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The production system and disease incidence in a national random longitudinal study of Swiss dairy herds

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Abstract

A prospective longitudinal observational study based on a stratified random sample of 113 Swiss dairy farms was conducted between April 1993 and July 1994 with the following objectives: (i) to provide statistically valid estimates of disease frequency in the Swiss dairy cow population, and (ii) to evaluate the feasibility and quality of an intensive farm-based data recording system. During the 15-month study period, farmers were asked to record every health and management event related to their cattle herd. This information was mailed back to the study centre at fortnightly intervals. Additionally, farms were visited regularly to verify received data and to discuss specific problems. During these farm visits, management data were recorded using questionnaires. A complete data set of individual animal events with a total observation time of about 1740 cow-years and 275 calf-years was collected and disease-incidence measures were calculated. The most frequent events were reproductive disorders and udder diseases, followed by lameness and metabolic disorders. Experience with the data collection technique used in this study suggests that a farm-based system is effective and reliable, as long as good contact with the farmers is maintained, and incentives to stimulate their motivation are provided. © 1997 Elsevier Science B.V.

Keywords: Dairy cattle diseases; Prospective longitudinal observational study; Disease-incidence measures; Farm-based data recording system; Switzerland

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1. Introduction

The economic importance of dairy farming is considerable in Switzerland. In 1990, 35.8% of the gross agricultural income (SFr8.7 billion) originated from milk production (Swiss Federal Office of Statistics, 1994a). In addition to the economic aspect, increasing emphasis is being placed on the ecological and cultural role of dairy farming with respect to the conservation of traditional characteristics of the Swiss landscape. Yet, in spite of considerable support through government subsidy, the number of dairy farms has decreased by about 20% to ≈ 59 000 farms over the past 10 years (Schweizer Bauernverband, 1993). Simultaneously, the average dairy herd size has increased steadily reaching an average of 12.8 cows in 1993 compared with 11.6 in 1983.

It is widely accepted that animal performance is directly influenced by health and management practices (Danuser and Gaillard, 1990; Miller and Dorn, 1990; Wanner, 1995). Consequently, animal health and management data is an essential resource in assisting farmers, veterinary practitioners and health services in their decision making (Ekesbo, 1994; Houben, 1995). When health data are used in combination with data on management practices, risk factors for diseases can be identified. This knowledge is needed for disease control and prevention, and improvement of animal welfare.

Animal health data can be collected at different sites, e.g., in veterinary practices, diagnostic laboratories, slaughterhouses and through associations of animal breeders (Stärk et al., 1996). But data from these sources have the potential to be biased because they represent only a selection of the whole animal population. A major advantage of prospective randomised on-farm data collection is that it provides a more accurate picture of the health situation in a livestock population. This approach has been used in a number of countries, e.g., for the national animal health monitoring system (NAHMS) in the USA (King, 1990), in Canada (Dohoo et al., 1982/83), in Sweden (Bendixen et al., 1986; Emanuelson, 1988) and in Pakistan (Akhtar and Ali, 1994).

In the context of the opening of global markets, the importance of an internationally-accepted disease-free status has increased. The transparent documentation of a disease status will build confidence between trading partners. Also, as a result of consumer demand, more advanced control programmes and detailed information on the safety of food animal products are required. An important basis for all these needs is the availability of animal health data (Stärk et al., 1996). Currently, data generated by a number of government surveillance systems and data on the health and productivity of most livestock species have not yet been systematically recorded and analysed in Switzerland. With this background, the study was conducted with the following objectives: (i) to provide statistically valid estimates of disease frequency in the Swiss dairy cow population, and (ii) to evaluate the feasibility of an intensive on-farm data recording system.

2. Material and methods

2.1. Study design

A prospective longitudinal observation study was conducted based on a random sample of Swiss dairy farms. Data were collected between April 1993 and July 1994.

The first three months were considered to be a training period for the farmers in data recording and were therefore excluded from the analysis. The final data set contains all observations recorded between 11 July 1993 and 10 July 1994.

2.2. Study population

The target population of this study included all Swiss dairy farms. Within each farm, individual cows and young calves represented the units for study. As most calves are sold for fattening at an early stage ($\approx$ 8–10 weeks), all calves older than two months were excluded from the study. Heifers were not included in the study as most of them spend a considerable amount of time on mountain pastures where it would not have been possible to ensure adequate data recording. It has also been reported that disease incidence in heifers is low (Kaneene and Hurd, 1990).

Small farms with < 5 cows were excluded from the study as they would have contributed only limited additional data. This type of farm represents about 11.2% of all Swiss dairy farms and about 3.2% of all Swiss dairy cows (Schweizer Bauernverband, 1993).

2.3. Sampling technique and farm enrolment

A computer-generated random sample of Swiss dairy farms with a minimal herd size of five dairy cows was selected. The sample was stratified according to the following herd size categories: 5–10, 11–15, 16–20 and > 20 cows per farm. As a result of differences in agricultural intensity between areas, the sample was further stratified by cantons, i.e., the 26 Swiss political districts. The sample was drawn by the Swiss Federal Office of Statistics on the basis of their current farm register. This register was based on the federal farm census of 1988. This compulsory census, which is repeated at 5-year intervals, is aimed at collecting information on farm size, livestock numbers and general farm characteristics.

At the start of the study, a total of 59 362 dairy farms were recorded in Switzerland (Schweizer Bauernverband, 1993). The sample size was planned such that an endemic disease prevalence of 10% could be estimated with an absolute precision of 5% at a confidence level of 95% (Cannon and Roe, 1982). This required a minimal sample of 96 farms. Assuming a participation rate of farmers of $\approx$ 30%, a total sample of 284 farms was selected.

