within-herd statistics (health status of all animals on the farm and stratified by age and/or performance group), as well as across-herd statistics based on regional farms of similar size and structure. Possible access to the health reports by authorized veterinarians or experts will help to maximize the benefits of data recording by ensuring that competent help with data interpretation is provided.

1.9 Trait definition

Most health incidents in dairy herds fit into a few major disease complexes (e.g., Heringstad *et al.*, 2007; Koeck *et al.*, 2010a,b, Wolff, 2012), each of which implies that specific issues be addressed when working with related health information. In particular, variation exists with regard to options for plausibility checks of incoming data including eligible animal group, time frame of diagnoses, and possibility of repeated diagnoses.

Distinctions must be drawn between diseases which may only occur once in an animal's lifetime (maximum of one record per animal) or once in a predefined time period (e.g., maximum of one record per lactation) on the one hand and disease which may occur repeatedly throughout the life-cycle. Assumptions regarding disease intervals, i.e., the minimum time period after which the same health incident may be considered as a recurrent case rather than an indicator of prolonged disease, need to be considered when comparing figures of disease prevalences and distributions. Furthermore, it must be decided if only first diagnoses or first and recurrent diagnoses are included in lifetime and/or lactation statistics. Differences will have considerable impact on comparability of results from health data analyses.

1.9.1 Udder health

Mastitis is the qualitatively and quantitatively most important udder health trait in dairy cattle (e.g. Amand *et al.*, 2006; Heringstad *et al.*, 2007, Wolff, 2012). The term mastitis refers to any inflammation of the mammary gland, i.e., to both subclinical and clinical mastitis. However, when collecting direct health data one should clearly distinguish between clinical and subclinical cases of mastitis. Subclinical mastitis is characterized by an increased number of somatic cells in the milk without accompanying signs of disease, and somatic cell count

(SCC) has been included in routine performance testing by many countries, representing an indicator trait for udder health (indirect health data).

Cows affected by clinical mastitis show signs of disease of different severity, with local findings at the udder and/or perceivable changes of milk secretion possibly being accompanied by poor general condition. Recording of clinical mastitis (direct health data) will usually require specific monitoring, because reliable methods for automated recording have not yet been developed. Documentation should not be confined to cows in first lactation but include cows of second and subsequent lactations. Optional information on cases that may be documented and used for specific analyses includes

a. Type of clinical disease (acute, chronic).
b. Type of secretion changes (catarrhal, hemorrhagic, purulent, necrotizing).
c. Evidence of pathogens which may be responsible for the inflammation.
d. Location of disease (affected quarter or quarters).
e. Presence of general signs of disease.

Appropriate analyses of information on clinical mastitis require consideration of the time of onset or first diagnosis of disease (days in milk). Clinical mastitis developing early and late in lactation may be considered as separate traits.

Table 2. Udder health trait considerations.

Parameters to check incoming health data	**Recommended inclusion criterion**	**Remarks**
Eligible animal group	Heifers and cows (obligatory: sex = female)	Exceptions possible (where appropriate, diagnoses in younger females may be considered separately)
Time frame of diagnoses	10 days before calving to 305 days in milk	Exceptions possible (where appropriate, diagnoses beyond -10 to 305 days in milk may be considered separately; shorter reference periods may be defined)
Repeated diagnoses	Possible per animal and lactation (possibility of multiple diagnoses per lactation)	Definition of minimum time period after which same diagnosis may be considered as recurrent case rather than prolonged disease

1.9.2 Reproductive disorders

Reproductive disorders represents a set of diseases which have the same effect (reduced fertility or reproductive performance), but differ in pathogenesis, course of disease, organs involved, possible therapeutic approaches, etc. To allow the use of collected health data for improvement of management on the herd and/or animal level, recording of reproductive disorders should be as specific as possible.

Grouping of health incidents belonging to this disease complex may be based on the time of occurrence and/or organ involved. Within each of these disease groups, specific plausibility checks must be applied considering, for example, time frame of diagnoses and possibility of multiple diagnoses per lactation (recurrence). Fixed dates to be considered include the length of the bovine ovarian cycle (21 days) and the physiological recovery time of reproductive organs after calving (total length of puerperium: 42 days).

1.9.2.1 Gestation disorders and peri-partum disorders

Examples:

a. Embryonic death, abortion.
b. Bradytocia (uterine inertia), perineal rupture.
c. Retained placenta, puerperal disease, … .

