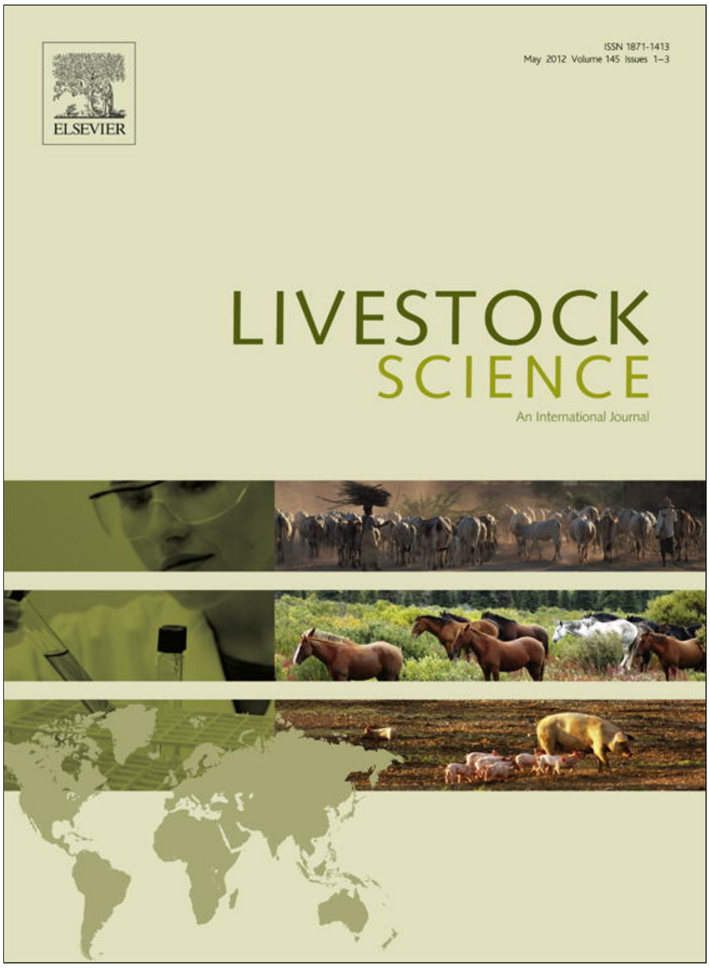
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Impact of animal health and welfare planning on medicine use, herd health and production in European organic dairy farms

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ABSTRACT

Achieving and maintaining high herd health and welfare status and low veterinary medicine inputs are important aims in organic livestock farming. Therefore, an on-farm intervention study (CORE Organic ANIPLAN) was conducted on 128 organic dairy farms in seven European countries aiming at minimising medicine use through animal health and welfare planning (AHWP). Medicine use (excluding complementary treatments such as homeopathic remedies) was assessed as the total number of treatments and as the number of treatments of various disease categories (udder, fertility, metabolism, locomotion and others) generated from farm records and national databases, respectively. Health and production data were calculated at farm level from milk recording data: Somatic cell score (SCS) was used as an indicator for udder health, incidences of low (<1.1) and high (>1.5) fat–protein ratio as indicators of rumen acidosis and imbalanced energy supply, respectively. Calving interval was used as an indicator for fertility. Milk recording data and treatment data were retrospectively collected for a one year period before and after the first farm visit. Focus areas of animal health and welfare plans were either generated in Stable Schools (adapted Farmer Field Schools) or using face-to-face advice but following similar principles. Most frequently chosen focus areas were metabolic disorders (66% of farms), udder health (58%), lameness (47%), and fertility (39%). General linear models for repeated measures were used to analyse the development at the farm level. The total number of treatments, the number of udder treatments and the number of metabolic treatments were all significantly reduced during the one year study period, whilst the number of treatments of lame cows increased. With the exception of SCS, which improved significantly, the other health indicators remained stable. Milk yield and average lactation number also remained unchanged. Choice of different focus areas had no significant effects on the corresponding treatment and

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health variables except for indication of rumen acidosis; for the latter situation on farms with an AHWP focus on metabolic issues improved, but this was not the case across all farms. Overall, the implementation of AHWP reduced total treatment incidence and improved the udder health situation across all farms regardless of the focus areas in the AHWP. Hence, AHWP can be regarded as a feasible approach to minimising medicine use without the impairment of production and herd health under several organic dairy farming conditions in Europe.

1. Introduction

Achieving and maintaining high herd health and welfare status and low veterinary medicine inputs are important aims in organic livestock farming (Hertzberg et al., 2003) and the concept of 'positive health and welfare' has been incorporated in EU Regulation 834/2007 concerning organic production as well as in the International Federation of Organic Agriculture Movements (IFOAM) principle of health (Hansen and Sjouwerman, 2007). Preventive application of allopathic drugs and antibiotics is not permitted but the use of chemically synthesised allopathic veterinary medicinal products or antibiotics to avoid animal suffering is possible according to the EU organic farming regulations. When allopathic medicines are used, withdrawal periods for organic products are twice the legal withdrawal periods (CEC, 1999). In Europe, as well as in the USA, the amount of antimicrobial drugs used per animal on organic dairy farms is lower than in conventional farms (Bennedsgaard et al., 2010; Pol and Ruegg, 2007; Zwald et al., 2004). Antimicrobial drugs for dairy cows are primarily used for mastitis treatments during lactation and as end of lactation 'drying-off' treatments (Menéndez Gonzalez et al., 2010).

Public concerns about drug use in animal food production, resistance to antibiotics and residues in food as well as in the environment have generally increased during the last decades (Refsdal, 2000) and awareness has risen especially in consumers of organic products (Stolz et al., 2009; van Wijk-Jansen et al., 2009).

