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Abstract

Passive surveillance is based on spontaneous reporting to veterinary authorities of disease suspicions by farmers and other stakeholders in animal production. Stakeholders are considered “actors” in sociology of organisations research. In veterinary public health, passive surveillance is considered to be the most effective method to detect disease outbreaks and to generate epidemiological information for decision-making on surveillance and control strategies. Nevertheless, under-reporting of cases is an inherent problem, reducing the ability of the system to rapidly detect infected animals.

Previous studies have shown, for example, that passive surveillance for bovine brucellosis in France, through compulsory reporting of all bovine abortions, has limited sensitivity, with variability in reporting rates despite similar cattle farming profiles. Based on this observation and on sociological literature in health surveillance, we hypothesised that oversight organisational factors in different areas influence

health actor contributions to passive surveillance. Therefore, to improve the efficiency of surveillance systems, we need to understand the organisational levers (supporting factors) and organisational drags (hindering factors) on the production and dissemination of health information.

We conducted semi-structured interviews with the surveillance actors in two administrative geographic divisions in France (Departments A and B) with similar cattle farming profiles but contrasting abortion reporting rates (low and high, respectively). We assumed that these rates were related to health actor organisation in each administrative division.

We mapped actor relationships and looked for behavioural recurrences and differences between the two departments. This analysis led to two socio-economic models explaining the configurations observed: pro-curative in Department A, and pro-preventive in Department B. These models showed a link between the level of competition endured by veterinarians on the sale of veterinary medicinal products and the overall contribution of the actors to health surveillance. The pro-preventive model had a higher contribution to surveillance than the pro-curative model. Importantly, the nature of the information produced in this configuration of actors corresponded to the needs of surveillance, providing collective and early information that circulated more readily between actors.

We highlighted three characteristics that help to identify the configuration of a system of actors: 1) the pressure of competition exerted on veterinarian activities; 2) the dominant business model and form of organisation of veterinary clinics; and 3) the frequency of interactions between the main surveillance actors outside of crises. The first two characteristics affect the local contribution to data reporting for surveillance, and the third affects network responsiveness in a health crisis.

Keywords

cattle; bovine health surveillance; qualitative research; ideal-type models; health actors; France

Introduction

Passive surveillance is based on spontaneous reporting of disease suspicions to veterinary authorities by farmers and other stakeholders in animal production (Hoinville, 2013). In veterinary public health, passive surveillance is reported to be the most effective method to detect disease outbreaks early and to generate epidemiological information. This information is used to help decision-making on surveillance and control strategies (Food and Agriculture Organisation of the United Nations (FAO), 2011). Nevertheless, under-reporting of cases is a classic problem in passive surveillance (Prete, 2008; Delabouglise et al., 2016). Under-reporting reduces the ability of the surveillance system to rapidly detect the presence of infected animals. Early detection is particularly important for diseases that are absent from a given territory, like bovine brucellosis in France. For this disease, early detection by the surveillance system in the country is based on the compulsory reporting of all bovine abortions, in addition to annual testing of adult bovines on all farms and to testing of introduced bovines, under certain conditions. However, passive surveillance of bovine brucellosis has limited effectiveness as less than one third of the abortions detected by farmers are reported (Bronner et al., 2015a). Reporting disease suspicions can have advantages for farmers. For example, when farmers report an abortion to their veterinarian, the veterinary visit and sample collection are paid for by the authorities. Farmers can take advantage of this payment to screen for other diseases as part of the same visit and sample collection. However, reporting disease suspicions can also have serious economic consequences for farmers, as a positive result for a regulated disease implies the immediate cessation of product and animal sales and purchases. These consequences may dissuade farmers from reporting suspicions in certain situations (Prete, 2008). In addition to these potential economic consequences, there are also technical and cognitive factors that influence suspicion reporting. Examples include the practical definition of a suspicion, which can differ from the regulatory definition in some cases, and the perception that farmers and veterinarians have of the risk of infection by a regulated disease (Bronner et al., 2014).