1.9.2.2 Irregular estrus cycle and sterility

Examples:

a. Cystic ovaries, silent heat.
b. Metritis (uterine infection), …

Table 3. Reproduction trait considerations.

Parameters to check incoming health data	Recommended inclusion criterion	Remarks
Eligible animal group	Heifers and cows	Minimum age should be consistent with performance data analyses
Time frame of diagnoses	Depending on type of disease	Fixed patho-physiological time frames should be considered (e.g. Duration of puerperium, cycle length)
Repeated diagnoses	Depending on type of disease: maximum of one diagnosis per animal (e.g. Genital malformation), maximum of one diagnosis per lactation (e.g. Retained placenta) or possibility of multiple diagnoses per lactation (e.g. Cystic ovaries)	Definition of minimum time period after which same diagnosis may be considered as recurrent case rather than prolonged disease (e.g. 21 days for cystic ovaries because of direct relation to the ovary cycle)

1.9.3 Locomotory diseases

Recording of locomotory diseases may be performed on different level of specificity. Minimum requirement for recording may be documentation of locomotion score (lameness score) without details on the exact diagnoses. However, use of some general trait lameness will be of little value for deriving management measures.

Because of the heterogeneous pathogenesis of locomotory disease, recording of diagnoses should be as specific as possible.

Rough distinction may be drawn between **claw diseases** and **other locomotory diseases**, but results of health data analyses will be more meaningful when more detailed information is available. Therefore, recording of specific diagnoses is strongly recommended. Determination of the cause of disease and options for treatment and prevention will benefit from detailed documentation of affected structure(s), exact location, type and extent of visible changes. Such details may be primarily available through veterinarians (more severe cases of locomotory diseases) and claw trimmers (screening data and less severe cases of locomotory diseases). However, experienced farmers may also provide valuable information on health of limbs and claws.

Care must be taken when referring to terms from farmers' jargon, because definitions are often rather vague and diagnoses of diseases may be inconsistent. Documentation practices differ based on training and professional standards, e.g., claw trimmers and veterinarians, as well as nationally and internationally, and different schemes have been implemented in various on-farm data collection systems. To ensure uniform central storage and analysis of data, tools for mapping data to a consistent set of keys must to be developed, and unambiguous technical terms (veterinary medical diagnoses) should be used in documentation whenever possible.

1.9.3.1 Claw diseases

Examples:

a. Laminitis complex (white line disease, sole haemorrhage, sole duplication, wall lesions, wall buckling, wall concavity).
b. Sole ulcer (sole ulcer at typical site = rusterholz's disease, sole ulcer at atypical site, sole ulcer at tip of claw).
c. Digital dermatitis (mortellaro's disease = hairy foot warts = heel warts = papillomatous digital dermatitis).
d. Heel horn erosion (erosio ungulae = slurry heel).
e. Interdigital dermatitis, interdigital phlegmon (interdigital necrobacillosis = foot rot), interdigital hyperplasia (interdigital fibroma = limax = tylom).
f. Circumscribed aseptic pododermatitis, septic pododermatitis.
g. Horn cleft, ...

The expertise of professional claw trimmers should be used when recording claw diseases. In herds with regular claw trimming (by the producer or a professional claw trimmer) accessibility of screening data, i.e., information on claw status of all animals regardless of regular or irregular locomotion (lameness) or absence or presence of other signs of disease (e.g., swelling, heat), will significantly increase the total amount of available direct health data, enhancing the reliability of analyses of those traits. Incidences of claw diseases may be biased if they are collected on based on examinations, or treatment, of lame animals.

Other information about claws which may be relevant to interpret overall claw health status of the individual animal, such as claw angles, claw shape or horn hardness, also may be documented. Some aspects of claw conformation may already be assessed in the course of conformation evaluation. Analyses of claw disease may benefit from inclusion of such indirect health data.

1.9.3.2 Foot and claw disorders - Harmonized description

Refer to ICAR Claw Atlas for detailed descriptions. The Claw Atlas is available on the ICAR website:

a. As a .pdf file in English here.
b. Translations in twenty other languages here.
c. As a poster in English here.
d. As a poster in German here.

1.9.4 Other locomotory diseases

Examples:

a. Lameness (lameness score).
b. Joint diseases (arthritis, arthrosis, luxation).
c. Disease of muscles and tendons (myositis, tendinitis, tendovaginitis).
d. Neural diseases (neuritis, paralysis), ...