The farmers were contacted by mail. The kind of data recording that would be required during the study period was explained. As an incentive, farmers were offered feedback with regard to health and productivity of their herd, as well as a modest monetary compensation. Farmers not responding to the initial letter were sent a reminder.

Farmers willing to participate were asked to sign a mutual agreement ensuring record keeping for 15 months and complete confidentiality of their records. They were paid depending on herd size and data recording performance. For each completed data sheet,

they received between SFr10 and SFr20 (approximately US$8–16). In addition, at the end of the study, they received a fidelity premium of SFr400 (approximately US$330) if they had completed more than 90% of all sheets. Once the study farms had been enrolled, a letter was sent to their farm veterinarian(s) informing them about the study.

At this stage, every farmer provided a complete inventory list of the cows and calves currently present on the farm. This list included names of animals, identification numbers (ear tag), breed, date of birth and date of last calving for cows. This register was updated each time a new animal entered the cohort during the study, e.g., purchase of cows, primiparous cows or newborn calves.

Names and addresses of veterinarians servicing individual farms were collected during the first farm visit. These veterinarians were sent relevant information by mail.

2.4. Data collection

Data collection was based on records kept by farmers using standard data recording sheets, direct interviews and laboratory analyses of samples collected from individual animals. All data were collected by the same two veterinarians during the entire study period.

Health-related data from cows and calves younger than two months were recorded using recording sheets (Fig. 1) provided by the study veterinarians. These forms were completed either by farmers themselves or by their veterinarians. Farmers were instructed to record every single health-related event they observed in their cows and calves, however minor it might be, and even if it did not require any human intervention. Health and management events were coded according to a hierarchically-organised coding system, allowing the recording at different levels of detail. A list of written case definitions for each code was provided. Conditions were explained adequately, such that, it was easy for the farmer to understand what was meant. For instance, locally-known expressions were used to describe specific health disorders. The case definitions were reviewed by practitioners and cattle production specialists before initiating data collection. To facilitate coding for farmers and veterinarians, codes expected to be frequently used were printed in the data entry sheet header. For the remaining codes, a reference list had to be consulted. This list was protected with a plastic cover so that it could be

Frequently used codes:						Farm ID		Farmer Name:		
						Sheet No.:		Recording period:		
Date	ID	Vet called? yes/no	Visit number	Event code	Therapy 1 AB 2 other drugs 3 surgery 4 other	Cost (vet)	Cost (drugs)	Milk withhold (days)	Lab yes/no	Comments

Fig. 1. Header of on-farm data recording sheet.

kept in the barn. This ensured that the codes were always at hand when needed. The code reference and recording sheets were available in German or French.

At 2-week intervals, a new set of recording sheets with the dates of the current observation period was sent to the farmers. Completed forms had to be returned using prepaid return envelopes after receipt of the new recording sheets. The relatively short interval between mailings was done to ensure that the farmers were reminded to continue recording all events of interest in their farms.

All farms were visited 5 times by one or both of the study veterinarians between March 1993 and October 1994: once before the beginning of data recording, 3 times during the study at intervals of 3 to 4 months, and once after the final data check to clarify remaining uncertainties. During one visit, the study veterinarians collected blood and faecal samples from all individual cows and calves for bacteriological, virological and parasitological analysis. These samples were used to calculate the prevalence of specific disease agents.

Data about management practices and other farm characteristics were collected during regular farm visits. Farmers were interviewed using a set of standard questionnaires, each covering one of the following topics: general farm characteristics, housing and feeding of cows, housing and feeding of calves including management of newborn calves, prophylactic health measures and a general assessment of the study and their attitude towards future involvement in data recording and research projects. The questionnaires were composed of closed questions to facilitate data entry, to control variation between answers and to facilitate data analysis. Each questionnaire was completed once, and the interview was conducted following a standard protocol. The information from the questionnaires was collected for descriptive analysis of the farms, also for future risk-factor analysis.

2.5. Data quality

Major emphasis was put on data quality. After receiving completed data recording sheets, the data were screened for correct coding, missing or out-of-range results and general plausibility. All errors detected were corrected (if necessary, after consulting with the farmer). Every event recorded was double-checked with the farmer. Event series of individual animals were checked for completeness through inspection of the animal's history for missing events such as calvings or inseminations. If data appeared to be missing or were inconsistent, this was discussed with the farmer at the next farm visit. Whenever possible, information provided by the farmer during on-farm interviews was verified through visual inspection of the items described. This allowed a subjective assessment of the reliability of information provided by individual farmers. Inconsistencies were discussed to prevent possible misunderstanding. When the recorded veterinary costs did not appear to be reasonable or were missing, the respective veterinarian was contacted. In most cases, he or she would then provide copies of the original invoice.

2.6. Data management and analysis

All data were entered and stored using the data management software Microsoft Access for Windows Version 2.0 (Microsoft, Redmond, USA). A relational database

was designed comprising different tables storing data about farm management, individual animal information, disease events and laboratory results. Data entry was done by the study veterinarians and two students. Data files were screened for proper coding, and to find missing and out-of-range results. Descriptive statistics (median, $5^{th}/95^{th}$ percentiles, range) were calculated using the structured query language of the data management software, the spreadsheet software Microsoft Excel for Windows Version 5.0 and NCSS Version 6.0.21 (Number Cruncher Statistical Systems, Kaysville, USA). Maps were generated using the geographical mapping software ArcView for Windows Version 2.0 (Environmental Systems Research Institute, Redlands, CA, USA).