Regarding abortions, the level of under-reporting has been shown to vary according to the department (administrative geographic division in France), including between departments with similar cattle production systems (Bronner et al., 2015b). This supports the hypothesis that factors – other than technical and cognitive factors – influence farmers' propensity to report disease suspicions at the departmental level. Importantly, the organisational structures may differ from one department to another, independently of the cattle farming profile: types of production, mean farm size, and geographic density of farms. Additionally, sociological studies have shown, in animal production and in other fields, that

sociological factors strongly influence the generation of "knowledge" and of "ignorance" by the authorities and surveillance systems (Carpenter, 2010; Dedieu et al., 2015; Fortané, 2015). For example, the division of labour among the agencies that regulate and control pesticide use in France increases under-reporting of occupational poisoning in agriculture, through fragmentation of responsibilities (Dedieu et al., 2015). Based on these observations, this study aimed to understand how the power games within the institutional network of a health surveillance system shape the production and dissemination of animal health information.

To assess differences in how local organisations are structured, we examined the interactions between the various stakeholders. Stakeholders are considered "actors" in sociology of organisations research. Our main focus was to evaluate how the socio-economic relationships between surveillance actors influence their contribution to the production and dissemination of health information at the departmental level. To answer this question, we conducted a sociological survey in the two departments, with the following objectives: 1) to determine the forms of organisation of the actors involved in bovine health surveillance; 2) to identify the nature of the information exchanged in each organisation form; and 3) to understand how the interdependence of actors influenced their decisions concerning health surveillance.

In this analysis, we used the methodology and conceptual tools of the sociology of organisations (Friedberg, 1997). This branch of sociology is based on the postulate that there is a gap between the formal rules of a system of actors and the way in which these rules are applied in practice. In the sociology of organisations, stakeholders are considered "actors", i.e. groups of individuals engaged in intentional actions. The approach taken is that actors adopt rational behaviour that pushes them to respect formal rules to a greater or lesser extent. This rationality is limited (Friedberg, 1997) because it is strongly influenced by cognitive biases and the social context, which determine both the opportunities and the capacities for action of the actors in the system (Bernoux, 2009; Crozier and Friedberg, 2014). Therefore, we can understand the interactions between actors through three analytical categories: collaboration, conflict, and absence of relation. These categories depend on the resources that they are able to exchange to seize existing opportunities or to create new ones. Actors can play with the rules of the system in order to achieve or maintain a position of power in the network. In this way, the power games between actors stabilise in a particular way to form a system of action, or "local order".

Characterising the local order makes it possible to understand around which rules the power games stabilise. Drawing on this analytical framework and on the "middle range theory" (Merton, 1968), we have attempted to reconstruct, on the basis of our empirical observations, the local orders of the network of actors involved in bovine health surveillance in two fields of study where we expected to see contrasting forms of organisation.

Our study was carried out in two departments with similar cattle farming profiles but contrasting levels of reporting for surveillance. Based on an analysis of the production and transmission of health information between surveillance actors in these two departments, we defined two "ideal-type" models (Weber, 1919) describing contrasting types of organisation. Each type of organisation explored corresponded to a specific type and mode of dissemination of health information among local actors, and thereby to a specific level of contribution of these actors to health surveillance.

Materials and Methods

Sociological survey design

To understand how local forms of organisation influence the reporting of health information, we needed a sample composed of two departments with similar farming profiles, but levels of reporting for surveillance that were as different as possible. We categorised the farming profiles of the departments based on the available information: number, size, and production type of the bovine farms in each department. We relied on the French national cattle and veterinary databases (managed by the French Ministry of Agriculture and Food) for information about herd sizes and abortion reporting, and on the typology of cattle herds developed by Sala et al. (2019) for production type classification (dairy versus beef herds). The two departments in our study both had a mixed production profile, with between 1 000 and 1 500 dairy cattle farms and a similar number of beef cattle farms in each department. Farms had similar mean sizes (64 females 24 months and older per herd in Department A, and 45 in Department B, all bovine productions considered), comparable numbers of cattle herds (around 3 900 in Department A and 3 700 in Department B), and similar density of herds (0.55 herds/km^2 in Department A and 0.78 herds/km^2 in Department B). Department A was characterised by

