Agronomy for Sustainable Development (2023) 43:55
https://doi.org/10.1007/s13593-023-00907-7

RESEARCH ARTICLE

How do work challenges interact with health management in dairy farms?

Vinciane Gotti[1,2] · Claire Manoli[1] · Benoît Dedieu[2]

Accepted: 20 July 2023 / Published online: 16 August 2023

Abstract

Herd health management is a critical issue for the future of dairy systems. The right combination of preventive and curative practices will depend on management system, level of work productivity, and self-sufficiency objectives, and will entail specific skills and work organizations. However, the combination of work dimensions and animal health management has rarely been explored in the literature on a livestock farming system scale. The *Grand Ouest* region of France spans a diverse array of livestock farming systems that can serve to design herd health management indicators, farming objectives and work arrangements, and explore their linkages. Here we ran semi-structured interviews on 10 dairy farms, analyzed the farmers' discourses, and built 7 variables and 25 modalities that, for the first time, cover three components, namely herd health, farming objectives and work arrangements, and we tested various associations between these variables. Our interview data confirms that consultants and veterinarians have a key role to play in building a pool of skills adapted to various types of health management system. Data suggests linkages between prevention measures, alternative or conventional curative interventions, and work-related parameters.

Keywords Dairy farms · Integrated management of animal health · Work · Skills

1 Introduction

Dairy farming is currently undergoing profound system-scale transformations driven by a cluster of factors tied to agroecological transition (Arrignon 2020), digitalization, societal expectations surrounding what livestock farming should be (letting animals graze for instance; Delanoue et al. 2018; Milne 2005), farmers' expectations surrounding flexibility and more free time (Sidot et al. 2005), and pressure from the downstream operators who are relentlessly pushing for higher cow and work productivity on farms (Hume et al. 2011). These profound transformations pose structural challenges to the sustainability of livestock farming and have led to diversification in dairy farming models (Fig. 1). This diversification is often thought of in terms of the dichotomy between:

small-scale self-sufficient extensive farming systems with low dairy productivity that meet societal demands for natural livestock farming

large-scale intensive farming systems that have adopted automated methods with large herds to gain in milk productivity, largely via the expression of high-level genetic potential (Pflimlin et al. 2009).

Between these two extreme models, each marked by technical implementation choices, lies an "agriculture of the middle" (Lyson 2008) that is geared to a wide range of possible technical choices but has so far been undersold and overlooked.

These socio-structural changes and competing agricultural models (agroecology *vs* sustainable intensification (Dedieu 2019; Gotti 2023)) have direct implications for work organization, defined as who is doing what. The "who" is becoming increasingly diverse (individuals or groups of farmers, family workers, contract workers). The "what" refers to the work tasks directly related to the combination of practices employed and the objectives of the work organization pursued to achieve a certain level of work productivity (which combines animal performance and animal numbers

✉ Claire Manoli
clairemanoli@gmail.com

[1] USC URSE, Groupe ESA, 49000, Angers, France

[2] UMR SELMET, INRAE, Cirad Institut Agro, Montpellier, France

Fig. 1 Three young farmers training with an advisor on the dairy health unit.

per worker) while also coping with other pressures on farm work, such as the farmer's multiple roles and responsibilities, expectations, and working conditions.

In this changing landscape, pressure to make farming systems more ecological is very much aimed at reducing inputs, and especially chemical inputs (FAO 2022). In dairy farming, this means chemical medicines, which essentially translates into cutting back on the use of antiparasitic drugs and antibiotics in an effort to adopt a more preventive and systemic approach known as "integrated management of animal health" (Fortun-Lamothe and Savietto 2022).

Studies on the integrated management of animal health have so far mostly been carried out on organic farms, as the integrated health concept is an important part of organic farming standards (Vaarst and Alroe, 2021) and "one health" or "eco health" philosophies (Zinsstag et al. 2011). Ecopathology is a long-standing epidemiological approach that has proposed some of the foundations for a systemic approach to livestock health that focuses on farmers' practices and the interactions between livestock and its environment, such as housing or milking parlors which are now shifting towards milking-robot mechanization (already equipping 10% of French dairy farms in 2020; Le Guern 2020). The systemic approach to livestock health encompasses the on-farm practices and operational decisions on livestock and resources and their interactions (notably feed) that together determine the system operation, starting with stimulation of the animal's biological functions.

Integrated management of animal health therefore looks at everything that comes into play within the livestock farming system. It covers the relationships between system configurations (Benigno et al. 2010), breeding practices, preventive medicine (Fortun-Lamothe and Savietto 2022) and the monitoring and treatment of animals for patterns of prevalent disease such as lameness, metabolic disease, and diarrhea in calves. It requires a specific set of skills at the intersection between livestock farmer, veterinarian and consultant (general practice or specialist, public or private), which can be in-house (through training) or partly outsourced (to veterinarians and other experts; Duval et al. 2017; Poizat et al. 2017; Raina et al. 2017). In the world of dairy farming, however, the reduction of veterinary drug inputs is being implemented at various different paces (Hellec and Manoli 2018) and the ways and means of integrated management differ widely from farm to farm (Fortané et al. 2015).

Here we investigate the consistency made by farmers without any "a priori" about the sense of the interrelations between the challenges facing dairy farming (chiefly work productivity) and the way farm operators organize a heterogeneous workforce ('who does what tasks') with integrated animal health and the skills it demands. We will discuss afterward the links between them.

While the literature does address the links between agricultural models and the place of health in a cohesive system (Dumont et al. 2013), few articles have explored the nexus of interactions between work pressure and productivity goals, agricultural models, system practices and technologies, skills and work organization, and how they intersect with the modalities of integrated management of animal health described above. We aim to analyze whether the knowledge produced enriches our understanding of farming system cohesiveness and diversity, in an effort to shed new light on 'integrated' health management.