To develop sustainable dairy production—particularly organic dairy production—it is essential to establish concepts which aim at minimizing medicine use whilst ensuring or improving herd health and its management. Studies in Norway, Denmark and Switzerland have shown that antibiotic udder treatments may be reduced without apparent negative effects on production and udder health status (Bennedsgaard et al., 2010; Ivemeyer et al., 2008; Østerås and Sølverød, 2009). Published information on treatment incidence of other health conditions on organic dairy farms as well as studies across countries is generally scarce. The EU network project 'Sustaining Animal Health and Welfare in Organic Farming' (SAFO; http://www.safonetwork.org) recommended the implementation of farm specific animal health plans to reduce medicine input and improve health and welfare in organic livestock farming (Vaarst, 2001). Experiences in the UK show that in order to be effective an animal health plan must become a dynamic document to be used as a farm management tool (Atkinson and Neale, 2008). Based on approaches developed in earlier studies and the Welfare Quality® project (Ivemeyer et al., 2007; March et al., 2008a; Vaarst et al., 2007; WelfareQuality®Consortium, 2009; Winckler et al., 2007) a set of principles for animal health and welfare planning (AHWP) processes have been further developed in the European research project CORE Organic ANIPLAN (Vaarst et al., 2010). These include: (1) aim at continuous development and improvement, (2) health promotion and disease handling based on a strategy including investigation of current status and indications (animal based and resource based parameters), evaluation, action and review. The process should (3) be farm specific, (4) guarantee farmer ownership, (5) involve external persons and external knowledge, (6) agree to organic principles, (7) acknowledge good aspects and (8) include a written plan based on the farmer's conclusions or action points.

So far, intervention studies on health improvement in organic dairy farming have mainly be concerned with evaluating udder health (Bennedsgaard et al., 2010; Green et al., 2007; Ivemeyer et al., 2008; Vaarst et al., 2007). Regarding other herd health issues, for example lameness (March et al., 2008b), or general use of AHWP (Brinkmann et al., 2009), few intervention studies have been conducted. A gap in knowledge exists concerning general effects of health and welfare planning on the health status and medicine use in organic dairy herds. The aim of this study was to describe herd health, production and treatment incidences in European organic dairy herds across a range of countries and to evaluate the effect of AHWP on health, production and medicine use after one year.

2. Materials and methods

2.1. Project framework and study design

The ANIPLAN project was conducted from 2008 to 2010. 128 certified organic dairy farms in seven European countries were involved in the study: 15 farms in Denmark (DK), six farms in Norway (NO), 10 farms in the Netherlands (NL), 15 farms in the United Kingdom (UK), 28 farms in Germany (DE), 39 farms in Austria (AT) and 15 farms in Switzerland (CH). The conceptual framework for the wider ANIPLAN project is described in Vaarst and Roderick (2008).

2.2. Selection of farms

Recruiting of organically-certified farms was performed by representatives from participating countries. In some countries farms were selected from existing extension and intervention herd health networks, such as the 'pro-Q' project in Switzerland (Ivemeyer et al., 2008), a dairy project in the Netherlands (Smolders and Wagenaar, 2009) and an intervention study on lameness in Germany (March et al., 2008a). Farms in the United Kingdom were recruited from a cohort associated with a dairy marketing cooperative. Norwegian farms were mainly recruited through personal contact. Austrian and Danish farms were contacted from a membership list of a national organic farming association or organic producer group respectively. There were no significant differences in health and medicine use between farms which had previously been involved in an intervention or advisory study before the ANIPLAN project and farms which had not. For farms in all countries except the UK milk recording data for at least one year previous to the project start had to be available. All farms participated voluntarily and agreed to take part in a herd health and welfare planning process.

2.3. Data sampling

For the collection of health and welfare data farms were visited twice in an interval of one year. All on-farm assessments were conducted during the winter housing period. For treatment records and milk recording data two periods were defined for analysis: year 0 being the period of 365 days before the first visit including the day of the first visit (Y0); year 1 containing the 365 days following the first visit (Y1). The farm was the unit for all analyses. In each country one to four researchers had been trained in data collection and assessments of animals (e.g. body condition score, lying behaviour, agonistic behaviour, cleanliness, injuries and lameness). Methods used for welfare assessment had been developed by the WelfareQuality®Consortium (2009); the assessment of management and housing was based on Ivemeyer et al. (2009).

2.4. Treatment data

The sources of treatment data differed between countries: Data from AT, DE, NL, UK and CH were derived from farm records and veterinary bills, respectively, whereas data from DK and NO originated from national central databases (Olsson et al., 2001; Stege et al., 2003). All treatments with antimicrobials, antiparasitics, hormones for treatment of fertility disorders, corticosteroids, non-steroidal anti-inflammatory drugs (NSAIDs) and infusions for treatment of metabolic diseases were included in the analyses. Treatments belonging to complementary medicine (such as phytotherapy or homeopathy) as well as physical treatments by veterinarians or farmers (e.g. foot trimming) were not included in the analyses, since recordings of these treatments were regarded highly variable and unreliable. A course of treatment connected to the same diagnosis was counted as one treatment if not interrupted for longer than seven days. Treatments per farm were reported as total of cases per cow and year. The number of cows per farm (NCOWS) was calculated as the mean over one year based on milk recording data (e.g. if 11 measurements per year and on average 6–8 weeks dry period: number of single measurements / 9). Treatments were allocated to different categories of disorders consisting of udder (tm_udder; including lactation and dry off therapies), lameness (tm_lameness; including degenerative and inflammatory claw and leg diseases), metabolic and digestive disorders (tm_metabolic; including milk fever, ketosis and digestive disorders), fertility related problems (tm_fertility; including parturition problems, retained placenta, endometritis, ovarian cysts and lack of heat) and others (tm_others; particularly including respiratory tract disorders, trauma, specific infections and parasites). Treatment data were not available from two farms in AT.

2.5. Health and production indicators from milk recording data

Information about udder health, indication of metabolic disorders, fertility, average lactation number, herd size and milk yield were gained from milk recording data. This information was available for all investigated farms, except UK farms, from Y0 and Y1. For this reason UK farms were excluded from analyses with variables based on milk recording data. In AT, CH, DE, DK and NL eleven milk recording measurements per year were conducted. In NO milk protein and fat content as well as cow somatic cell count (CSCC) were measured five to six times a year, while milk yield was measured ten to twelve times a year. Milk recording data were obtained from national central databases (DK, NO) or from private milk recording or breeding organizations (AT, CH, DE, NL).