a low abortion reporting rate (0.52%) and Department B by a high reporting rate (1.05%), compared to the national mean reporting rate (0.56%). The abortion reporting rates were calculated as the ratio of the number of abortions relative to the total number of adult females (i.e. 24 months and older) in the areas of interest. The average annual rate of abortion on farms (excluding special health episodes) varied between 0.5% and 20%, depending on the study (Forar et al., 1995; Hovingh, 2009; Nusinovici et al., 2012). We assumed that the difference in annual reporting rates was mainly due to a difference in the proportion of reported abortions, and not to a difference in the occurrence of abortions in each department. Importantly, there were no significant differences between the two departments in terms of their cattle production systems, nor in terms of their respective health situations with regard to the main abortion-causing diseases (bovine viral diarrhoea (BVD), Q fever, and neosporosis).

We first selected three departments that met our criteria. We conducted a preliminary survey of two to three interviews in each of the three departments with key actors in the local surveillance system. This first step enabled us to choose the two departments where we observed the strongest contrast in the forms of organisation of the surveillance actors.

Sociological survey conduct

In 2018, we conducted a series of 36 semi-structured interviews with local animal health surveillance actors (17 and 19 interviews in Departments A and B, respectively). The mean length of interviews was 90 minutes. The interviewees were identified and selected based on our knowledge of the surveillance network, on official websites and documents from the organisations, and on the advice of the actors we met. We targeted the organisations and types of actors that were directly or indirectly involved in bovine health surveillance, and for each category, we selected managers as well as field actors. For example, in the departmental veterinary services, we targeted the head of the animal health department and the technician involved in bovine health surveillance. Our aim was to interview the people who have the most knowledge on how local bovine health surveillance is carried out in practice. In both departments, we interviewed bovine farmers, independent farm animal veterinarians, representatives of farmers' and veterinarians' organisations and of veterinary laboratories, departmental veterinary services, and departmental councils.

Data analysis

We analysed the data collected during the survey using inductive reasoning. This reasoning is carried out through the analysis and cross-checking of the data from our investigation (interview content and grey literature). We identified "consolidated facts" based on the cross-checked interpretation of the actors' discourse, which we then sought to compare again with the data in order to test their robustness. We did not make any *a priori* hypotheses to confirm or refute in the field, but only analytical hypotheses drawn from our interpretations and therefore from the field. For example, during our investigation, following cross-checking of the discourse of farm animal veterinarians and the staff of the departmental health-support association (called the “GDS”), we found that there were contradictory signals of collaboration and competition. By exploring and clarifying these overlaps, we sought to understand why these two types of relationships coexisted and around which issues they manifested themselves.

We began by creating sociograms to characterise the interdependencies and power relations between actors in each department. The sociogram is a tool that helps to highlight the basis of power relations: the key resources that explain why some actors are dominant. Then, we looked, theme by theme, for the recurrences and differences in the behaviour of actors between the two departments studied, and identified the underlying mechanisms. Our objective was to go beyond the discourse of the actors and to grasp the causal mechanisms that explain the power relations in the local context in which they were located. We used "ideal-types" (Weber, 1965) to extract concepts from the facts. The ideal-type is an analytical tool used to simplify social mechanisms in order to gradually highlight a local order. In this way, we gradually built two explanatory models by extracting the main mechanisms from the data, and by constantly checking the hypotheses generated by the analysis, through a comparison with the data. These ideal-type models express the mechanisms identified and constituting the local orders of each department. Verbatim extracts of the interviews were translated into English; their original version (in French) can be found in the Supplementary material.

Results

Characterisation of the departmental networks for bovine health surveillance

a. Description of actors and their roles

195 The actors interviewed in both departments are listed in Table 1. The departmental network of bovine
196 health surveillance is composed of five categories of "health actors" (1 to 5) and three categories of
197 "peripheral actors" (6 to 8) (Figure 1; Table 1):