2 Material and methods

2.1 Choice of the case study

The *Grand Ouest* region of France (northwest France) is a highly dynamic dairy farming area that features this diversity of production systems. The dynamics at play in the *Grand Ouest* region are driven by changes in socio-structural conditions that affect farmwork organization and the skills and working conditions of dairy farmers: ever-bigger herds (since the end of dairy quotas), the rise in collective farming and paid labor where one out of two farms has turned to using wage workers (Cahuzac and Détang-Dessendre 2011), fewer family-run farms and increasingly diverse farm households (e.g. a spouse working outside the home), and rising expectations for more vacation or leisure time (Seegers et al. 2004) for greater parity with other categories of careers. Here we used the case study method in order to study and understand a single unit intensively (Gerring 2004). This method is used to better understand and learn with a heuristic approach by focusing on a few cases (VanWynsberghe and Khan 2007). We made interviews on a small sample of dairy farms in the *Grand Ouest* of France to design a set of variables and modalities that connect these elements together.

2.2 Choice of the relevant indicators

The expression of work pressure (in number of dairy cows per work unit) and productivity goals (in liters per work unit) is likewise hugely variable among this wide range of systems. These two indicators provide a way to express how much pressure farm workers are under. The work pressure indicator expresses how many cows a worker needs to take care of in the livestock farming system. It needs to be expressed in tandem with milk productivity goals because the amount of milk produced depends on genetics and feed system. Here we chose to use milk productivity in order to (i) study livestock farmers' choices in terms of animal productivity and (ii) compare different livestock farming systems working with the same genetic breed (Holstein) ; iii) lastly, breakthrough technologies like robots and sensors are re-shaping the farm work landscape (Hostiou et al. 2014). Their integration is also variable within farms in the region.

2.3 Location and sampling of the farms

Studies were carried out in the northwest region of France, a bastion of dairy farming featuring a wide diversity of dairy farms in terms of production systems and grazing practices (Chatellier 2011). These farms provide an opportunity to study different practices, work arrangements and production systems over a small geographic area.

The goal was to have a diverse range of dairy farms based on several criteria: feed system and especially fodder system (either relying heavily on grazing or based on maize throughout the year), number of animals per work unit, workforce composition (from one permanent farmer alone to several partners, with or without employees), and use of robots and sensors. We started out with 150 farm contacts from different databases (producer associations such as *Contrôle Laitier* (farmers' association in charge of milk analysis for animal performance monitoring) and *Civam* (farmers' associations in charge of rural development and promotion of grassland systems) and pre-selected 30 farms based on our sampling criteria. From that subset, we chose the 10 most diverse farms according to the sampling criteria and the farmers' motivations for working with the PhD student on two 2–3-h interviews.

The reason for choosing a sample of 10 farms was to construct a detailed understanding of the functioning of the farming systems under study, in line with the originality of our subject. Our method borrowed comprehensive qualitative discourse analysis via semi-directive interviews (Darré et al. 2007). The lack of previous scholarship on the links between different dimensions of livestock work and integrated management of animal health in farming made it necessary to re-visit farms two times and conduct semi-directive interviews to better understand how the farmers themselves forged links between these two domains. These interviews were conducted by the PhD student, either by phone due to the lockdown restrictions in place, or by going out to visit the farm in-person. The goal was to identify suitable variables to capture these links and to explore the modalities of these variables on farms. As such, the sample was not meant to be representative but to provide the data needed to identify and describe these variables through a range of cases.

2.4 Collection of farm data

The interviews took place between November 2021 and March 2022 and lasted 90 min on average. All interviews were recorded and all the participants gave written consent to share the data collected from their interviews anonymously within the framework of the thesis being studied. Three farmers had to be interviewed by telephone due to lockdown measures in place, and the remaining seven were interviewed in-person. The farmers who gave interviews by telephone were met at a later date in order to fill in any missing information. In each case, the self-identified head farmer was interviewed to get a better understanding of the coherence of the system as a whole. The interviews were semi-directive, i.e. the farmers were able to express themselves freely for the entire time (Darré et al. 2007; De Singly 2012), while an interviewer steered the discussion toward three main subjects: (i) general presentation of the farm to retrace its history, crop rotations, a description of the herd and its workers; (ii) general management of herd health, by discussing general herd health and hygiene practices, recurrent health problems, and the farmer's relationship with veterinarians and livestock farming advisors; and (iii) any training the head farmer had received in animal health, and their motivations and expectations for following such training. Each farmer granted access to an overall bill of health of the farm and to its accounting records of veterinary expenses and other livestock costs, such as purchases of alternative medicines.

2.5 Description of the sample

The sample of dairy farms (n=10) ranged from individual farms based on a grazing system to bigger, heavily-automated no-graze feedlot operations, with a continuum maintained between these two types of systems. "EL" designates each farm interviewed (Table 1). The sample of farms encompasses a broad diversity of farms in terms of work cell (permanent farmers) (Cournut et al. 2018), farm area, investments in automated systems, and size and

Table 1 Description of the 10 case study farms (EL).