Two different types of incidence measures were used to describe disease frequencies: cumulative incidence (CI) and incidence density (ID). The number of calving events was used as denominator in the categories calving disorders and puerperal disorders. As the total number of pregnant cows was not known due to the lack of systematic pregnancy testing, the number of events resulting in the abortion of pregnancy was added to the number of calvings to get an estimated denominator to calculate the CI in the category, disorders during pregnancy.

If an animal experienced multiple disorders associated with the same calving event within a specific disease category, only the first occurring event was counted. Secondary and tertiary visits linked to the same event were excluded. CI is expressed per 100 calving events.

For the other disease categories, ID was calculated per cow-year at risk. For the following categories of disease events, every occurrence was counted: calf diseases, udder diseases, lameness, metabolic disorders and diseases of the digestive tract. Animals that experienced multiple events of the same type during the study period would therefore be counted more than once.

To calculate the time at risk when more than one episode of disease was possible, the following approach was used. An animal diagnosed as diseased was considered treated and immediately recovered. The denominator was then the sum of the observation periods of all the individuals. This approach avoids definition of recovery periods (Bendixen, 1987). This method was used to calculate the time at risk for calf diseases, diseases of the udder, lameness, metabolic disorders and diseases of the digestive tract. It has to be understood that this will result in an underestimation of the true ID.

For reproductive disorders, only the period between the previous calving or abortion, and the first recording of such an event, was considered as time at risk. If no such event occurred, the last insemination was considered as the end point for the time at risk calculation. ID is expressed per 100 animal-years.

3. Results

3.1. Response rate

Of 284 selected farms, 227 (80%) responded to the first mail contact. Of the respondents, 118 (52%) expressed willingness to participate in the study. All farmers

with negative responses had been asked to provide minimal farm information and reasons for their refusal. This information could be obtained from 74 farmers (44.6% of all non-participants). The most common reasons for not wanting to participate were lack of time (46%), age or imminent retirement (32%), no interest (14%), uncooperative veterinarians (3%), herd size less than 5 cows (1%) or other reasons (4%). Eventually, 118 farms (42% of the original sample) were enrolled in the study. Five farms (4%) dropped out during the study period. Additionally, two farmers had to quit because their farm lease was terminated. Data from these 2 farms were nevertheless included in the analysis by including the initial three-month preliminary data-recording period in the analysis period. This was done to obtain information for an entire year.

At this stage, the obtained sample of farms was re-evaluated with respect to its significance as a representative of the underlying target population. Three farm characteristics were compared with animal census data (Swiss Federal Office of Statistics, 1994b). The sample was reasonably comparable regarding spatial characteristics of the target population (Figs. 2 and 3). It also corresponded well with the breed distribution in the general dairy cow population (Fig. 4). Small herds with 5 to 10 cows were under-represented and medium herd sizes with 11 to 15 cows were slightly over-represented in the study sample (Fig. 5).

3.2. Farmers' attitude towards data recording

Only few farmers had to be reminded about missing data recording sheets. At the end of the study, all 113 participating farmers had sent back all their recording sheets.

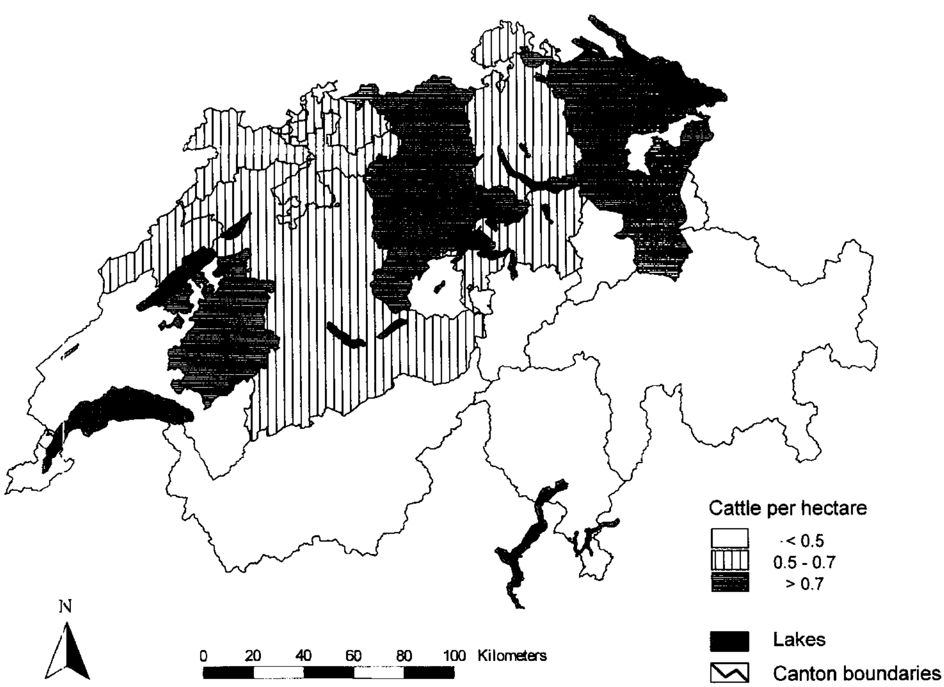

Fig. 2. Cattle density per canton (Swiss Federal Office of Statistics, 1994b).