Mean daily milk yield (DMY), lactation number (LN), milk fat (FAT%) and protein (PROT%) content were calculated at a farm level as means from all individual cows' test day measurements for Y0 and Y1, respectively. Udder health was described per herd and year as mean somatic cell score (SCS; = mean of all ($\log_2$ (CSCC/100,000) + 3) per year; Wiggans and Shook, 1987).

Concerning the indication of metabolic disorders, thresholds for milk composition data were applied and the percentage of measurements beyond predefined thresholds was calculated. In all herds except those consisting of the Jersey breed, a fat–protein ratio (FPR) lower than 1.1 was used to identify indication of rumen acidosis (%lowFPR). A FPR higher than 1.5 was used to indicate imbalanced energy supply (%highFPR). In the five Jersey herds (one in NL and four in DK) the applied thresholds were: FPR < 1.3 as indication for rumen acidosis (%lowFPR) and FPR > 1.7 as indication of energy imbalance (%highFPR). The mean calving interval (CI) was calculated as mean of the number of days between successive calvings for all calvings that occurred during year 1.

2.6. Health and welfare planning process

Health and welfare data obtained during the first farm visit were fed back to the farmers by written reports using a benchmarking approach at national level. Based on these data all farms began an advisory process involving the production of an AHWP aiming at improving health and welfare and reducing medicine use (Vaarst et al., 2010). The advisory methods differed between countries but followed common principles as described above. In DE and AT a farm individual face-to-face process between advisor and farmer was conducted with at least one additional farm visit after the first assessment. In NL and NO farms, advice was given on the day of the first visit and later via phone and/or e-mail. Most of the farms in DK (9; 60%), CH (13; 87%) and UK (5; 83%) participated in Stable Schools (an adapted form of Farmer Field Schools focussing on farmer-to-farmer advice, Vaarst et al., 2007). Based on the data of the first assessment, farmers were encouraged to choose at least two farm specific focus areas for improvement. These focus areas were recorded in a written AHWP which also contained suggested measures. The focus areas were collected in a database with 160 predefined measures which enabled assessment and categorization of the advice and actions taken by individual farmers. The focus areas were allocated to the areas: udder health (fa_udder), metabolic diseases and nutrition (fa_metabolic), feed harvesting and conservation (fa_harvest), fertility (fa_fertility), lameness (fa_lameness), calf health (fa_calves), behaviour (fa_behaviour; e.g. comfort around resting, outdoor run) and others (fa_others;

e.g. mineral supplementation, water supply). Data on the AHWP process were not available from nine farms in the UK. These farms were excluded from the respective analyses.

2.7. Statistical analyses

All analyses were performed at the farm level. Normal distribution of raw data was evaluated graphically by normal-qq-plots. Data were analysed using general linear models for repeated measurements with changes of the repeated dependent variable from year 0 to year 1 as within-subject effect. For production measures (NCOWS, DMY, LN, FAT%, PROT%) and the total treatment incidence, country was included as a between-subject effect. For health data and treatment data allocated to disorders, the inclusion of the appropriate AHWP focus area (e.g. the health data for focus area on udder health was somatic cell score) was additionally considered as a between-subject effect. All interactions were maintained in the model calculations. The following model regarding the dependent variables allocated to certain disorders was applied:

$$y_{ijkl} = \mu + rep_{i(jkl)} + country_j + fa_k + rep_{i(jkl)} * country_j + rep_{i(jkl)} * fa_k + rep_{i(jkl)} * fa_k + rep_{i(jkl)} * country_j * fa_k + \varepsilon_{ijkl}$$

where y_{ijkl} = dependent health or treatment variable allocated to a disorder, μ = overall mean effect (intercept), $rep_{i(jkl)}$ = within-subject effect of changes of the repeated dependent variable from year 0 to year 1 *i(jkl)* (within-observation-unit), $country_j$ = between-subject effect of country *j*, fa_k = between-subject effect of focus area *k* in AHWP allocated to the same disorder and ε_{ijkl} = random residual *l* belonging to observation $y_{ijkl.}$ The three-way interaction between *rep*, *country* and *fa* as well as all corresponding two-way interactions and main effects were included in the model. Distribution of residuals was evaluated graphically using normal-qq-plots in order to test model assumptions. For all analyses, the level of significance was set at $\alpha = 0.05$. All statistical analyses were carried out using PASW Statistics 18 (IBM, SPSS, USA, 2009).

3. Results

3.1. Description of farms and herds

The number of farms per country varied from 6 in NO to 39 in AT (see Table 1). The smallest farm had 10 cows (CH), the largest farm 340 (UK). Mean herd size per country varied from 21 cows in NO to 192 cows in the UK. Average milk yield was about 19.3 kg per cow per day in CH and highest in DK with 24.1 kg. Milk fat percentage ranged from 4.04% in CH to 4.61% in DK and protein content ranged from 3.34% to 3.70% in CH and NL, respectively. Average lactation number was highest in CH (3.7 lactations) and lowest in Norway (2.3 lactations). More detailed descriptive information reflecting herd sizes and production data of investigated herds are shown in Table 1.

Investigated herds consisted of several purebred breeds and crossbreds. In AT the predominant breed was Austrian Fleckvieh. In CH the main breeds were Brown Swiss and Swiss Fleckvieh. In DE, NL and UK the predominant breed was Holstein Friesian (HF). In DK most farms had HF cows and four farms kept pure Jersey (JE) herds. In NO all herds had Norwegian Red (NR).