	AA (ha)	Work units (WU)	Work units on the dairy unit (WUdu)	Employees	%Grass (Grass/AA)	Pastured area/cow (are)
EL1	1533	3	3	1	26	0
EL2	288	4	2.67	1	9	0
EL3	460	6.5	2	1.5	13	0
EL4	115	2	2	1	43	25
EL5	78	1.25	1.25	0.25	79	140
EL6	103	2.5	2.5	0.5	45	30
EL7	113	2	2	0	29	24
EL8	103	1.5	1.5	0	32	0
EL9	50	1	1	0	80	133
EL10	128	3.67	3.67	0.67	81	88
	Dairy cows	Milk/cow (L)	Milking robots	Sensors	Work pressure (P) (dairy cows/WUdu)	Work productivity (PT) (L/WUdu)
EL1	135	11000	2	No	45	345000
EL2	120	11500	2	Yes	45	495000
EL3	197	11500	3	Yes	98.5	1132750
EL4	100	10000	0	Yes	50	500000
EL5	42	4250	0	No	34	142800
EL6	100	9500	0	Yes	40	380000
EL7	65	9600	0	No	33	312000
EL8	63	10300	1	Yes	42	432600
EL9	30	5600	0	No	30	150000
EL10	68	6500	0	No	17	107500

productivity of the herd. The goal of the sampling criteria cited above was to have a small but widely diverse sample. The sampling criteria were weighted differently, ranging from single to triple, for number of dairy cows for example. Other criteria also illustrated the diversity of the sample, such as productivity and work pressure values which varied between farms on a scale of 1 to 5. Note that these criteria account for the number of people who work in the dairy unit, not the total number of people working on the farm (WUdu). Note too that all work units (WU, WUdu and employees) are expressed in full-time equivalents. Organic farms were not a sampling criterion in this study, but note that EL5, EL9 and EL10 were organic farms.

Moreover, high-dairy-output farms are common in northwest France, but this high productivity is slightly over-represented here due to the inclusion of farms that are also automated. This automation concerns not only milking robots but also the use of sensors, especially those that help monitor mating and reproduction periods. We are therefore dealing with large highly productive herds, but the diversity of farms studied ranges from small-scale grazing systems to very-high-yield systems with no grazing and largely maize-based diets.

2.6 Thematic analysis of the discourses

The integrally recorded interviews were fully transcribed, which enabled us to analyze the farmers' narratives and identify the main themes that emerged in their discourses. These major themes were identified by a color code in the transcripts of the farmers' discourses, and the verbatims associated with this color code were pasted into an Excel spreadsheet. Through analysis of the verbatims, we were then able to split each major theme into several sub-themes (which we call "basic variables" hereafter) to refine the discourse analysis. Finally, for each basic variable, we were able to identify the different ways in which the farmers approach them (which we call "modalities" hereafter). These modalities were then recorded in a new Excel spreadsheet, associated with their basic variable, for each interviewed farmer. This allowed us to go back to the farmers' representations of the themes addressed: the modalities could thus either converge or diverge according to farmer interviewed, and where there was convergence, we were able to form groups of farmers that shared the same modalities on most of the basic variables studied.

2.7 Analysis of links between variables using Bertin method

Bertin method (Bertin, 1969) is a method widely used for data analysis in qualitative research that is based on graphic representation of variables (Fiorelli et al. 2010). In this study we used Bertin method for two purposes: 1) to construct aggregative variables when two variables were highly associated, i.e. shared the same combinations of modalities; 2) to identify patterns of association between the final variables of our analysis. Figure 2 gives details on how we constructed aggregative variables. In the example given in Fig. 2, the aggregative variable "AB1" was created after identifying that variable "A" and variable "B" were related. In this example, as all the modalities of variable A and variable B are related, we were able to aggregate these variables into one variable "AB" with combined modalities.

For this analysis of variables identified through thematic analysis of each farmer's discourse, we added a further two variables in order to represent work pressure and work productivity. Analysis of linkages between all these variables using Bertin method allowed us to identify 5 patterns of association between variables, as described in section 3.1.7. of the results.

3 Results and discussion

3.1 Basic and aggregate variables identified thanks to discourse analysis

The interviews gave rise to five variables describing the relationship of the integrated management of animal health to work. Aggregate variables cover several domains: (i) mobilizable levers for controlling time spent working, (ii) skills-building in animal health, (iii) balance between animal health and performance, (iv) prevention strategy, (v) primary care strategy. Two others variable are added to these five variables: they are elementary variables we could not aggregate but remain significant to describe and illustrate links between work dimensions ang healthcare strategies: (i) work pressure (P) and (ii) work productivity (PT). These two variables were not expressed by farmers and do not result from discourse analysis, but were necessary to represent work configurations of farms. Values of these variables are presented in Table 1.

3.1.1 Aggregate variable T: "Mobilizable levers for controlling time spent working", goals and applications in the farm

This is an aggregate variable of the different work organization strategies. It groups together two basic variables: one that accounts for the prevalence of problems linked to excessive work time, and the other that accounts for the levers used or considered in the short term to cut down on the time the farm manager spends working. This variable reveals different strategies of organizing work, with two main levers mobilized/mobilizable: (i) increasing the workforce, and (ii) putting new technologies in place to manage the herd (sensors and/or robots). This variable has four modalities in the sample, with different combinations of these two levers. This variable is described in Table 2.

3.1.2 Aggregate variable Sb: "skills-building in animal health"

This variable reveals the relationship between farmers and the world of consultants and training with a view to improving skills in predicting and managing animal health issues.

This is an aggregate variable that groups together three basic variables touching on: (i) interactions with the veterinarian by addressing level of trust and needs; (ii) relationships with livestock advisors by addressing engagement, mistrust or recourse to high-level independent specialists (nutritionists) or exchanges with peers; and (iii) the appeal of training on animal rearing, particularly on alternative care methods (homeopathy, aromatherapy, acupuncture, plant therapy). The modalities of these variables have been aggregated into a "skills-building" variable that is broken down into four modalities. This variable is escribed in Table 3.

3.1.3 Aggregate variable B: "balance between animal health and performance"

This variable groups together two basic variables that express the links farmers make between certain performance parameters and balanced animal health. Over the course of the discussions, two parameters emerged that led to the identification of two basic variables. The first concerns the link farmers make between level of dairy output and health of their animals. The second relates to the link farmers make between periods of no productivity (expressed through criteria of age at first calving

Fig. 2 Method followed for the aggregation of variables.