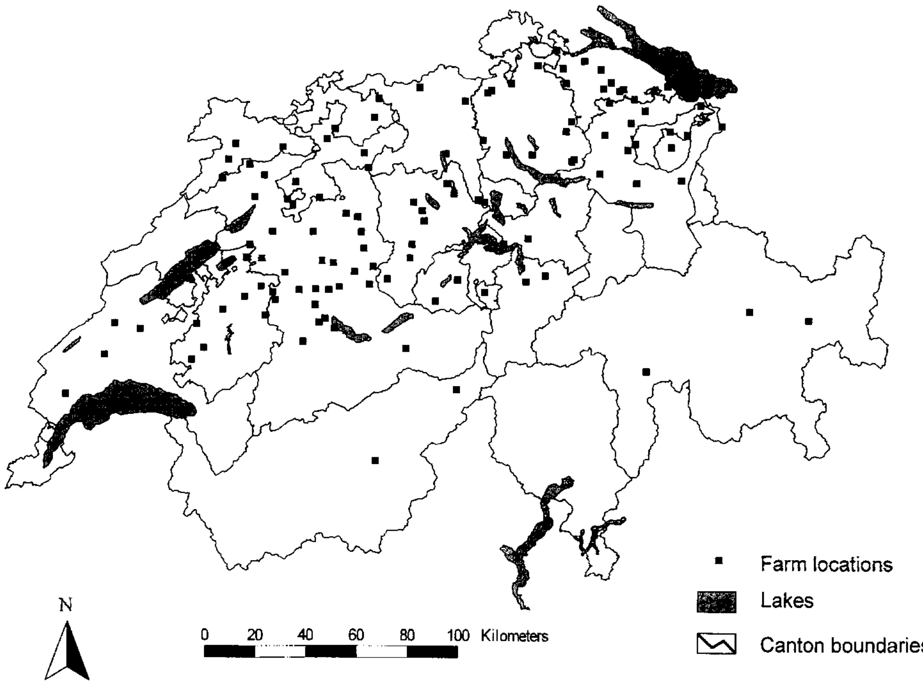

Fig. 3. Geographical distribution of Swiss dairy farms studied 1993–1994.

Depending on the study entry date for individual farms, this corresponds to 32 or 33 recording sheets. The two farmers, who had to quit the study, returned all recording sheets valid for the period of their participation.

From all farmers completing the study, 20% identified financial compensation as the major motivation factor for their initial cooperation. Later on, when farmers received

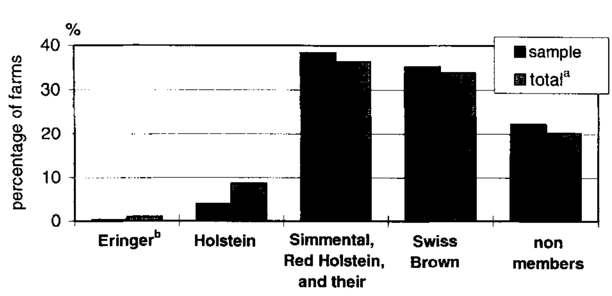

Fig. 4. Distribution of cattle breeder association member ([a] Swiss Farmer Association, 1993) and breeds on Swiss dairy farms studied 1993–1994 ($n = 113$), [b] Eringer = Local dairy breed.

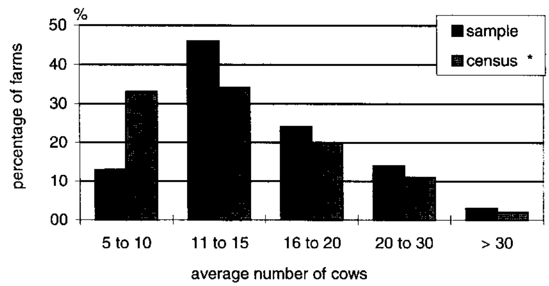

Fig. 5. Herd size distributions for Swiss dairy farms studied 1993–1994 ($n = 113$) and Swiss agricultural census data 1990 (Swiss Federal Office of Statistics, 1994b).

feedback in the form of reports and comparison of their own production performance with the rest of the study population, this information became an important incentive. On the average, the farmers needed 15 min a week to fill in the data recording sheets (range 5–30 min, $25^{th}/75^{th}$ percentile, 10/15 min).

Farmers were also asked if they would participate in a similar future study. Eighty-two percent were basically willing to do so, while 15% made their decision based on the study design. Only one farmer said that he would never take part in a similar study again. Two farmers (2%) regretted that they would not be able to participate in a future study, because they had to give up farming for unrelated reasons. In upcoming studies, 59% of farmers would prefer to be financially compensated, while 35% would possibly participate without compensation, and 4% were sufficiently interested to continue in a similar study without any payment.

3.3. Farm characteristics

For 73% of the farmers, milk production generated most of their farm income (Table 1a). Few farmers (9%) were producing milk and no other agricultural product. Virtually, all farmers (98%) delivered their milk to cooperative-owned creameries. The remaining 2% of farmers used the milk exclusively for feeding fattening calves.

All but one farmer kept other livestock or pets on their premises. The most common species were cats (95%) and dogs (78%), followed by poultry (60%), pigs (53%), rabbits (43%), horses, ponies or donkeys (30%), goats (18%), sheep (13%), exotic poultry (10%), bees (4%), red deer and moufflon (1%).

Most farmers (78%) had formal training in agricultural production, and 8% possessed other qualifications. Also, most properties (92%) were owned by the farmer, another 7% were leased, and one farmer was running the farm for the owner.