Low frequencies of distinct diagnoses will probably interfere with analyses of other locomotory diseases involving a high level of specificity. Nevertheless, the improvement of locomotory health on the animal and/or farm level will require detailed disease information indicating causative factors which need to be eliminated. The use of data from veterinarians may allow deeper insight into improvement options. Despite a substantial loss of precision, simple recording of lame animals by the producers may be the easiest system to implement on a routine basis. Rapidly increasing amounts of data may then argue for including lameness or lameness score in advanced analyses.

Table 4. Considerations for locomotion traits.

Parameters to check incoming health data	**Recommended inclusion criterion**	**Remarks**
Eligible animal group	No sex or age restriction	Sex- and/or age-dependent differences in intensity of systematic recording should be considered
Time frame of diagnoses	No time restriction	-
Repeated diagnoses	Possibility of multiple diagnoses per animal independent of lactation	Definition of minimum time period after which same diagnosis may be considered as recurrent case rather than prolonged disease (no clear physiological reference period)

1.9.5 Metabolic and digestive disorders

The range of bovine metabolic and digestive disorders is generally rather broad, including diverse infectious and non-infectious disease. Although each of these diseases may have significant impacts on individual animal performance and welfare, few of them are of quantitative importance. Major diseases can broadly be characterized as disturbances of mineral or carbohydrate metabolism, which are caused in the lactating cow primarily by imbalances between dietary requirements and intakes.

1.9.5.1 Metabolic disorders

Examples:

a. Milk fever (i.e., hypocalcaemia, periparturient paresis), tetany (i.e., hypomagnesiaemia).

b. Ketosis (i.e., acetonaemia), …

1.9.5.2 Digestive disorders

Examples:

a. Ruminal acidosis, ruminal alkalosis, ruminal tympany.

b. Abomasal tympany, abomasal ulcer, abomasal displacement (left displacement of the abomasum, right displacement of the abomasum).

c. Enteritis (catarrhous enteritis, hemorrhagic enteritis, pseudomembranous enteritis, necrotisizing enteritis).

Table 5. Considerations for metabolic traits.

Parameters to check incoming health data	Recommended inclusion criterion	Remarks
Eligible animal group	Depending on type of disease: no sex or age restriction or restriction to adult females (calving-related disorders)	Sex- and/or age-dependent differences in intensity of systematic recording should be considered
Time frame of diagnoses	Depending on type of disease: no time restriction or restriction to (extended) peripartum period	Possible definition of risk periods (where appropriate, diagnoses beyond may be considered separately)
Repeated diagnoses	Depending on type of disease: maximum of one diagnosis per lactation (e.g. Milk fever), possibility of multiple diagnoses per lactation and independent of lactation (e.g. Enteritis)	Definition of minimum time period after which same diagnosis may be considered as recurrent case rather than prolonged disease (no clear physiological reference period)

1.9.6 Others diseases

Diseases affecting other organ systems may occur infrequently. However, recording of those diseases is strongly recommended to get complete information on the health status of individual animals. Interpretation of the effect of certain diseases on overall health and performance will only be possible, if the whole spectrum of health problems is included in the recording program.

Examples:

a. Diseases of the urinary tract (hemoglobinuria, hematuria, renal failure, pyelonephritis, urolithiasis, ...).

b. Respiratory disease (tracheitis, bronchitis, bronchopneumonia, ...).

c. Skin diseases (parakeratosis, furunculosis, ...).

d. Cardiovascular disease (cardiac insufficiency, endocarditis, myocarditis, thrombophlebitis, ...).

Table 6. Considerations for other disease traits.

Parameters to check incoming health data	Recommended inclusion criterion	Remarks
Eligible animal group	No sex or age restriction	Sex- and/or age-dependent differences in intensity of systematic recording should be considered
Time frame diagnoses	No time restriction	-
Repeated diagnoses	Possibility of multiple diagnoses per animal independent of lactation (e.g. Tracheitis)	Definition of minimum time period after which same diagnosis may be considered as recurrent case rather than prolonged disease (no clear physiological reference period)

1.9.7 Calf diseases

Impaired calf health may have considerable impact on dairy cattle productivity. Optimization of raising conditions will not only have short-term positive effects with lower frequencies of diseased calves, but also may result in better condition of replacement heifers and cows. However, management practices with regard to the male and female calves usually differ between farms and need to be considered when analyzing health data. On most dairy farms the incentive to record health events systematically and completely will be much higher for female than for male calves. Therefore, it may be necessary to generally exclude the male calves from prevalence statistics and further analyses.