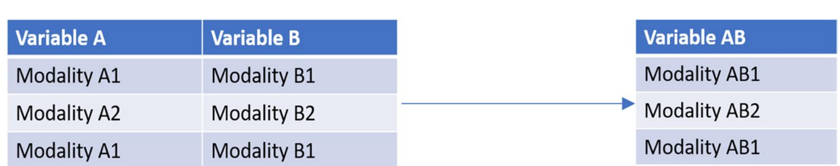

Table 2 Description of variable T: "Controlling time spent working."

Variable T: Controlling time spent working			
Modalities	Number of farms	Levers mobilized	Example
T1	1	None	"What I like is dipping into everything: the soil, crops, animals… it takes a lot of time and a lot of skill, but it's what I enjoy. You find ways to make it easier, you go and see the building […] well, I made it more practical to optimize the work for one person alone." [EL3]
T2	1	Bigger workforce Robots and sensors	"I took me 5 hours to get every cow fed, so it's our choice to have a farm that is still quite big but we have tools—like the robot and hired hands— that enable us to free up time on the side." [EL7]
T3	6	Bigger workforce	"I'd like to hire someone, so I'm trying to…to stabilize production, the price of milk… to be able to take someone on." [EL8]
T4	2	Robots and/or sensors	"Well, at first we only had one milking robot, and that wasn't working for us, we still had to push the cows and everything… so we invested in a second one, and now it's better. We can't take on more cows, but we're good. Either way, it's now more comfortable in terms of workload." [EL10]

Table 3 Description of variable Sb: "Skills building."

Variable Sb: Skills building				
Modality	Number of farms	Relationship to training	Relationship with advisors	Veterinary interaction
Sb1	3	One or more training courses per year	Exchanges between preferred peers	Relationship of trust Little need for intervention
Sb2	4	Interest in technical training	Recourse to technical salespeople to re-think diet and mineral uptake	Relationship of trust Need to delegate care to a competent veterinarian
Sb3	2	Little interest	Recourse to independent nutritionists	Relationship of trust but regrets over the costs incurred
Sb4	1	Interest but lack of time	Recourse to independent nutritionists	Several veterinarians called on for different services

and length of dry period) and the health of their animals. Some of the farmers interviewed now advise against shortening periods of non-productivity to curb economic losses, on the grounds that these dry periods are beneficial because they give the animals time to build up resistance and resilience to health-risk factors during productive periods. This variable is described in Table 4.

3.1.4 Aggregate variable PS "prevention strategy"

This variable groups together basic variables that describe the different levers used by livestock farmers to prevent disease, i.e., preventive medicine (with synthetic or alternative drugs), biosecurity measures, and diet. Preventive medicine with synthetic drugs includes the preventive measures that livestock farmers use, such as vaccines, chemical vermifuges and antibiotics. Alternative preventive medicine includes options such as essential oils and homeopathy but also acupuncture and osteopathy. Some livestock farmers employ practices that fall into the category of biosecurity, defined as measures that combine (i) isolating animals, (ii) strict disinfection schedules, and (iii) restricting animal flows. Lastly, some livestock farmers insist on the positive impact of good diet as the single most important preventive measure for averting potential health problems. This variable is described in Table 5.

3.1.5 Aggregate variable PC: "Primary care"

This variable groups together two modalities: modality PC1 (n=3), where cattle farmers systematically use alternative medicine in primary care, and modality PC2 (n=7) where they systematically administer chemical medicine in primary care. This basic variable was left as is, because it is not related to variable A on prevention strategies. Indeed, cattle farmers who only use alternative medicine alone or diet alone as a prevention strategy also only use alternative medicine in first-line curative treatment. Nevertheless, of the seven farmers who use chemical medicine as first-line curative treatment, five use alternative medicine as a preventive strategy. This goes to show that the use of alternative methods is not a function of any given system or the

Table 4 Description of variable B: "Balance between health and performance."

Variable B Balance between health and performance				
Modality	Number of farms	Dairy production	Unproductive periods	Example
B1	3	Low, in relation to health	Long, in relation to health	"Well, here at the farm we think that… if we let animals follow their natural cycle as far as possible, you of course need to produce milk, but we're still here to look after the animals so we don't push them. We don't force milk production, and we let the animals have a rest, you know?" [EL2]
B2	4	High, with no relation to health	Long, in relation to health	"Age at first calving? Well… we could do better but it's true that it doesn't bother us… we prefer it this way so that the heifer has time to grow properly, it's better for their career. Like for dry periods, we could reduce the duration but we choose to give them a little more time to rest." [EL6]
B3	3	High, with no relation to health	Short, with no relation to health	The farmer does not link animal health to performance in their discourse

Table 5 Description of variable A: "prevention strategy."

Variable A: Prevention strategy			
Modality	Number of farms	Levers used	Example
PS1	2	Diet alone	"In prevention… well, diet is everything! If you have a good, balanced diet, if it covers everything, you don't need to add anything else. So, no, I don't add anything." [EL1]
PS2	1	Preventive medicine with alternative medicine	"We look after the animals and it's true their immunity needs a little extra boost at certain times. In winter we give them homeopathic cures or we give essential oils to the calves." [EL2]
PS3	5	Preventive medicine via synthetic drugs Biosecurity	"I pay attention to the feet, too. I'll soon be taking delivery of a trimming cage, because when the trimmer comes, you never know where they've been… they could bring in germs from other farms…[EL2]
			"We use plugs there, during the dry periods, then antibiotics." [EL5]
PS4	5	Preventive medicine (synthetic drugs)	"It's true we've been tentatively trying out alternative medicine … we're testing some protocols with essential oils to see if they work." [EL6]
		Preventive medicine (alternative medicine) Biosecurity	"We had cases of crypto with the calves… so since then we systematically disinfect all niches, cubicles and troughs." [EL9]

livestock farmer's own convictions and values, but rather a tool that they are increasingly turning to as a complement to traditional medicine. This variable is described in Table 6.