3.4. Cow husbandry

Most farms (97%) still use the traditional tethering housing system (Table 2). The most common types of floor and bedding were rubber mats (83%) and straw (93%).

Table 1
Descriptive statistics of studied Swiss dairy farms, 1993–1994 ($n = 113$)

	Mean	Median	Range
(a) General characteristics			
Number of cows	15.5	15	5–40
Number of calves	5.7	5	0–22
Number of fattening calves	5.4	2	0–55
Altitude of farm house [a]	701.6	640	390–1603
Annual milk quota (kg) [b]	68900	65000	0–171300
Percentage of total income originating from farming (%)	93.1	100	10–100
Percentage of farm income from milk production (%)	69.4	70	33–100
Persons working in stable	2.5	2	1–10 [c]

(b) Farming activities besides milk production (more than one category possible, $n = 113$)

Type of farming activity	n	%
Crop farming	63	56
Calf fattening	36	32
Pig fattening	22	20
Cattle breeding	20	18
Beef fattening	12	11
Pig breeding	11	10
Fruits	11	10
Other	15	13

[a] Meters above sea level.
[b] Two farmers used all milk for fattening calves.
[c] A social rehabilitation centre with 10 persons was also included.

During the study period, 65% of the farmers occasionally used a ‘cow trainer’. This is an electronic device consisting of an individually adjustable metal loop installed over the back of the cow. Weak electric impulses pass through the loop. The device is positioned such that as soon as a cow arches her back for defecation or urination, the animal receives a weak electric shock if she is standing too far away from the dung ditch. The cow responds by stepping backwards, which prevents her from soiling the bedding area (Oswald, 1992). The device is switched off and lifted during milking, or if being used for other reasons.

The main cow feed in summer was grass and in winter, hay and silage. All farmers provided minerals and salt. All except two farmers let their cows graze in summer for an average of 129 days (range 10–210 days). In 18% of the farms, at least part of the herd was sent to mountain pastures during summer for grazing. During winter, all farmers kept their cows in closed barns. Thirty-seven percent let the cows outside on pasture or into a yard at least once every two weeks.

3.5. Milking systems

Most farmers (75%) were using a bucket milking system. Pipeline milking systems were in use on 22% of farms and only 3% had a milking parlour.

Table 2
Cow husbandry practices in studied Swiss dairy farms, 1993–1994 ($n = 113$)

Husbandry practice	n	%
Tying system		
Rope, chain or strip	100	88
Yoke tying	10	9
None	3	3
Stables		
Short standing	40	35
Medium standing	65	58
Long standing	5	4
Cubicle housing system	3	3
Floor		
Concrete floor	13	12
Rubber mat	94	83
Slatted floor	3	3
Wooden floor	3	3
Bedding		
Straw	68	60
Hashed straw	37	33
Sawdust	8	7
Use of 'cow trainer' device		
None	32	28
Never used	7	6
Used occasionally	60	53
Permanently used	14	12

Farmers used different prophylactic measures for maintaining udder hygiene. More than one of the following strategies may be applied by an individual farmer. The most common was drying off cows using antibiotics. About half of the farmers (47%) used this method only for cows with a recent mastitis history. Other farmers (44%) basically dried off every cow using antibiotics. Regular teat dipping with products containing iodine was done by 40%, and regular California Mastitis Testing (Radostits et al., 1994) was used by 39% of the farmers. Monthly milk cell counts for individual cows are offered by breeder associations, and this service was used by 27% of the farmers. Bulk milk cell counts are regularly conducted at the creameries as required by the Swiss milk quality assurance system.

3.6. Breeding practices

All farmers used artificial insemination for at least some of their cows. According to the farmers, most of the first services (84%) were done using artificial insemination.

For oestrus detection, most farmers (84%) relied on observing their cows during milking and feeding times, which was done by 15% at least three times a day. During summer, 97% of farmers relied on observing the behaviour of their cows on their way to

and from pasture. Pasturing of individual cows is the method of heat detection during winter in 47% of farms. A bull was used by 47% as an additional heat-detection method, even if cows had been artificially inseminated. Two percent of the farmers continuously kept a bull together with their cows. Only 4% of the farmers had regular reproductive examinations conducted by veterinarians on breeding-age females.

Special feed additives to bring cows into oestrus earlier were used frequently (63%). Many farmers used traditional recipes and a range of ingredients such as vitamins, minerals, yeast and special plant mixtures. Oestrus-inducing drugs were used regularly by 4% of the farmers.

For artificial insemination of heifers, most farmers (51%) chose pedigree bulls with a documented history of easy calvings. Twenty-nine farmers (26%) did not take calving difficulties into consideration and chose the same breeds and bulls for their heifers as they used for their cows. Crossbreeds with a history of few calving difficulties were used by 18% of farmers. The remaining 5% of farmers mainly used their own bull for breeding purposes.

Milk production parameters were the main traits for the selection of a bull for cow insemination (55%). For 35% of farmers, the hereditary type of the bull was an important decision factor. The exclusive use of fattening-type breeds or the cost of an insemination dose were the selection criteria for 5% of the farmers. The remaining farmers mainly used their own bull. A total of 787 pregnancy checks was done during the study period, i.e., 49% of 1619 inseminated cows were checked.