3.2. Description of status of herd health and medicine use

Health data based on milk recording data and treatment incidences during the project year (Y1) and the preceding year (Y0) within each country are shown in Tables 2 and 3, respectively. Average baseline SCS (Y0) ranged between countries from 2.42 in NO to 3.47 in DE. The number of samples with %lowFPR ranged from 11.1% in DE to 42.7% in NO. The number of %highFPR in DE was 16.9% in Y0, while in all other countries it was below 10%. Inter-calving period ranged from 364 days in NO to 420 days in NL while both countries had a very low incidence of fertility treatments. The total number of treatments ranged in Y0 from 0.35 treatments per cow and year in NO to 1.14 treatments per cow and year in UK. The highest treatment incidence for a particular health condition across all countries was for treatments associated with udder health. The category ‘other’ medical treatments was of relevance only in UK, due to the treatment of parasites in cows.

3.3. Description of focus areas in the health and welfare planning process

The main focus areas chosen by the farmers related to metabolic disorders and udder health. The frequencies of the focus areas chosen, differentiated by categories and countries, are shown in Table 4.

3.4. Development of production, health and treatment data after one year of health and welfare planning

Herd sizes (NCOWS) increased significantly from Y0 to Y1 (factor rep) but at different rates for different countries (significant interaction rep*country; Table 5). Mean LN, DMY and PROT% did not change from Y0 to Y1 across countries. Fluctuations in FAT% depended on the country (interaction of rep*country, Table 5); it decreased in CH and DE, whereas it increased in all other countries.

SCS decreased significantly from Y0 to Y1. Other herd health variables did not change across countries. Regarding %lowFPR there was no overall effect of planning (factor rep, Table 5), but when metabolic issues had been included in the AHWP (fa_metabolic), farms had less %lowFPR (indication of acidosis). There was no specific effect of focus area on any other health variables.

Medicine use (treatment incidences) decreased significantly for total treatment incidence as well as in the area of udder treatments and treatments of metabolic diseases (factor rep, Table 6). Lameness treatments increased slightly (Table 3) but significantly (Table 6). Except metabolic treatments (tm_metabolic), level of treatment incidences (in total and per category) differed significantly between countries (factor country, Table 6). Farms which included udder health in their AHWP had a significantly higher level of SCS than other farms. No significant specific effect of focus area on the change of related treatment incidences (interaction rep*focus area) was determined (Table 6).

Table 1
Herd size (mean, min–max), daily milk yield, milk fat and protein content and lactation number (mean, standard deviation [sd]) during the year before (Y0) and after (Y1) initial farm visit.

CC (n farms)		NCOWS (n)		DMY (kg)		FAT% (%)		PROT% (%)		LN (n)	
		Y0	Y1	Y0	Y1	Y0	Y1	Y0	Y1	Y0	Y1
AT (39)	Mean	38	40	22.5	22.2	4.19	4.20	3.44	3.43	3.2	3.3
	± sd	19–62	19–61	2.9	3.0	0.22	0.21	0.14	0.13	0.6	0.5
CH (15)	Mean	29	29	19.3	18.9	4.04	3.97	3.34	3.33	3.7	3.6
	± sd	12–73	10–73	3.2	2.9	0.19	0.21	0.14	0.15	0.5	0.6
DE (28)	Mean	66	69	22.1	22.1	4.42	4.28	3.37	3.32	3.1	3.0
	± sd	33–158	32–168	3.5	3.5	0.20	0.19	0.09	0.11	0.6	0.6
DK (15)	Mean	119	125	24.1	24.1	4.61	4.75	3.59	3.63	2.5	2.6
	± sd	56–184	56–182	3.5	5.1	0.75	0.82	0.28	0.34	0.3	0.3
NL (10)	Mean	73	75	20.6	20.8	4.56	4.64	3.70	3.71	3.2	3.1
	± sd	39–151	40–170	3.2	3.6	0.62	0.61	0.22	0.24	0.4	0.5
NO (6)	Mean	21	22	21.3	20.6	3.98	4.20	3.50	3.47	2.3	2.3
	± sd	13–27	13–29	2.8	1.5	0.65	0.37	0.10	0.08	0.2	0.3
UK (15)	Mean	192	201	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	± sd	75–340	75–338								
Total (113[a])	Mean	57[a]	60[a]	22.0	21.8	4.30	4.30	3.45	3.44	3.1	3.1
	± sd	12–184	10–182	3.4	3.7	0.44	0.46	0.19	0.22	0.6	0.6

[a] Without UK farms because of missing milk recording data; n.a. = not available; NCOWS = herd size, DMY = average daily milk yield, PROT% = average milk protein content, FAT% = average milk fat content, LN = average lactation number; Y0 = period of 12 months before initial farm assessment, Y1 = period of 12 months after initial assessment

4. Discussion

4.1. Study design and choice of variables

The European project ANIPLAN with participants from seven countries (Austria, Switzerland, United Kingdom, Norway, Netherlands, Germany and Denmark) was established with the aim of minimizing medicine use in organic dairy herds through animal health and welfare planning (AHWP). The project aimed at monitoring the effectiveness of implementing AHWPs that were based on organic principles, were farm specific yet relevant for different farming conditions. Regarding the implementation of the AHWP, these were not standardized across all countries, but in Stable Schools (see Vaarst et al., 2007) as well as in direct advisor–farmer communication common AHWP principles, as described by Vaarst et al. (2010), were followed in all countries.

In most countries, the selected farms were not necessarily representative of the situation on all organic farms in each country, but the data reflect the various farm conditions across the participating European countries (e.g. from larger scale highly specialized high output production in Denmark and United Kingdom to alpine farming in Switzerland and Austria, as well as small-scale farms in Norway). Test-day information data can be considered comparable across countries since the analysed farms were participating in regular milk recording schemes.