3.2 Characterization of work–health management linkages based on farmers' patterns of association between variables

The final analysis is an exploration of potential linkages between variables related to work and animal health. The data coming from the 10 farms using Bertin's graphing technique gathers the previous aggregated variables, built with the farmers discourses, and two other indicators: "Work pressure" (P) and "Work productivity" (PT), to better understand the coherence of our groups. Work pressure is calculated as number of dairy cows per WU on the dairy unit. It is considered as an indicator of the work demands directly related to herd size. Work productivity is calculated as number of liters of milk/dairy cows multiplied by WU on dairy unit. It expresses the farmers ambitions related to a major proxy of the dairy income. These variables enable a better understanding of the other qualitative variables that express representations of the work and the care the animals need as captured in quantified indicators of work pressure on dairy unit staff and productivity goals. Both these variables, were kept for our analysis even if they are not independent in their

Table 6 Description of variable PC "Primary care."

Variable PC: Primary care			
Modality	Number of farms	Levers used	Example
PC1	3	Alternative medicine systematically used	"we realize that antibiotics are more and more expensive financially and there is probably an antibiotic resistance and when we don't need it, it's better... so we try to avoid as much as possible by using alternative medicine first" [EL3]
PC2	7	Chemical medicine systematically used	"When we have cases, especially mastitis, we do not hesitate, we put an antibiotic, we react quickly" [EL 9]

construction: productivity is based on the work pressure and productivity of the dairy cows. Analysis shows that the two pieces of information are not redundant.

The Bertin's analysis highlights five patterns of association between variables related to animal health management (preventive and curative care) and work issues captured via indicators of work pressure, work productivity, work organization, and building health-related skills (Fig. 3).

The grayscale color gradient is used here to highlight the various modalities: a darker gray signal that the modalities expressed equate to a more intensive practice, i.e., practices with higher yield.

Pattern 1 (*n*=3) can be summarized as farmers who believe that managing the herd via the most natural approach possible guarantees good, balanced health. All pattern-1 farmers had followed numerous training courses, including training in alternative medicine. All have a good relationship with veterinarians, who are trusted because they attend to needs and rarely solicit other workers in the farm. All use alternative medicine as first-line care. All aim to make their system humanly viable, with lower work and productivity pressure than other farms studied, which is why they favor a larger workforce to better redistribute the work pressure. They do not use the "recourse to robots and/or sensors" lever, preferring time spent with the animals and observing them to better detect potential health problems, which they believe can be countered mainly through diet.

Pattern 2 (*n*=1) concerns one permanent cattle farmer working alone with a highly productive herd and very high work pressure compared to other (large-workforce) farms. Nevertheless, his farm makes ample use of automated technology. Health is monitored by a veterinarian who has earned the farmer's trust and is often called on. However, despite robust productivity, this Pattern-2 farmer differs from Pattern 5 in that he is increasingly turning to alternative medicine to preclude health problems, and lets his animals have slightly longer non-productive periods in which to better rest and recover and start the next lactation in good shape. He also implements biosecurity measures similar to those used with other monogastric animals, because he considers them a model of efficiency. He strives for robust work productivity and high efficiency from his livestock but also from the veterinarians and consultants/advisers that he uses.

Pattern 3 (*n*=2) groups together farmers who are looking to improve their work organization, either by expanding

Fig. 3 Patterns of the farmers based on how they associate work with health management: darker grey is used to highlight more intensive practices.

	Variable T	Variable P	Variable PT	Variable Sb	Variable PS	Variable PC	Variable B	
EL1	T3	P1	PT1	Sb1	PS1	PC1	B1	
EL2	T3	P1	PT1	Sb1	PS1	PC1	B1	**Pattern 1**
EL3	T1	P2	PT1	Sb1	PS2	PC1	B1	
EL5	T2	P4	PT4	Sb2	PS4	PC2	B2	**Pattern 2**
EL6	T3	P2	PT2	Sb2	PS4	PC2	B2	**Pattern 3**
EL4	T3	P2	PT2	Sb2	PS3	PC2	B2	
EL7	T3	P3	PT3	Sb4	PS3	PC2	B2	**Pattern 4**
EL8	T3	P3	PT2	Sb3	PS3	PC2	B3	
EL9	T4	P2	PT3	Sb2	PS3	PC2	B3	**Pattern 5**
EL10	T4	P2	PT3	Sb3	PS3	PC2	B3	

the workforce or using new technologies, or even both. They have intermediate work pressure and productivity, and they mobilize levers to manage both. They have introduced various tools (sensors and/or robots) and measures (biosecurity, preventive medicine) to better avert the health risks they wish to avoid as much as possible, in order to steer clear of a case-by-case approach that they consider a waste of time on their farms. They are not ready to use alternative medicines because they are not comfortable with deploying and them and fear they would upset the delicate health balance of their herd.

Pattern 4 (*n*=1) concerns one farmer whose priority is to increase his free time by expanding his workforce and then by decreasing the work pressure. He does not have the time for training, despite his interest in it—especially health-related training in order to put alternative preventive medicine protocols into place. His approach to health is mostly by way of increased anticipation of potential health problems on the farm. To do so, he uses a host of health, safety and biosecurity measures and calls on many different veterinarians to monitor the herd, as well as an independent nutritionist, in order to get different points of view.

Pattern 5 (*n*=3) groups together high-performing farmers via work productivity. Pattern-5 farmers want to either expand their workforce, as they are already equipped with robots and/or sensors, or to bring in new technologies, as they have already expanded their workforce. Their goal is to decrease work pressure while maintaining a high level of work productivity. They use sensors in order to be as proactive as possible and boost the technical and economic performance of their farms. They put rigorous health–hygiene and biosecurity protocols into place, and do not let their animals go out to graze in order to keep firm control over all health-risk factors. They receive little training, and try to use veterinarians as little as possible to keep costs down.

These five patterns illustrate different head-farmer strategies and logics of the links between work organization and integrated management of animal health.