3.7. Management of newborn calves

Many farmers (46%) separated the calf from the cow immediately after calving or left it briefly for the cow to lick the calf dry (35%). The rest of the farmers separated the calf and the cow after a period of 2 h up to several days after calving. Most calves (93%) were fed colostrum in the first 6 h of their life. The quantity of the first colostrum ration was < 2 l on 56% of the farms, between 2 and 4 l on 42% and on 2% of farms, calves were allowed to suckle directly from the cow (quantity unknown). Most farmers (82%) did not use any preventive umbilical treatment. The different types of calf housing and feed are listed in Table 3.

3.8. Preventive measures

Claws of all cows were trimmed regularly once (31%) or twice (69%) during the period of 1 yr. Additional trimmings were done on specific cows when necessary.

Calves were dehorned on 14% of the farms. Only 5% of the farmers used prophylactic vaccinations for their calves. On one farm, the cows were vaccinated against bovine virus diarrhoea during the study period. Parasitic treatment of cows and calves was used by 9% of the farmers. Most of the vaccinations and worming treatments occurred in heifers; these treatments were not recorded during this study.

Table 3
Calf management practices in studied Swiss dairy farms, 1993–1994

Calf management practice	Calf husbandry system			
	Calf raising (n = 109) [a]		Calf fattening (n = 74)	
	n	(%)	n	(%)
Location of the calf pens				
In cow shed	83	(76)	53	(47)
In separate shed	24	(22)	20	(18)
In separate shed with open front	2	(2)	1	(1)
Calf accommodation				
Tethered	48	(44)	30	(27)
Individual boxes	4	(4)	5	(4)
Grouped housing in barn	57	(52)	39	(35)
Calf feeding				
Milk in bucket	58	(53)	36	(32)
Milk in bucket with nipple	50	(46)	29	(26)
Milk in calf feeder	1	(1)	8	(7)
Addition of milk powder	12	(11)	46	(41)

[a] Four of the 113 study farms did not keep calves for raising replacement heifers and 39 farms (35%) did not keep fattening calves.

3.9. Study cohort

During the study period, a total of 2262 cows were monitored resulting in a total observation period of 634 972 cow-days (1739.6 cow-years). For reproductive disorders, the total time at risk was 179 685 cow-days (492.3 cow-years). Additionally, 1956 calves

Table 4
Incidence measures of disease by category in studied Swiss dairy farms, 1993–1994 (n = 113)

Disease category	No. of cases	Total days at risk	Events [a]	Median		25[th]/75[th] percentile	Range
				ID [b]	CI [c]		
Reproductive disorders	646	179685	NA [d]	117.3	NA	57.8/210.8	0–749
Diseases of the udder	727	635396	NA	35.7	NA	20.1/62.8	0–123
Lameness	277	635396	NA	10.0	NA	0/22.2	0–98
Metabolic disorders	235	635396	NA	9.7	NA	0/18.5	0–77
Disease of the digestive tract	100	635396	NA	0.0	NA	0/8.1	0–114
Puerperal disorders	212	NA	1789	NA	10.0	0/18.5	0–46
Calving disorders	154	NA	1789	NA	6.7	0/13.3	0–50
Disorders during pregnancy	75	NA	1864	NA	0.0	0/7.7	0–38
Calf diseases	247	100387	NA	53.4	NA	0/145.4	0–578

[a] Events = pregnancies for disorders during pregnancy; Events = calvings for calving disorders and puerperal disorders.
[b] Incidence density per 100 animal-years.
[c] Cumulative incidence per 100 events.
[d] NA = not applicable.

younger than two months accumulated 100 387 calf-days (275.0 calf-years). The breed distribution of the cows was as follows: Simmental, Red Holstein and their crossbreeds represented 47%, Swiss Brown 41%, and Holstein 11%. The average age of the cows present in the study population on January 1, 1994 was 5.4 yr (standard deviation, SD = 2.4).

During the observation period, 577 cows (25.5% of the total number of cows monitored) entered the cohort after the study start (11% purchased, 89% primiparous cows). A total of 515 cows (22.8%) was removed from the study population for the following reasons: slaughter due to infertility (26%), slaughter due to other reasons such as age (24%), slaughter due to insufficient milk production (17%), slaughter due to udder diseases (10%) and urgency slaughter or sudden death (4%). The average age at slaughter was 6.0 yr. A number of cows (19%) were sold for breeding or milk production.

The average age at first calving was 956 days (SD = 133 days) and the average time

Table 5
Incidence measures of most frequent diseases in studied Swiss dairy cows and calves, 1993–94 ($n = 113$)

	ID [a]
(a) Diseases of cows	
Noncycling	48.2
Endometritis	37.2
Ovarian cyst	30.4
Other diseases of reproductive tract	22.8
Acute mastitis	20.2
Subclinical/chronic mastitis	12.5
Hypocalcaemia	8.2
Return to service	7.1
Sole ulcer	5.7
Diarrhoea	3.4
(b) Pregnancy- and birth-related diseases of cows	CI [b]
Retained placenta	9.5
Stillbirth	3.7
Dystocia	2.4
Abortion	2.2 [c]
(c) Diseases of calves	ID
Diarrhoea	35.0
Omphalitis	13.9
Respiratory diseases	13.5
Other diseases	7.2

[a] ID = incidence density per 100 animal-years.
[b] CI = cumulative incidence per 100 calvings.
[c] Cumulative incidence per 100 pregnancies.

between calving events was 387 days (SD = 62). The age at first calving for Holstein, Simmental and Red Holstein crossbreeds and Swiss Brown were 943 days (SD = 190 days), 925 days (SD = 128 days), and 1000 days (SD = 104 days), respectively. The calving intervals for the different breeds were Holstein 399 days (SD = 62 days), Simmental and Red Holstein crossbreeds 381 days (SD = 60 days) and Swiss Brown 391 days (SD = 63 days).