SCS is a well-established measure to describe udder health by a normally-distributed variable (Wiggans and Shook, 1987). The use of a low fat–protein ratio (<1.1 for all breeds except Jersey) as an indication of potential acidosis problems on herd level is based on results from Bramley et al. (2008). The authors stated that the fat–protein ratio (FPR) is mainly influenced by low fat%-values, but discrimination between groups of cows with acidosis and healthy cows was more distinct using FPR. A high FPR can be considered as a suitable indicator for energy status. In particular, a FPR > 1.5 has been suggested as an indicator for abnormally high lipolysis in Holstein Friesian cows (Buttchereit et al., 2010; Heuer et al., 2000). Prediction of energy imbalance by FPR has been determined as more precise than by low protein content (Heuer et al., 2000). Comparable thresholds of fat–protein ratios of <1.0 indicating risk of acidosis and of >1.5 indicating risk of imbalanced energy supply, respectively, are used as farm management tools delivered with test day information from the Dutch breeding company CR-Delta (CR-Delta, 2010). Due to an absence of published thresholds for FPR in Jersey cows, these were extrapolated from lactation curves provided by Friggens et al. (2007). Friggens et al. (2007) regard the use of single milk composition measures to predict energy balance as less precise but suggest using a combination of several milk component variables. However, in the present study

Table 2
Somatic cell count, prevalence of low and high fat–protein ratio and calving interval as health indicating parameters based on milk recording data (mean, standard deviation [sd]) during the year before (Y0) and after (Y1) initial farm visit.

CC (n farms)		SCS		%lowFPR		%highFPR		CI	
		Y0	Y1	Y0	Y1	Y0	Y1	Y0	Y1
AT (39)	Mean	2.80	2.79	26.1	25.0	9.1	10.2	395	397
	± sd	0.61	0.58	11.8	11.7	6.9	8.3	30	27
CH (15)	Mean	2.75	2.63	23.9	27.7	6.5	5.0	387	380
	± sd	0.53	0.57	9.3	10.5	6.4	4.5	26	21
DE (28)	Mean	3.47	3.40	11.1	13.1	16.9	13.6	404	407
	± sd	0.52	0.55	7.4	9.4	11.2	8.7	21	23
DK (15)	Mean	3.35	3.33	20.8	17.7	5.8	5.6	401	403
	± sd	0.16	0.26	10.3	7.9	2.6	2.9	19	22
NL (10)	Mean	3.29	3.11	23.7	22.2	5.0	6.5	420	404
	± sd	0.48	0.55	10.2	8.3	2.1	3.7	26	25
NO (6)	Mean	2.42	2.41	42.7	31.0	8.7	11.5	364	380
	± sd	0.36	0.26	24.6	13.1	10.7	8.1	13	12
Total (113[a])	Mean	3.06	3.00	22.3	21.7	9.5	9.3	398	398
	± sd	0.61	0.61	13.3	11.6	7.9	7.5	27	25

SCS = somatic cell score, %lowFPR = prevalence of low fat–protein ratio, %highFPR = prevalence of high fat–protein ratio; CI = calving interval; Y0 = period of 12 months before initial farm assessment, Y1 = period of 12 months after initial assessment.

[a] UK data not available for these parameters.

Table 3
Treatment incidences per cow and year (total as well as for categories of udder, lameness, metabolic, fertility and other disorders: median [med], min–max [range] during the year before (Y0) and after (Y1) initial farm visit.

CC (n farms)		tm_all		tm_udder		tm_lameness		tm_metabolic		tm_fertility		tm_others	
		Y0	Y1	Y0	Y1	Y0	Y1	Y0	Y1	Y0	Y1	Y0	Y1
AT (37)	Med	0.74	0.50	0.44	0.37	0.00	0.00	0.03	0.02	0.08	0.03	0.02	0.00
	Range	0.04–1.50	0.00–1.70	0.00–1.17	0.00–1.29	0.00–0.21	0.00–0.51	0.00–0.27	0.00–0.19	0.00–0.54	0.00–1.07	0.00–0.11	0.00–0.20
CH (15)	Med	0.39	0.33	0.10	0.10	0.00	0.01	0.05	0.00	0.06	0.10	0.00	0.04
	Range	0.09–1.04	0.00–0.58	0.00–0.30	0.00–0.22	0.00–0.06	0.00–0.10	0.00–0.18	0.00–0.14	0.00–0.62	0.00–0.33	0.00–0.13	0.00–0.10
DE (28)	Med	0.92	0.92	0.48	0.48	0.03	0.07	0.09	0.09	0.18	0.20	0.00	0.01
	Range	0.16–3.13	0.14–2.30	0.00–1.37	0.00–1.01	0.00–0.70	0.00–0.45	0.00–0.50	0.00–0.49	0.00–1.06	0.00–1.02	0.00–0.12	0.00–0.11
DK (15)	Med	0.49	0.47	0.18	0.16	0.06	0.06	0.11	0.09	0.06	0.06	0.02	0.01
	Range	0.30–1.13	0.18–0.90	0.06–0.64	0.03–0.64	0.00–0.25	0.00–0.27	0.02–0.19	0.00–0.22	0.00–0.23	0.00–0.21	0.00–0.44	0.00–0.09
NL (10)	Med	0.52	0.42	0.32	0.11	0.00	0.00	0.12	0.07	0.02	0.03	0.00	0.01
	Range	0.13–2.78	0.36–1.74	0.00–1.98	0.00–1.02	0.00–0.03	0.00–0.08	0.00–0.66	0.00–0.26	0.00–0.50	0.00–0.44	0.00–0.58	0.00–0.12
NO (6)	Med	0.35	0.35	0.08	0.17	0.00	0.04	0.08	0.12	0.00	0.00	0.00	0.00
	Range	0.08–0.59	0.22–1.06	0.00–0.37	0.00–0.21	0.00–0.27	0.00–0.55	0.07–0.14	0.06–0.18	0.00–0.09	0.00–0.08	0.00–0.04	0.00–0.08
UK (15)	Med	1.14	0.92	0.47	0.48	0.09	0.10	0.06	0.05	0.14	0.17	0.13	0.09
	Range	0.19–2.54	0.12–2.91	0.02–1.02	0.01–1.94	0.00–0.44	0.02–0.86	0.01–0.41	0.00–0.33	0.00–0.84	0.00–0.60	0.01–0.97	0.01–1.63
Total (126)	Med	0.68	0.50	0.31	0.25	0.02	0.02	0.07	0.05	0.08	0.08	0.01	0.02
	Range	0.04–3.13	0.00–2.91	0.00–1.98	0.00–1.93	0.00–0.70	0.00–0.85	0.00–0.66	0.00–0.49	0.00–1.06	0.00–1.07	0.00–0.97	0.00–1.63