4 Discussion

We identified five variables linking farm work and animal health management that are rarely evoked in research into animal health but that all emerged via interviews with heads of dairy farms. The two others are linked with farmers objectives in relation with work. This led to a detailed understanding of the consistency of the farms interviewed, linking performance levels and care administered to the animals with levers for organizing work time via staffing and work automation, and for acting on work pressure and productivity.

Several key points emerged from this study. First of all, the role of prevention in health management, which was important for the farmers, albeit on different levels: (i) preventive medicine, (ii) how health relates to performance, and (iii) biosafety. The literature amply covers the increasing attention paid to preventive medicine (Sanders et al. 2011), especially the increased use of alternative medicine as prophylaxis (Hellec et al. 2021). However, studies on preventive medicine as an integrative component of animal health have focused mainly on organic farms (Cabaret and Nicourt 2009) or monogastric species (Fortané et al. 2015; Lamothe et al. 2017). The literature on organic farming has also shown links between intensity of livestock management and implementation of health plans (Blanco-Penedo et al. 2019) .This study shows not only that the use of alternative medicine is fast emerging as a preventive strategy on dairy farms but also that there is a concurrent rise in the adoption of biosecurity measures and the performance objective as a lever to prevent health problems.

Biosecurity practices are a subcomponent of preventive practice for better animal health. Internal biosecurity helps prevent contamination inside the herd, and external biosecurity helps prevent the entry of pathogens coming from outside the herd. Biosecurity practices have been widely documented as contributing positively to animal health, particularly in the control of infectious diseases (Bigras-Poulin 1997), and practices such as isolating animals, disinfection schedules, or batching have been described as important (Shortall et al. 2017) but relatively rare in French dairy cattle farming (Frappat et al. 2012)). Farmers who choose zero grazing with batching of their animals in different buildings or clearly-designated feedlots consider biosecurity as a strategy to prevent many health problems. They are also increasingly putting footbaths in place not only for the animals but also for anybody from the outside who steps onto the farm. This is close to approaches used in monogastric livestock farming, which also has a strong foothold in the *Grand Ouest* area of France. Within our sample of interviewed farms, biosecurity practices, especially batching practices and footbaths for outside visitors, are present in all types of systems including in small or organic farms. Outdoor livestock farming systems have recently been reported as a threat for biosecurity implementation measures (Delsart et al. 2020), but our study shows possible compromises tested by farmers in these outdoor grazing-based systems.

The farmers interviewed mentioned the important role of advisors (livestock consultants, veterinarians), as highlighted by Duval et al. (2017), but peer exchanges between farmers facilitated by professionals were not as prevalent as the literature suggests (Vaarst et al. 2007), and they only emerged in the skills-building variable. The timing of the interviews may partly explain why the farmers did not raise this issue themselves. Indeed, interviews took place after a long lockdown involving a ban on gatherings between groups of people (farmers included). The farmers had not had the opportunity to come together for a year, and so did not speak about exchanges as an important part of their experience and practice.

Nevertheless, the interviews highlighted a new type of consultant who is increasingly in demand: the independent nutritionist. In the *Grand Ouest* region, the decision to use this type of consultant is often driven by the fact that the livestock farmers do not trust commercial technician-consultants, who are perceived as primarily concerned with making sales (Compagnone et al. 2018). Independent nutritionists do not work for companies that market feed or other livestock products, and so the farmers perceive them as more objective in their advice.

This characterization of the "balance between health and performance" variable revealed a new consideration : the strategy of arranging non-productive periods to let the dairy cows rest and thus improve the overall health of animals over the course of their careers (Andersen et al. 2005). Indeed, our initial hypothesis was that livestock farmers would set their dairy production goals according to impact on animal health, as was the case with farmers who lowered their dairy output to make their animals more resilient from a health perspective since they would no longer be producing at maximum capacity. On the other hand, the livestock farmers who wanted to maximize their dairy output focused on another aspect of performance—the duration of non-productive periods—so as not to "push the animals." They leave more time before the first calving to ensure good growth and prepare the heifers for a career in milk production, then allow for a longer dry period than what is currently recommended in order to let the animals rest between two lactations. This ensures better overall health throughout a dairy cow's career. This practice employed by the livestock farmers sampled here is not verified in the literature, which argues more for the benefits of early calving on economic and technical performance (Cozler et al. 2008).

According to the patterns explored, it seems that there are some links existing between farmer organization of work and health management variables. Indeed, the work productivity, work pressure and skills' building seem to be linked according to our patterns: we hypothesize that the farmers with more free time or with a more efficient work time organization will invest this time by attending health trainings. It also seems that the use of alternative medicine is no longer reserved exclusively for organic farms but they are used by all types of farming systems. These links still are hypothetical and need to be further explored.

Although rich, the set of patterns described here remains only exploratory and is by no means comprehensive, making it a hazardous exercise to draw firm conclusions on the entire population of dairy farmers. We extended this research by performing a follow-up survey on a larger population of dairy farmers to test the robustness and genericity of these five exploratory patterns (Gotti et al; in prep).

5 Conclusion

The combination of work dimensions and animal health management have rarely been explored on a livestock farming system scale, and our objective was to explore this combination. Our results bring key insights to better understand potential trajectories for systemic management of animal health, which is part of the challenge for "One Health" and transitioning toward agroecology principles. We identified 5 variables that helped describe the very different logics mobilized by farmers who turn to alternative medicine and have low work productivity versus farm operations that aim for high productivity and implement strong biosecurity measures. We also suggest that there are other system consistencies between these two extremes that exist but have been largely under-researched. This diversity of system consistencies is an important factor for advisors working with farmers on implementing animal health plans. Our study confirms the importance of consultants and veterinarians in building a pool of useful skills for the integrated management of animal health.

The study foregrounds the decisive role of training on the use of alternative medicines and the emergence of independent nutritionists as a new kind of consultant that livestock farmers believe to be more in tune with their needs and values.