3.10. Incidence measures

Incidence measures were calculated by diagnosis code category and by individual codes (Tables 4 and 5). Among the different disease categories, reproductive disorders and udder diseases were the most frequent disease events in cows, followed by lameness and metabolic disorders. With respect to pregnancy-related diseases, problems most frequently occurred during the puerperal phase. With respect to individual disease codes, noncycling, endometritis, ovarian cysts and other diseases of the reproductive tract (not further specified) were most frequently recorded (Table 5).

In calves, health problems occurred at a rate of 53.4 incidents per 100 calf-years at risk. Diarrhoea, omphalitis and respiratory diseases together accounted for 80% of diseases in calves (Table 5).

4. Discussion

4.1. Representativeness of farm sample

The recruitment of participants for a long-term voluntary study based on intensive data recording represents a major challenge. During the recruitment phase, we realised that the farm register used was not as up-to-date as expected. For this reason, a number of farmers were selected although they had already stopped farming. From the original sample, 42% could be enrolled in the study. This corresponds to the generally expected response rate for mail surveys (Martin et al., 1987). In the California NAHMS study of 1986–1987, not more than 53% of farmers could be enrolled although all farmers had been visited personally to solicit their cooperation (Sischo et al., 1990).

We recognise that volunteering could have resulted in selection bias. Therefore, the sample was assessed by comparison with census data. This evaluation demonstrated that the sample provided a reasonable representation of the target population with respect to geographical distribution and breed. Farms with small herd sizes were under-represented. As the characteristics of the target population were based on past census data, it is possible that it did not provide a correct representation of very recent structural changes in the farming community.

Animal disease monitoring systems rely greatly on data recording by animal owners. If the system is perceived by the owners as serving their direct needs and not just the needs of a government or other agency, a high level of farmer collaboration can be achieved, ensuring adequate data quality (Martin et al., 1987). We believe that this goal was realised in the present study through prompt feedback of information to farmers.

These data were used by farmers as the basis for obtaining specific certificates of the status of their products from the associations of producers involved in integrated or biodynamic farming. It also gave them the opportunity for an objective comparison of their farm performance with other comparable farms. Monetary compensation is likely to have reduced the selection bias caused by voluntary enrolment to some extent as it provided a motivation for a number of farmers not especially interested in animal health surveillance.

4.2. Data recording system

The data recording system was designed with the objective to obtain a complete representation of the health-related events in the sample population. Even minor problems not requiring veterinary services were recorded. In the beginning of the study, some farmers had problems related to the use of code lists and recording sheets. But in general, the recording system appeared easy to use. An obvious disadvantage is that farmers are not trained in conducting disease diagnoses. Bias originating from forgetting or misclassification of events are an obvious problem in this type of study. To provide valid data, it was important to familiarise farmers with different disease categories and symptoms and how they corresponded to the expressions used for coding. The study tried to achieve this by using nontechnical expressions and locally used terminology. We believe that misclassification bias was reduced by discussing the different event types with the farmers, and providing descriptions in different languages, as well as the option to record data in very broad categories. A further attempt to reduce bias was made by validating and correcting the recorded data in cooperation with the farmer. This procedure was extremely time-consuming but was adopted to ensure high data quality. A similar coding system has been described for on-farm recording of pig health data (Christensen et al., 1994). The use of such a system was considered feasible although it was argued that the validity of crude disease classification should not be overestimated. To enhance recording consistency, the first three months of our study were considered as training period and used to discuss and clarify problems. During that period, changes to the recording system would have been possible, but it turned out that no modifications were necessary.

From each farm, a full year of data was used in the analysis to cover one production cycle. Two farms dropped out during the study and the initial three training months had to be included to obtain a full year's data. As these two farmers seemed to have provided high quality data from the start of the recording, we believe that the inclusion of those data does not reduce the quality of the data set.

Complete data recording was enhanced by regular reminders to farmers at two-week intervals. This relatively short time span of individual data collection periods raised concerns for some farmers. If there had been no health-related events, they had to send back empty forms, which they considered unnecessary. However, most farmers appreciated the regular reminder. This was particularly important during the early phase of the study period. The data recording sheets obtained from farms which were included in the analysis were almost entirely completed.

Personal contact with the two study veterinarians seemed to be very important to

maintain a farmer's motivation. There were cases when it was difficult to establish a good relationship with the farmer on first contact, but towards the end of the study, the relationship with most of them was relaxed and friendly. We think that the involvement of only two veterinarians with a background in farming in the study facilitated the establishment of a personal contact. Maintenance of such close contact with individual participants is only possible for a limited study period and if distances to individual farms are not too long (each of the farm visit rounds resulted in a total travel distance of 12 000 km). Once the data recording process was understood by the farmers, the system did not require major discussions with individual farmers.

Excluding heifers and calves older than two months of age from the study resulted in confusion among some participating farmers. This approach had been justified on the basis of other studies which reported that these animals generally had relatively few health problems (Kaneene and Hurd, 1990). However, some farmers forgot the definition of the study population and recorded events related to their heifers as well. These additional recordings required inquiries to clarify the status of the animals. To avoid such problems, future studies may have to include all age groups.