CC = country code; tm_… = treatment incidences per cow and year in category of…; Y0 = period of 12 months before initial farm assessment, Y1 = period of 12 months after initial assessment.

conducted over several countries, it was only practical to gather standardised easily obtainable health variables. The use of calving interval as a measure of fertility at the herd level is feasible and reliable because this information was gained through milk recording data and was available across all countries except UK. Nevertheless, the calving interval parameter has the disadvantage that only pluriparous cows are represented and the information on cows that did not conceive is not included. This may bias the data towards cows that survive and likely are healthier than those that have been culled. However, this potential bias would be similar in both years and therefore not affect changes due to the AHWP intervention.

Treatment data can be regarded as less exact than milk recording data and there are likely to be variations between farms in the quality of treatment recording by farmers and veterinarians (Menéndez Gonzalez et al., 2010). Consequently, there is a risk that the true treatment incidences in some herds may be underestimated. This may especially be the case for the baseline data (Y0) and awareness of the importance of proper treatment records may have improved through the project activities. However, since farms served as their own controls, differences in quality of records between farms are less likely to affect the analysis. On the contrary, more accurate and complete records in Y1 would rather underestimate a potential reduction effect with regard to medicine use. Regarding the different categories of veterinary drugs, no differences in quality of farm records, especially for drugs with withdrawal period, were expected. Treatment data from the central databases in Scandinavian countries can probably be considered as more reliable than individual farm recordings. Treatment data were assessed as treatments per cow and year and not as defined daily doses (Menéndez Gonzalez et al., 2010) as the information reflecting drug quantity and duration of treatments was not available in all cases. Furthermore, defined daily doses are usually used in veterinary research for analysis of antimicrobial use only (Jensen et al., 2004).

Table 4
Number (percentage) of farms per country with different focus areas (fa) in the animal health and welfare plan.

CC (n farms)	fa_udder	fa_lameness	fa_metabolic	fa_harvest	fa_fertility	fa_calves	fa_behaviour	fa_other
AT (39)	30 (77%)	28 (72%)	32 (82%)	3 (8%)	16 (41%)	6 (15%)	16 (41%)	4 (10%)
CH (15)	5 (33%)	1 (7%)	4 (27%)	3 (20%)	4 (27%)	1 (7%)	6 (40%)	6 (40%)
DE (28)	19 (68%)	13 (46%)	27 (96%)	1 (4%)	17 (61%)	16 (57%)	1 (4%)	4 (14%)
DK (15)	4 (27%)	5 (33%)	3 (20%)	0 (0%)	1 (7%)	6 (40%)	8 (53%)	7 (47%)
NL (10)	4 (40%)	2(20%)	7 (70%)	0 (0%)	2 (20%)	0 (0%)	6 (60%)	4 (40%)
NO (6)	3 (50%)	5 (83%)	3 (50%)	2 (33%)	4 (67%)	4 (67%)	6 (100%)	5 (83%)
UK (6)	4 (67%)	2 (33%)	2 (33%)	0 (0%)	2 (33%)	4 (67%)	1 (17%)	2 (33%)
Total (119)	69 (58%)	56 (47%)	78 (66%)	9 (8%)	46 (39%)	37 (31%)	44 (37%)	32 (27%)

CC = Country code; fa_… = focus area of… in animal health and welfare plan.

Table 5
Effects of changes between years (rep), country and their interaction on the production variables as well as the effects of rep, country, focus area (if a related area was chosen in the health and welfare plan) and their interactions on the respective health variables.

Variable (n farms)	Factor	Effect level	DF	F	*P*	Effect direction for significant factors
Production						
NCOWS	Rep	Within	1	17.42	<**0.001**	Y0<Y1
(128)	Country	Between	6	43.14	<**0.001**	
	Rep*country	Within	6	2.99	**0.009**	In all countries: Y0<Y1
LN	Rep	Within	1	0.11	0.747	
	Country	Between	5	11.31	<**0.001**	
(113)	Rep*country	Within	5	0.58	0.716	
DMY	Rep	Within	1	1.09	0.299	
	Country	Between	5	4.21	**0.002**	
(113)	Rep*country	Within	5	0.42	0.833	
PROT%	Rep	Within	1	0.55	0.460	
	Country	Between	5	11.24	<**0.001**	
(113)	Rep*country	Within	5	2.04	0.079	
FAT%	Rep	Within	1	2.88	0.092	AT, DK, NL, NO: Y0<Y1 CH, DE: Y0>Y1
	Country	Between	5	6.89	<**0.001**	
(112)	Rep*country	Within	5	6.70	<**0.001**	
Health						
SCS	Rep	Within	1	5.58	**0.020**	Y0>Y1
	Country	Between	5	10.39	<**0.001**	
	fa_udder	Between	1	3.56	0.062	
	Rep*fa_udder	Within	1	1.42	0.237	
	Rep*country	Within	5	0.80	0.554	
	Country*fa_udder	Between	5	0.79	0.560	
(113)	Rep*country*fa_udder	Within	5	1.72	0.137	
%lowFPR	Rep	Within	1	1.19	0.279	
	Country	Between	5	3.53	**0.006**	
	fa_metabolic	Between	1	0.15	0.697	Yes: Y0>Y1; no: Y0<Y1
	Rep*fa_metabolic	Within	1	7.10	**0.009**	
	Rep*country	Within	5	7.67	<**0.001**	AT, DK, NL, NO: Y0>Y1 CH, DE: Y0<Y1
	Country*fa_metabolic	Between	5	4.67	**0.001**	AT,DE,DK: yes<no; CH,NL,NO: yes>no
(112)	Rep*country*fa_metabolic	Within	5	2.93	**0.016**	
%highFPR	Rep	Within	1	0.36	0.548	
	Country	Between	5	1.01	0.415	
	fa_metabolic	Between	1	0.02	0.900	
	Rep*fa_metabolic	Within	1	1.03	0.314	
	Rep*country	Within	5	0.87	0.503	
	Country*fa_metabolic	Between	5	1.19	0.320	
(112)	Rep*country*fa_metabolic	Within	5	1.06	0.389	
CI	Rep	Within	1	0.10	0.752	
	Country	Between	5	4.17	**0.002**	
	fa_fertility	Between	1	1.99	0.161	
	Rep*fa_fertility	Within	1	0.67	0.415	
	Rep*country	Within	5	1.44	0.216	
	Country*fa_fertility	Between	5	1.06	0.389	
(113)	Rep*country*fa_fertility	Within	5	0.63	0.680	