Examples:

a. Omphalitis (omphalophlebitis, omphaloarteriitis, omphalourachitis).
b. Umbilical hernia.
c. Congenital heart defect (persitent ductus arteriosus botalli, patent foramen ovale, ...).
d. Neonatal asphyxia.
e. Enzootic pneumonia of calves.
f. Disturbance of oesophageal groove reflex.
g. Calf diarrhea, ...

Table 7. Considerations for calf health traits.

Parameters to check incoming health data	Recommended inclusion criterion	Remarks
Eligible animal group	Calves	Sex-dependent differences in intensity of systematic recording should be considered
Time frame of diagnoses	Depending on type of disease (e.g. Neonatal period, suckling period)	Possible definition of risk periods (where appropriate, diagnoses beyond may be considered separately)
Repeated diagnoses	Depending on type of disease: maximum of one diagnosis per animal (e.g. Neonatal asphyxia) or possibility of multiple diagnoses per animal (e.g. Diarrhea)	Definition of minimum time period after which same diagnosis may be considered as recurrent case (no clear physiological reference period)

1.10 Use of data

Rapid feedback is essential for farmers and veterinarians to encourage the development of an efficient health monitoring system. Information can be provided soon after the data collection begins in the form individual farm statistics. If those results include metrics of data quality, then producers may have an incentive to quickly improve their data collection practices. Regional or national statistics should be provided as soon as possible as well. Early detection and prevention of health problems is an important step towards increasing economic efficiency and sustainable cattle breeding. Accordingly, health reports are a valuable tool to keep farmers and veterinarians motivated and ensure continuity of recording.

Direct and indirect observations need to be combined for adequate and detailed evaluations of health status. Reference should be made to key figures such as calving interval, pregnancy rate after first insemination, and non-return rate. A short time interval between calving and many diagnoses of fertility disorders is due to the high levels of physiological stress in the peripartum period, and also may indicate that a farmer is actively working to improve fertility in their herd. A low rate of reported mastitis diagnoses is not necessarily proof of good udder health, but may reflect poor monitoring and documentation.

In addition to recording disease events, on-farm system also can be used to record useful management information, such as body condition scores, locomotion scores, and milking speed (USDA, 2010). Individual animal statuses (clear/possibly infected/infected) for infectious diseases such as paratuberculosis (Johne's disease) and leukosis also may be tracked. Such data may be useful for monitoring animal welfare on individual farms.

1.10.1 Improvement of management (individual farm level)

1.10.1.1 Farmers

Optimised herd management is important for economically successful farming. Timely availability of direct health information is valuable and supplements routine performance recording for early detection of problems in a herd. Therefore, health data statistics should be added to existing farm reports provided by milk recording organisations. Examples from Austria are found in Egger-Danner *et al.* (2007) and Austrian Ministry of Health (2010).

1.10.1.2 Veterinarians

The EU-Animal Health Strategy (2007-2013), 'Prevention is better than cure', underscores the increased importance placed on preventive rather than curative measures. This implicates a change of the focus of the veterinary work from therapy towards herd health management.

With the consent of the farmer, the veterinarian can access all available information about herd health. The most important information should be provided to the farmer and veterinarian in the same way to facilitate discussion at eye-level. However, veterinarians may be interested in additional details requiring expert knowledge for appropriate interpretation. Health recording and evaluation programs should account for the need of users to view different levels of detail.

The overall health status of the herd will benefit from the frequent exchange of information between farmers and veterinarians and their close cooperation. Incorrect interpretation or poor documentation of health events by the farmer may be recognised by attending veterinarians, who can help correct those errors. Herd health reports will provide a valuable and powerful tool to jointly define goals and strategies for the future, and to measure the success of previous actions.

Immediate reactions

It is important that farmers and veterinarians have quick access to herd health data. Only then can acute health problems, which may be related to management, be detected and addressed promptly. An Internet-based tool may be very helpful for timely recording and access to data.