Perspectives for future work include testing the validity of the variables and exploratory patterns identified here on a larger population, and more closely examining the organization of work through the distribution of tasks and communication between workers around health and safety practices.

Authors' contributions The first author is a PhD candidate who collected and analyzed the data and drafted the manuscript. The second author is tutoring the PhD candidate, and the third author is the PhD supervisor. All authors have critically reviewed and revised the manuscript and approved the final version as submitted.

Funding The research presented in this article is part of PhD work funded by Angers School of Agriculture (ESA), the INRAE's ACT division, and Pays de la Loire regional council funding for innovation.

Availability of data and material (data transparency) The data analyzed in this study is subject to the following licenses/restrictions: the farmer interviews data is confidential. Requests to access these datasets should be addressed to: vinciane.gotti.these@gmail.com.

Code availability N/A

Declarations

Ethics approval Ethical review and approval were not required under local legislation and institutional code of practice for research involving human participants.

Consent to participate The farmers involved in this study were required to give written informed consent to participate, in compliance with national legislation and governing institutional code of practice.

Consent for publication The farmers involved in this study were required to give written informed consent for publication of the data, in compliance with national legislation and governing institutional code of practice.

Conflict of interest The authors declare no competing interests.

References

Andersen JB, Madsen TG, Larsen T, Ingvartsen KL, Nielsen MO (2005) The effects of dry period versus continuous lactation on metabolic status and performance in periparturient cows. J Dairy Sci 88(10):3530–3541. https://doi.org/10.3168/jds.S0022-0302(05)73038-1

Arrignon M (2020) La transition agro-écologique: une politique de développement durable comme les autres ? Vertigo 20(1). https://doi.org/10.4000/vertigo.27869

Benigno C, Bourn D, Catbagan D, Cresencio R, Chetra S, Gealone M, Gealone P, Mattiole R, Molina J, Morales R, Slingenbergh J, Sinthasak S, Umbrero R, Wint W (2010) What is environmental animal health management? https://doi.org/10.13140/RG.2.1.3666.7289

Bigras-Poulin M (1997) Epidémiologie appliquée à la lutte collective contre les maladies animales transmissibles majeures. Prev Vet Med 1(31):151–153. https://doi.org/10.1016/S0167-5877(97)83398-3

Blanco-Penedo I, Sjöström K, Jones P, Krieger M, Duval J, van Soest F, Sundrum A, Emanuelson U (2019) Structural characteristics of organic dairy farms in four European countries and their association with the implementation of animal health plans. Agric Syst 173:244–253. https://doi.org/10.1016/j.agsy.2019.03.008

Cabaret J, Nicourt C (2009) Les problèmes sanitaires en élevage biologique: Réalités, conceptions et pratiques. INRA Prod Anim, 22(3): 3. https://doi.org/10.20870/productions-animales.2009.22.3.3350

Cahuzac É, Détang-Dessendre C (2011) Le salariat agricole. Une part croissante dans l'emploi des exploitations mais une précarité des statuts. Economie rurale. Agric Alimentations Territoires 323:323. https://doi.org/10.4000/economierurale.3050

Chatellier V (2011) Élevages laitiers, territoires de l'Ouest de la France et prairies. Les Rendez-vous de l'INRA au SPACE 2011, Rennes, France. p 11. https://hal.inrae.fr/hal-02802508

Compagnone C, Lamine C, Dupré L (2018) The production and circulation of agricultural knowledge as interrogated by agroecology. Revue d'anthropologie Des Connaissances, 122(2). https://doi.org/10.3917/rac.039.a

Cournut S, Chauvat S, Correa P, Dos Santos Filho JC, Dieguez F, Hostiou N, Pham DK, Serviere G, Srairi MT, Turlot A, Dedieu B (2018) Analyzing work organization on livestock farm by the work assessment method. Agron Sustain Dev 38(6):58. https://doi.org/10.1007/s13593-018-0534-2

Cozler YL, Lollivier V, Lacasse P, Disenhaus C (2008) Rearing strategy and optimizing first-calving targets in dairy heifers: A review. Animal 2(9):1393–1404. https://doi.org/10.1017/S1751731108002498

Darré J-P, Mathieu A, Lasseur J (2007) Le sens des pratiques : Conceptions d'agriculteurs et modèles d'agronomes. INRA Editions, Versailles, France

De Singly F (2012) Le questionnaire: l'enquête et ses méthodes. Armand Colin, France

Dedieu B (2019) Transversal views on work in agriculture. Cahiers Agricultures, 8(28). https://doi.org/10.1051/cagri/2019008

Delanoue E, Dockes A-C, Chouteau A, Roguet C, Philibert A (2018) Regards croisés entre éleveurs et citoyens français : vision des citoyens sur l'élevage et point de vue des éleveurs sur leur perception par la société. INRA Prod Anim 31:51–68. https://doi.org/10.20870/productions-animales.2018.31.1.2203

Delsart M, Pol F, Dufour B, Rose N, Fablet C (2020) Pig farming in alternative systems: strengths and challenges in terms of animal welfare, biosecurity, animal health and pork safety. Agriculture 10(7):7. https://doi.org/10.3390/agriculture10070261

Dumont B, Fortun-Lamothe L, Jouven M, Thomas M, Tichit M (2013) Prospects from agroecology and industrial ecology for animal production in the 21st century. Animal 7(6):1028–1043. https://doi.org/10.1017/S1751731112002418

Duval JE, Bareille N, Fourichon C, Madouasse A, Vaarst M (2017) How can veterinarians be interesting partners for organic dairy farmers? French farmers' point of views. Prev Vet Med 146:16–26. https://doi.org/10.1016/j.prevetmed.2017.07.013

FAO (2022) The future of food and agriculture – drivers and triggers for transformation. FAO. https://doi.org/10.4060/cc0959en