Within = within subject effects; between = between-subject effects; rep = changes of the repeated dependent variable from Y0 to Y1; fa_… = focus area of… in health and welfare plan; Y0 = period of 12 months before initial farm assessment, Y1 = period of 12 months after initial assessment; tm_… = treatment incidences per cow and year in category of…; NCOWS = herd size, LN = average lactation number, DMY = average daily milk yield, PROT% = average milk protein content, FAT% = average milk fat content, SCS = somatic cell score, %lowFPR = prevalence of low fat–protein ratio, %highFPR = prevalence of high fat–protein ratio; CI = calving interval; *P*-values <0.05 are emphasised in bold.

4.2. Production parameters, health indicators and treatment incidences

Average daily milk yield estimates from the project farms fell within the range between the mean of 20.6 l/day in Swiss organic farms (Bielfeldt et al., 2004; Ivemeyer et al., 2008) and 23.7 l/day in Danish organic farms (Bennedsgaard et al., 2003). The average lactation number in project farms (3.1 lactations) was lower than the general in Swiss organic dairy farms with 3.28 lactations (Ivemeyer et al., 2008) and higher than the mean of organic farms in DK and NO with 2.5 and 2.98 lactations, respectively (Bennedsgaard et al., 2003; Hardeng and Edge, 2001).

With an average SCS of 3.06 in Y0 and of 3.00 in Y1 (a SCS of 3.0 meaning a backtransformed somatic cell count of 100,000 cells per ml) the project farms had a higher somatic cell count than average Swiss farms (2.69; n = 1674; Bielfeldt et al., 2004). The SCS of project farms at the beginning of the project was similar to the average annual SCS of 3.05 in 5210 dairy farms in France (Gay et al., 2007). Literature on FPR values on herd level is not known by the authors. Calving interval in organic herds was 388 days in Norway (Valle et al., 2007). In a Dutch study the average calving interval was about 403 days in organic dairy farms (Nauta et al., 2006), demonstrating that project farms ranged in the same order of magnitude regarding calving interval.

Table 6
Effects of changes between years (rep), country (and for specific health and treatment areas also the effect of the related focus area in the health and welfare plan) and their interactions on the treatment variables.

Variable (n farms)	Factor	Effect level	DF	F	*P*	Effect direction for significant factors
tm_all	Rep	Within	1	4.02	**0.047**	Y0 > Y1
(126)	Country	Between	6	6.81	< **0.001**	
	Rep*country	Within	6	0.80	0.569	
tm_udder	Rep	Within	1	7.98	**0.006**	Y0 > Y1
	Country	Between	6	5.33	< **0.001**	
	fa_udder	Between	1	4.10	**0.045**	Yes > no
	Rep*fa_udder	Within	1	0.48	0.491	
	Rep*country	Within	6	0.91	0.490	
	Country*fa_udder	Between	6	1.35	0.242	
(117)	Rep*country*fa_udder	Within	6	1.34	0.248	
tm_metabolic	Rep	Within	1	4.34	**0.040**	Y0 > Y1
	Country	Between	6	1.87	0.093	
	fa_metabolic	Between	1	0.17	0.679	
	Rep*fa_metabolic	Within	1	0.37	0.546	
	Rep*country	Within	6	1.31	0.259	
	Country*fa_metabolic	Between	6	0.91	0.489	
(117)	Rep*country*fa_metabolic	Within	6	0.69	0.656	
tm_fertility	Rep	Within	1	0.80	0.374	
	Country	Between	6	3.34	**0.005**	
	fa_fertility	Between	1	1.18	0.280	
	rep*fa_fertility	Within	1	0.33	0.569	
	Rep*country	Within	6	0.46	0.840	
	Country*fa_fertility	Between	6	1.74	0.119	
(117)	Rep*country*fa_fertility	Within	6	0.65	0.694	
tm_lameness	Rep	Within	1	3.98	**0.049**	Y0 < Y1
	Country	Between	6	3.58	**0.003**	
	fa_lameness	Between	1	3.49	0.065	
	Rep*fa_lameness	Within	1	0.04	0.852	
	Rep*country	Within	6	0.78	0.584	
	Country*fa_lameness	Between	6	1.49	0.188	
(117)	Rep*country*fa_lameness	Within	6	1.07	0.388	
tm_others	Rep	Within	1	0.08	0.777	
	Country	Between	6	8.72	< **0.001**	
(126)	Rep*country	Within	6	0.65	0.687	

Within = within subject effects; between = between-subject effects; rep = changes of the repeated dependent variable from Y0 to Y1; fa_… = focus area of… in health and welfare plan; Y0 = period of 12 months before initial farm assessment, Y1 = period of 12 months after initial assessment; tm_… = treatment incidences per cow and year in category of… ; *P*-values < 0.05 are emphasised in bold.