Long term adjustments

Less-detailed reports summarizing data over longer time periods (e.g., one year) may be compiled to provide an overview of the general health status of the herd. Such summary reports will facilitate monitoring of developments within farm over time, as well as comparisons among farms on district and/or province level. References for management decisions which account for the regional differences should be made available (Austrian Ministry of Health, 2010; Schwarzenbacher *et al.,* 2010). Definitions of benchmarks are valuable, and for improvement of the general health status it is important to place target oriented measures.

1.10.2 Monitoring of the health status (population level)

Ministries and other organisations involved in animal health issues are very interested in monitoring the health status of the cattle population. Consumers also are increasingly concerned about aspects of food safety and animal welfare. Regardless of which sources of health information are used, national monitoring programs may be developed to meet the demands of authorities, consumers and producers. The latter may particularly benefit from increased consumer confidence in safe and responsible food production.

It is recommended that all information, including both direct and indirect observations, be taken into account when monitoring activity and preparing reports. For example, information on clinical mastitis should be combined with somatic cell count or laboratory results.

It is extremely important to clearly define the respective reference groups for all analyses. Otherwise, regional differences in data recording, influences of herd structure and variation in trait definition may lead to misinterpretation of results. To ensure the reliability of health statistics it may be necessary to define inclusion criteria, for example a minimum number of observations (health records) per herd over a set time period. Such lower limits must account for the overall set-up of the health monitoring program (e.g., size of participating farms, voluntary or obligatory participation in health recording).

Key measures that may be used for comparisons among populations are incidence and prevalence. In any publication it must be clear which of the two rates is reported, and also how the rates have been calculated.

Incidence

Number of new cases of the disease or health incident in a given population occurring in a specified time period which may be fixed and identical for all individuals of the population (e.g., one year or one month) or relate to the individual age or production period (e.g., lactation = day 1 to day 305 in milk).

For example, the lactation incidence rate (LIR) of clinical mastitis (CM) can be calculated as the number of new CM cases observed between day 1 and day 305 in milk.

Equation 1. For computation of lactation incidence rate for clinical mastitis.

$$LIR_{CM} = \frac{\text{new cases of CM between day 1 and day 305 in milk}}{\text{total number of individual s present between day 1 and day 305 in milk in the population}}$$

Another, and arguably a more accurate incidence rate could be calculated, by taking into account the total number of days at risk in the denominator population. This allows for the fact that some animals will leave the herd prematurely (or may join the herd late) and will therefore not contribute a 'full unit' of time of risk to the calculation.

Equation 2. For computation of lactation incidence rate for clinical mastitis taking account of day as risk.

$$LIR_{CM} = \frac{\text{new cases of CM between day 1 and day 305 in milk}}{N(\text{days}) / 305}$$

Where N(days) is the total number of days that individual cows were present in the herd when between 1 and 305 days in milk; ie a cow present throughout lactation will add 305 days, a cow culled on day 30 of lactation will only contribute 30 days etc., … (divided by 305 as that is the period of analysis).

Prevalence

Number of individuals affected by the disease or health incident in a given population at a particular point in time or in a specified time period.

Equation 3. For computation of prevalence of clinical mastitis.

$$Prevalence_{CM} = \frac{\text{number of occurrences of CM between day 1 and day 305 in milk}}{\text{population during the same time period (e.g. N(days) / 305)}}$$

1.10.3 Genetic evaluation (population level)

Traits for which breeding values are predicted differ between countries and dairy breeds. However, total merit indices have generally shifted towards functional traits over the last several years (Ducrocq, 2010). Currently, most countries use indirect health data like somatic cell counts or non-return rates for genetic evaluation to improve health and feritility in the dairy population. Direct health information may be used in the future, and already has been included in genetic evaluations for several years in the Scandinavian countries (Heringstad *et al.,* 2007; Østeras *et al.,* 2007; Johansson *et al.,* 2006; Johansson *et al.,* 2008; Interbull, 2010; Negussie *et al.,* 2010).

Trait definitions for genetic analyses must account for frequencies of health incidents, with low incidence rates requiring more records for reliable estimation of genetic parameters and prediction of breeding values. Broader and less-specific definitions of health traits may mitigate this problem, with a possible loss of selection intensity. However, obligatory plausibility checks of data must be performed as specifically as possible, and any combination of traits at a later stage must account for the pathophysiology underlying the respective health traits. Examples of trait definitions found in the literature are given together with the reported frequencies in Table 8.