198 1) Farmers, the first level of the network, as providers of source information. Concerning abortion
199 reporting, they are the actors who detect abortions and make the decision to call a veterinarian; 2)
200 Independent farm animal veterinarians (called "veterinarians" in the rest of this article), the second-
201 level key actors in the information chain. They make the decision to report the abortion and to test the
202 animal for bovine brucellosis; 3) The GDS, an association run by a board of farmers and consisting of
203 technical staff. All farmers can be members but the GDS membership is not compulsory. The GDS
204 organises collective surveillance and control measures (such as bovine screening, biosecurity
205 measures, or infected bovine slaughter), and records the health information of its member-farms,
206 which enables an overview of the department situation. The GDS defines protocols to assist farmers
207 and veterinarians in implementing short-term and long-term measures for non-regulated diseases. It
208 also covers part of the farmers' expenses related to these protocols, and offers financial support from
209 a mutualised fund to help cover high economic losses due to diseases; 4) The departmental veterinary
210 services, responsible for administrative supervision of the GDS regarding regulated diseases. They
211 check that compulsory measures are effectively implemented and intervene whenever an irregularity
212 is noted by the GDS; 5) The departmental veterinary laboratory that carries out diagnosis and
213 screening analyses for regulated and non-regulated diseases, and in some departments (like in
214 Department A), private veterinary laboratories related to clinics that also perform analyses for non-
215 regulated diseases.

216 6) Agricultural professional organisations (APO), as associations of farmers that mutualise expenses
217 for materials and/or services, such as technical consulting. They are sometimes authorised to sell
218 preventive veterinary medicinal products[1], in which case they also offer health consulting; 7)
219 Departmental councils, which in some departments, like the two departments studied in the
220 sociological survey, give an annual subsidy to the GDS to cover part of the analyses carried out for
221 their protocols. This is an indirect way of offering financial support to the veterinary laboratories; 8)

[1] Antiparasitics, vitamins, trace elements, serums, vaccines, products used in the control of cow oestrus (French Ministry of Agriculture and Food, 2011)

222 The Chamber of Agriculture, as a public body representing farmers and the rural world, and offering
223 advisory services to farmers and other rural actors. This body is involved in bovine health surveillance
224 as long as it is responsible, together with the GDS, for issuing official documents that state the health
225 status and traceability of all individual bovines and herds.

226 The first five actors presented above are directly involved in health surveillance. They are referred to
227 as “health actors” in the rest of this article.

228

229 ***Table 1.*** *Summary of the interviews conducted in the two departments during the sociological survey*

Actors	**Number of interviews**	
	Department A	**Department B**
Farmers (GDS members and non-members)	6	6
Independent veterinarians	5	4
Departmental health-support association (GDS)	2	1
Departmental veterinary services	1	2
Departmental veterinary laboratory	2	1
Agricultural professional organisation*	1	1
Departmental council	1	1
Chamber of Agriculture	1	1
Sub-total	**19**	**17**
Total	**36**	

230 * *Only the agricultural professional organisation of Department A was authorised to sell veterinary*
231 *medicinal products.*

232 **b. Health information flow between the actors**

233 The network of health actors is composed of information producers (veterinarians and laboratories),
234 information receivers (veterinary services and the GDS), and farmers who convey the field material
235 needed for information production.

236 There are two types of health information: 1) analytical results, produced by the veterinary laboratory;
237 2) diagnosis, produced by the veterinarian. Analytical results are the only health information to be
238 transmitted in a systematic way out of the “singular colloquium” (a type of doctor-to-patient
239 relationship) between the farmer and the veterinarian: the veterinary laboratories have all the results of
240 the analyses they carry out, and systematically send a copy to the concerned veterinarian and farmer,
241 and to the GDS when the farmer is a GDS member. They also send a copy to the veterinary services
242 for regulated diseases. Hence, veterinary laboratories, veterinary services, and the GDS do not
243 depend on farmers and veterinarians for access to analytical results. However, they do depend on
244 them for production of this information: veterinarians prescribe analyses and take samples, and
245 farmers, as financers, make the final decision to request an analysis.

246 The information produced by farmers when reporting a disease suspicion improves knowledge on the
247 local epidemiological situation. As a result, this information is important to health actors when
248 establishing and refining surveillance and control strategies at the local level. Veterinarians, the GDS,
249 and/or veterinary services (based on the diseases suspected) rely on the epidemiological situation to
250 make decisions about implementing individual or collective surveillance and control measures, on the
251 concerned farm and on other farms related to it (e.g. neighbouring farms or farms with an economic
252 link).