Most of the problems related to data collection were caused by the farm veterinarians. Some of them refused to fill in the forms during their visits and either the farmers or the study veterinarians had to complete the forms based on invoice information provided subsequently by the veterinarians. The major reason for veterinarians not collaborating fully was lack of time and a reluctance to provide information about their pricing policy to third parties. Additionally, some farms were served by several veterinarians which made data recording difficult when they wanted to have their fees and services treated confidentially.

Experience based on data collection, data entry and analysis suggests that the information collected in this study provides a complete and accurate representation of the health-related events on the study farms. Similar experience has been described for NAHMS in Michigan (Kaneene and Hurd, 1990).

4.3. Production system

The dairy cattle husbandry system in Switzerland does not appear to have changed over the last decades. Most cows are still kept tethered, whereas, cubicle housing systems are an exception. The results are consistent with findings from the census conducted in 1990 where 79% were using a bucket milking system (75% in this study) and exactly the same percentage of farms used a tethering system as in this study (97%; Schweizer Bauernverband, 1993). The main feeds for cows were grass, hay and silage which were produced on farms. The average herd size of 15.5 cows was slightly higher than the average of 14.0 cows estimated from census data, including only the data from farms with at least 5 cows. In comparison with other countries in Europe and USA, herd sizes are small. An average of 2.5 persons were employed per farm in Switzerland according to the 1990 census (Schweizer Bauernverband, 1993), which is similar to the 2.2 reported for the study farms. As expected, the mean of the annual milk consignments of the study farms (68 900 l) is slightly higher than the Swiss average of 60 790 l

reported during the 1990 census (Schweizer Bauernverband, 1993), when farms with less than 5 cows were included.

4.4. Disease incidence

Every new occurrence of individual events within the categories calf diseases, udder diseases, lameness, metabolic disorders and diseases of the digestive tract was considered independent from repeated events of the same type. This assumption may not be valid for some diseases, for example, udder diseases, where repeated events of the same disease are likely to be dependent. The same procedure would have been preferable for reproductive disorders, but it was recognised during data collection that it was difficult for farmers and even veterinarians to reduce the clinical signs of the cow to a single diagnosis code. In some instances, cows were diagnosed with different diseases of the same category within a short period. Therefore, it was decided to use only the first event diagnosed within this category for incidence estimation.

The definition of the beginning and the end point of the period at risk for ID calculation is another possible source of bias (Bendixen, 1987). The seven broad disease categories included diseases with different potential risk periods. Therefore, the entire observation time of every animal was considered as potential time at risk for all categories, except for reproductive disorders. Also, valid definitions for the recovery periods for the different diseases were not readily available. Even if they had been available, they would not have been applicable to broad disease categories including diseases with different recovery periods. Furthermore, if recovery periods had been used, incidence of other diseases but from the same category during that interval would have been missed. The approach we used was employed before in similar studies (for example, Hurd and Kaneene, 1990). It is likely to result in underestimation of true ID as the time at risk was increased.

The risk period for reproductive disorders was defined as the time between the date of previous calving and conception, or occurrence of the first reproductive disorder. In most cases it was not possible to obtain the date of conception, because pregnancy

Table 6
Comparison of disease incidences in dairy cows from different countries (ID per 100 animal-years)

Region	Reproductive disorders	Udder diseases	Calving disorders	Lameness	Metabolic disorders	Diseases of digestive tract	Source
Switzerland	152.2	40.5	8.9	16.4	11.6	7.2	Our study
Michigan	49.9	33.1	13.8	6.6	10.2	7.3	Kaneene and Hurd, 1990
United Kingdom	NR	42	NR	30	NR	NR	Chamberlain and Wassell, 1995
Pakistan	59.2	43.6	12.4	7.6	NR	35.7	Akhtar and Ali, 1994

[a] NR = not reported.

checks were not a standard procedure. The date of last insemination was then used as an estimate of the conception date.

A comparison of the results with other published data is presented in Table 6. Udder diseases and reproductive disorders were the most important disease categories identified in this study. This is in accordance with figures reported earlier for Switzerland (Danuser et al., 1988). The difference in the figures for disease incidence for reproductive disorders between our study and earlier reports are caused by the limited 'time at risk' period we used. Data from NAHMS in Michigan (Kaneene and Hurd, 1990) showed the same order of importance between disease categories and similar estimates, except for lameness (6.6) which appears to be more frequent in Switzerland (16.4). In Pakistan (Akhtar and Ali, 1994), reproductive and udder disorders were also the most frequent diseases. Problems of the digestive tract ranked third in that country, possibly due to insufficient feed quality. In the UK (Chamberlain and Wassell, 1995), udder problems have the same importance as in the other countries, but more cases of lameness have been observed.

5. Conclusion

The study has shown that an intensive in-farm data recording scheme is technically feasible and can provide internally consistent data about farm management. Farmers seem to be willing to collaborate in such projects provided they are offered either informational or monetary compensation for their contributions. Personal contact appears to be essential to maintain motivation. The cost of such a study depends on the number of farms involved, the travel distances and the personnel responsible for data collection and analysis. It was possible to closely monitor 113 farms with two full-time veterinarians. Therefore, this technique will be limited in applicability when used in large, sparsely populated countries. For Switzerland, it seems to be a feasible system that can be used to document health status. It is planned to perform similar surveys for other livestock species and to repeat the dairy cattle survey in the future. On-farm collection of individual animal health data is often time-consuming, but necessary to accurately estimate disease incidence measures.

Our study has shown that reproductive disorders and udder problems are the most frequent diseases in Swiss dairy cows. Further analysis to identify risk factors can help contribute towards economically efficient dairy farming in Switzerland.

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