Many studies have shown that breeding measures based on direct health information can be successful (e.g., Amand, 2006, Zwald *et al*., 2006a,b; Heringstad *et al*., 2007). When using indirect health data alone or in combination with direct health data it must be remembered that the information provided by the two types of traits is not identical. For example, the genetic correlations among clinical mastitis and somatic cell count are in the range of 0.6 to 0.7 depending on the definition of the indirect measure of mastitis (e.g., Koeck *et al*., 2010b). Correlation estimates are lower for fertility traits, with moderately negative genetic correlation of -0.4 between early reproduction disorders and 56-day non-return-rate (Koeck *et al*., 2010a).

Heritability estimates of direct health traits range from 0.01 to 0.20 and are higher when only first rather than all lactation records are used (Zwald *et al*., 2004). Results from Fleckvieh and Norwegian Red indicate that heritabilities of metabolic diseases may be higher than heritabilities of udder, locomotory, and reproductive diseases (Zwald *et al*., 2004; Heringstad *et al*., 2005). When comparing genetic parameter estimates, methodological differences such as the use of linear versus threshold models need to be considered.

Existing genetic variation among sires with respect to functional traits can be used to select for improved health and longevity. Experience from the Scandinavian countries shows that genetic evaluation for direct health traits can be successfully implemented. For several disease complexes it may be advantageous to combine direct and indirect health data (e.g.Johansson *et al.,* 2006, Johanssen *et al.,* 2008, Negussie *et al.,* 2010, Pritchard *et al.,* 2011 and Urioste *et al.,* 2011; Koeck *et al.,* 2012a,b).

Further information on already-established genetic evaluations for functional traits including considered direct and indirect health information can be found on the Interbull website (http://www.interbull.org/ib/geforms).

Examples of national genetic evaluations (2010)

Form GE | Status as of: 2010-04-21

DESCRIPTION OF NATIONAL GENETIC EVALUATION SYSTEMS

Country (or countries)	(DFS), Denmark, Finland, Sweden
Main trait group[1] **NOTE!** Only one trait group per form!	Udder Health
Breed(s)	JERSEY
Trait definition(s) and unit(s) of measurement[2] Attach an appendix if needed	1. TD Somatic Cell Score ln(SCC), mean=4.56 lact 1 2. - " - , - " - mean=4.86 lact 2 3. - " - , - " - mean=4.03 lact 3 4. Clinical mastitis as 0 or 1, -15 - 50 DIM, mean=0.159 lact. 1 5. – " - , 51 - 300 DIM, - " -=0.127 lact. 1 6. – " - , -15 - 150 DIM, - " - =0.161 lact. 2 7. – " - , -15 - 150 Dim, - " - =0.179 lact. 3 8. Fore udder attachment , - " - =5.75 lact. 1 9. Udder depth , - " - =5.71 lact. 1
Method of measuring and collecting data	Traits 1-3: Milk recording Traits 4-7: Veterinary reporting and from milk recording scheme Traits 8-9: Linear traits done by classifiers

DESCRIPTION OF NATIONAL GENETIC EVALUATION SYSTEMS

Country (or countries)	Norway
Main trait group[1] **NOTE!** Only one trait group per form!	HEALTH
Breed(s)	AYS. Norwegian Dairy Cattle (NRF).
Trait definition(s) and unit(s) of measurement[2] Attach an appendix if needed	Somatic Cell Score: 305-day lactation geometric mean. Other Diseases: Recorded veterinary treatments for ketosis, milk fever or retained placenta between 15 days prepartum and 120 days post partum. 0=no treatments recorded. 1=one or more treatments recorded. Clinical Mastitis: Recorded veterinary treatments for acute clinical or chronic clinical mastitis in periods of 1st, 2nd and 3rd lactation. 0=no treatments recorded. 1=one or more treatments recorded. CM1: 1st lactation, -15 to 30 days in milk. Treated .0994. CM2: 1st lactation, 31 to 120 days in milk. Treated .0439. CM3: 1st lactation,121 to 305 days in milk. Treated .0627. CM4: 2nd lactation, -15 to 30 days in milk. Treated .1043. CM5: 2nd lactation, 31 to 305 days in milk. Treated .1529. CM6: 3rd lactation, -15 to 30 days in milk. Treated .1318. CM7: 3rd lactation, 31 to 305 days in milk. Treated .1782. CM Index: 1/3*CM1 + 1/3*CM2 + 1/3*CM3

Table 8. Lactation incidence rates (LIR), i.e. proportions of cows with at least one diagnosis of the respective disease within the specified time period.