There are few previous studies available with regard to treatment incidences as obtained in the present study. Most studies focussed on antimicrobial drug use. A Swiss study with mainly conventional farms revealed 0.78 antimicrobial treatments per year in the area of udder, 0.08 in the area of lameness, and 0.19 in the area of fertility (Menéndez Gonzalez et al., 2010). These results point at a higher antimicrobial drug use in Swiss conventional farms than in the project farms. According to Bennedsgaard et al. (2010) the antimicrobial drug use in 118 Danish organic dairy herds in 2006 was 0.35 for udder treatments, 0.12 for metabolic treatments, 0.07 for lameness treatments and 0.10 for treatment of reproductive disorders. Thus, compared with the Danish treatment data in the present study from year 0, the data are in the same range for lameness and metabolic disorders, whereas project farms had a lower treatment incidence associated with udder health and fertility during year 0. On Norwegian project farms, treatment incidences for udder diseases (0.17 reported treatments per cowyear), metabolic diseases (0.08 treatments per cowyear) and fertility disorders (0.04 treatments per cowyear) are similar to those found in a study of 149 Norwegian organic dairy farms (Valle et al., 2007).

4.3. Development of health and medicine use

The total treatment incidence with allopathic veterinary drugs and the treatment incidences for both udder and metabolic diseases significantly decreased in the one year period following the first farm assessment compared to the previous 12-month period. These effects were independent of country of herd location. Taking into account, that treatment incidences in Y0 might be underestimated as explained above, these results might be rather more distinct. Regarding udder health, both the somatic cell score (SCS) improved and treatment incidences decreased.

Treatments of metabolic disorders were reduced while metabolic health variables such as high and low FPR remained constant. A possible explanation for this may be that the chosen thresholds for metabolic disorders were not precise enough. Especially in small herds, the prediction of energy imbalance from FPR is limited because of a higher standard deviation of herd means (Heuer et al., 2000).

Treatments of lameness were rare, but slightly increased within the project year although the total number of treatments decreased. A possible explanation for this development may be that awareness of lameness was raised through the assessment of lameness conducted as part of the wider study at the beginning of the project and thus farmers started to treat earlier or more frequently. Although lameness is a highly prevalent problem also in organic dairy farming (Brinkmann and Winckler, 2004; March et al., 2008b), initial treatment mostly consists of claw trimming and cows are only rarely treated using veterinary drugs unless lameness is caused by infectious agents (e.g. interdigital dermatitis, digital dermatitis).

Regarding fertility, treatment incidences for such conditions as metritis or ovarian dysfunction and intercalving period did not change significantly. This might be due to the fact that a large number of cows conceived in year 0, before the AHWP process started. Furthermore, some of the impact of fertility treatments may be expected and observed beyond the one year observation period.

As there were no control farms included in the study, the extent that general public discussion of medicine use (especially the use of antimicrobials) in farm animal production and the development of bacterial resistance influenced the results remains unanswered. In countries such as the Netherlands, with a substantial prevalence of MRSA (Methicillin-resistant *Staphylococcus aureus*) (Wagenaar and van de Giessen, 2009), this could have been influential through increased farmers' awareness resulting in a reduced treatments. The Dutch MARAN report (MARAN, 2009) and Smolders (2010) showed a decreasing use of antibiotics on Dutch conventional and organic dairy farms in 2009 compared to previous years. In Switzerland, with a very low prevalence of MRSA (Huber et al., 2010), the amount of veterinary antimicrobials sold has remained stable over recent years. There was a slight decrease of 3.2% in the amount of veterinary antimicrobials sold in 2009 whilst from 2006 to 2008 there was an increase of 7.1% (Büttner et al., 2009).

There was no specific effect of selected focus areas in the AHWPs on the development of related treatment incidences and health parameters, respectively. For FPR of <1.1 (as a predictor of rumen acidosis) only, fewer animals fell below this threshold on farms which had focussed on metabolic disorders in the AHWP process. The lack of other correlations between chosen focus area and related health and treatment variables could be explained by the fact that the project year 1 started immediately after the first visit and yet the focus areas became evident during a period between 0 and 10 months after the initial visit. For some farms, this period to the end of the monitoring (AHWP implementation) period may have been too short to record any intervention effects on related health and treatment parameters. For this reason, a period of two or three years implementation and monitoring after the introduction of the health planning and advisory period would have been interesting and useful to analyse specific effects. The early more unspecific improvements in health and treatment situation consequent of overall planning effects may be due to general farmers' motivation in voluntarily joining a project aiming at reduction of medicine use. Previous studies did not find significant improvements in somatic cell score earlier than after two project years when farmers had the explicit goal of improving udder health (Brinkmann et al., 2011; Ivemeyer et al., 2008; Ivemeyer et al., 2009). Green et al. (2007) achieved, after one year of extension in farms with major problems of clinical mastitis, a significant reduction of clinical mastitis cases. The extension project pro-Q showed a significant effect of udder health status for probability of improvement: the higher the baseline problem, the higher the probability of improvement one and two years after start of the extension process, respectively (Ivemeyer et al., 2008; Ivemeyer et al., 2009). The udder health status expressed as SCS was 2.77 in the pro-Q project (Notz et al., 2009). This may partly explain the short-term SCS improvement of ANIPLAN project farms which started with a mean SCS of 3.06.

The overall aim of reducing total veterinary medicine use through AHWP can be regarded as being achieved. This result supports previous udder health intervention studies which realized a reduction of the use of antibiotics (Bennedsgaard et al., 2010; Ivemeyer et al., 2008). Further longer term studies are required to investigate limits as to which medicine use can be reduced and whether it is possible to produce organic milk without the use of antimicrobials and other chemically synthesised allopathic veterinary medicinal products.

5. Conclusions

A reduction of medicine use (udder treatments, metabolic treatments and total number of treatments) in organic dairy herds was achieved within a time period of one year under different conditions across seven European countries. At the same time an improvement of udder health (SCS) and a stable situation in other health areas (metabolic disorders, fertility) was found, however regardless of the focus area in the AHWP. The AHWP process which was implemented on the farms may therefore be regarded a feasible approach to minimise medicine use without impairment of health, longevity and productivity under most European organic dairy farming conditions. However, further long-term studies are necessary to investigate effects of specific advice included in herd health and welfare plans.

Conflict of interest statement

The authors declare no conflict of interest.

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