Fiorelli C, Dedieu B, Porcher J (2010) Proposal for an analytic framework of the compromises adopted by livestock farmers to improve their work organisation. Cahiers Agric 19(5):383–390. https://doi.org/10.1684/agr.2010.0424

Fortané N, Bonnet-Beaugrand F, Hémonic A, Samedi C, Savy A, Belloc C (2015) Learning processes and trajectories for the reduction of antibiotic use in pig farming: a qualitative approach. Antibiotics (Basel, Switzerland) 4(4):435–454. https://doi.org/10.3390/antibiotics4040435

Fortun-Lamothe L, Savietto D (2022) Integrated management of animal health: Definition. Dictionnaire d'agroécologie. https://dicoagroecologie.fr/en/dictionnaire/integrated-management-of-animal-health/. Accessed 5 Aug 2023

Frappat B, Bareille N, Oulhen C, Fourichon C, Declerck E (2012) La biosécurité dans les élevages bovins du grand ouest : Un défi à relever. Renc Rech Rum 19:141, Paris

Gerring J (2004) What is a case study and what is it good for? American political science review, 98(2), 341–354. JSTOR, http://www.jstor.org/stable/4145316. Accessed 22 Mar 2023

Gotti V (2023) Integrated animal health management studied via the prism of work: the case of dairy farms in the French Grand Ouest region. Dissertation AgroParisTech University. https://hal.inrae.fr/tel-03957139

Hellec F, Manoli C (2018) Soigner autrement ses animaux. La construction par les éleveurs de nouvelles approches thérapeutiques. Économie Rurale 363:7–22. https://doi.org/10.4000/economierurale.5384

Hellec F, Manoli C, de Joybert M (2021) Alternative Medicines on the Farm: A Study of Dairy Farmers' Experiences in France. Front Vet Sci 8. https://doi.org/10.3389/fvets.2021.563957

Hostiou N, Allain C, Chauvat S, Turlot A, Pineau C, Fagon J (2014) L'élevage de précision : Quelles conséquences pour le travail des éleveurs ? INRA Prod Anim 27(2):113–212 (**ISBN: 9782738014054**)

Hume DA, Whitelaw CBA, Archibald AL (2011) The future of animal production: Improving productivity and sustainability. J Agric Sci 149(S1):9–16. https://doi.org/10.1017/S0021859610001188

Lamothe L, Combes S, Balmisse E, Collin A, Ferchaud S, Germain K, Pinard - Van Der Laan M-H, Schouler C, Le Floc'h N (2017) A conceptual framework to promote integrated health management in monogastrics (p. np). Book of abstracts EAAP 2017, Tallin. Wageningen Academic Publishers. https://hal.archives-ouvertes.fr/hal-01595645

Le Guern P (2020) Robots, élevage et techno-capitalisme. Une ethnographie du robot de traite. Réseaux 220–221(23):253–291. https://doi.org/10.3917/res.220.0253

Lyson TA (2008) Agriculture of the middle: lessons learned from civic agriculture. Food and the mid-level farm: renewing an agriculture of the middle. Cambridge, MA, pp. 165–178

Milne JA (2005) Societal expectations of livestock farming in relation to environmental effects in Europe. Livest Prod Sci 96(1):3–9. https://doi.org/10.1016/j.livprodsci.2005.05.014

Pflimlin A, Faverdin P, Béranger C (2009) Un demi-siècle d'évolution de l'élevage bovin. Bilan et perspectives. Fourrages (Versailles) 200:429–464

Poizat A, Bonnet-Beaugrand F, Rault A, Fourichon C, Bareille N (2017) Antibiotic use by farmers to control mastitis as influenced by health advice and dairy farming systems. Prev Vet Med 146:61–72. https://doi.org/10.1016/j.prevetmed.2017.07.016

Raina V, Sharma N, Khajuria S, Kumar K, Choudhary S, Syed Z, Hussain K (2017) Training needs of dairy farmers. Int J Agri Environ and Biotechnol 10(2):245. https://doi.org/10.5958/2230-732X.2017.00029.8

Sanders P, Bousquet-Mélou A, Chauvin C, Toutain P-L (2011) Utilisation des antibiotiques en élevage et enjeux de santé publique. INRA Prod Anim 24(2):199–204 (https://hal.archives-ouvertes.fr/hal-01191161)

Seegers H, Fourichon C, Billon D, Hortet P (2004) Cost-benefit analysis of mastitis control by simulation: Model description and profitability of strategies targeting subclinically infected cows. Proceedings of the Society for Veterinary Epidemiology and Preventive Medicine, Martigny, Switzerland, 24th-26th March 2004, 179–186

Shortall O, Green M, Brennan M, Wapenaar W, Kaler J (2017) Exploring expert opinion on the practicality and effectiveness of biosecurity measures on dairy farms in the United Kingdom using choice modeling. J Dairy Sci 100(3):2225–2239. https://doi.org/10.3168/jds.2016-11435

Sidot G, Moreau JC, Guillaumin A (2005) L'attente des éleveurs par rapport à l'évolution de leur métier et des conditions de travail. Fourrages (Versailles) 181:95–103

Vaarst M, Nissen TB, Østergaard S, Klaas IC, Bennedsgaard TW, Christensen J (2007) Danish stable schools for experiential common learning in groups of organic dairy farmers. J Dairy Sci 90(5):2543–2554. https://doi.org/10.3168/jds.2006-607

VanWynsberghe R, Khan S (2007) Redefining Case Study. Inter J Qual Meth 6(2):80–94. https://doi.org/10.1177/160940690700600208

Zinsstag J, Schelling E, Waltner-Toews D, Tanner M (2011) From "one medicine" to "one health" and systemic approaches to health and well-being. Prev Vet Med 101(3–4):148–156. https://doi.org/10.1016/j.prevetmed.2010.07.003