Breed trait	Time period (parities considered)	LIR (%)	Reference
Danish Red			
Udder diseases	-10 to 100 days in milk (1st lactation)	22	Nielsen *et al.*, 2000
Reproductive disturbances		12	
Digestive and metabolic diseases		3	
Feet and legs disorders		6	
Danish Holstein			
Udder diseases	-10 to 100 days in milk (1st lactation)	21	Nielsen *et al.*, 2000
Reproductive disturbances		10	
Digestive and metabolic diseases		3	
Feet and legs disorders		6	
Danish Jersey			
Udder diseases	-10 to 100 days in milk (1st lactation)	24	Nielsen *et al.*, 2000
Reproductive disturbances		3	
Digestive and metabolic diseases		2	
Feet and legs disorders		4	
Norwegian Red			
Clinical mastitis	-15 to 120 days in milk (1st, 2nd, 3rd lactation)	15.8 19.8 24.2	Heringstad *et al.*, 2005
Milk fever	-15 to 30 days in milk (1st, 2nd, 3rd lactation)	0,1 1,9 7,9	
Ketosis	-15 to 120 days in milk (1st, 2nd, 3rd lactation)	7.5 13.0 17.2	

Breed trait	**Time period (parities considered)**	**LIR (%)**	**Reference**
Retained placenta	0 to 5 days in milk (1st, 2nd, 3rd lactation)	2.6 3.4 4.3	
Swedish Holstein			
Clinical mastitis	-10 to 150 days in milk (1st, 2nd, 3rd lactation)	10.4 12.1 14.9	Carlén *et al.*, 2004
Finnish Ayrshire			
Clinical mastitis	-7 to 150 days in milk (1st, 2nd, 3rd lactation)	9.0 10.6 13.5	Negussie *et al.*, 2006
Fleckvieh (Simmental)			
Clinical mastitis	-10 to 150 days in milk	9.6	Koeck *et al.*, 2010a
Early reproductive disorders	0 to 30 days in milk	7.2	Koeck *et al.*, 2010a
Late reproductive disorders	31 to 150 days in milk	14.3	Koeck *et al.*, 2010b
U.S. Holstein			
Milk fever	1 to 7days in milk	2.9	Cole *et al.*, 2006
Retained placenta	1 to 7days in milk	3.7	Cole *et al.*, 2006
Metritis	7 to 30 days in milk	9.8	Cole *et al.*, 2006
Displaced abomasum	0 to 305 days in milk	4.2	Cole *et al.*, 2006
Ketosis	0 to 305 days in milk	6.6	Cole *et al.*, 2006
Cystic ovaries	0 to 305 days in milk	12.0	Cole *et al.*, 2006
Clinical mastitis	0 to 305 days in milk	13.4	Cole *et al.*, 2006

Breed trait	**Time period (parities considered)**	**LIR (%)**	**Reference**
Locomotory disorders	0 to 305 days in milk	20.9	Cole *et al.*, 2006
Canadian Holsteins			
Mastitis	0 to 305 days in milk (1st lactation)	12.6	Koeck *et al.*, 2012b
Displaced abomasum	0 to 305 days in milk (1st lactation)	3.7	Koeck *et al.*, 2012b
Ketosis	0 to 100 days in milk (1st lactation)	4.5	Koeck *et al.*, 2012b
Retained placenta	0 to 14 days in milk (1st lactation)	4.6	Koeck *et al.*, 2012b
Metritis	0 to 150 days in milk (1st lactation)	10.8	Koeck *et al.*, 2012b
Cystic ovaries	0 to 305 days in milk (1st lactation)	8.2	Koeck *et al.*, 2012b
Lameness	0 to 305 days in milk (1st lactation)	9.2	Koeck *et al.*, 2012b

1.11 Disease Codes

A full list of disease codes is available:

a. On the ICAR website here - https://www.icar.org/index.php/publications-technical-materials/amendments-recording-guidelines/diseases-codes-for-cows/ and,

b. Can be downloaded as an .xlsx file here - https://www.icar.org/wp-content/uploads/2020/01/ICAR-Claw-Health-Key-coding-20180921.xls

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