253 **c. Types of actors: overview versus field actors**

254 We can see from the nature of the information available to each health actor that they can be divided
255 in two types: 1) field actors, who have precise information on a limited number of farms (veterinarians,
256 farmers); and 2) overview actors, who have limited information on a large number of farms (veterinary
257 laboratories, veterinary services, and the GDS) (Table 2). Overview actors have access to the health
258 status of the farms concerning several infectious diseases. The veterinary laboratories know the status
259 of all the farms for which they performed analyses concerning all the diseases screened. The
260 veterinary services know the status of all farms in the department concerning regulated diseases. The
261 GDS also has access to this information and, in addition, knows the status of all its members

concerning the non-regulated diseases that have been screened. Veterinarians and farmers have more precise and diverse health information, but only on client farms for veterinarians, and on their own farm for farmers.

These two types of actors play a complementary role in the network and depend on one another for complete access to health information. Farmers and veterinarians are essential for other actors to have access to more precise information, for example on the risk of occurrence of specific diseases on certain farms, or on the diagnosis associated with inconclusive analyses, which both require good knowledge of farming practices and of the overall situations on farms (Figure 1). As we mentioned, analytical results are the only information that veterinary laboratories, veterinary services, and the GDS have. This is partial, and thus biased, information that sometimes needs complementary elements to inform the actors' decisions. Similarly, veterinarians and farmers can inform their own decisions thanks to the overall information they can obtain from the overview actors. For example, by knowing the percentage of local farms infected with a given disease, veterinarians can orientate their differential diagnosis (i.e. which disease should be suspected first in the presence of a clinical sign or a set of clinical signs), and farmers can decide to implement specific preventive measures on their farms.

Table 2. *Types of information available to each health actor*

HEALTH ACTORS	***INFORMATION SYSTEMATICALLY AVAILABLE***	***FARMS CONCERNED***
Veterinarians*	Results of the requested analyses, diagnosis	Client farms
Farmers*	Results of the requested analyses, with diagnosis	Own farm
Departmental veterinary Services**	Test results for regulated diseases without diagnosis	All farms in the department
Veterinary laboratories**	Results of tests performed, without diagnosis	All farms in the department
Departmental health-support association (GDS)**	Results of tests requested by veterinarians, without diagnosis	Members of the GDS (and all farms in the department for regulated diseases)

* Field actors; ** Overview actors

d. Preventive versus curative veterinary measures

Veterinary measures can be divided into preventive and curative. Curative measures are most often an individual approach: if one or several animals are sick, they are treated along with other animals at risk in the same herd, i.e. those in close contact with the sick animals or exposed to the identified hazard. As opposed to curative measures, preventive ones more often involve a population-based approach, which inherently produces more collective information, hence more information on the health statuses of farms. Therefore, preventive approaches lead to specific information flows between veterinarians and farmers (Figure 2). Preventive measures can be divided into two categories. Firstly, screening for specific diseases either on a regular basis (in parallel with mandatory prophylaxis for regulated diseases) or occasionally, when a situation is associated with a higher risk of infection (e.g. purchase of an animal), or when a specific clinical sign or a set of clinical signs leads to suspicion of the disease (e.g. abortions leading to suspect an abortive infectious disease like Q fever or bovine brucellosis). Secondly, medical and health biosecurity measures to prevent infection in cattle. The first category of preventive measures produces data for surveillance, for both regulated and non-regulated diseases, as greater screening leads to more accurate knowledge of the local health situation.

From the interviews conducted in both departments, we observed that spontaneous data reporting for the surveillance of regulated infectious diseases in cattle was closely related to the proportion of preventive measures in place for non-regulated diseases. Importantly, among infectious diseases, the major preoccupations of the cattle farmers interviewed in this study were diseases that are not regulated (i.e. for which testing is not mandatory), in particular respiratory and abortive infectious diseases. Some preventive measures are common to several regulated and non-regulated diseases and can produce information on the farm health status for both categories of diseases. For example, when an abortion is reported, the veterinary visit and blood sampling of the aborted animal to look for bovine brucellosis bacteria (a regulated disease) are paid for by the authorities, and the same visit and sampling can be used to screen for other, non-regulated and more frequent abortive diseases, including Q fever, BVD, and neosporosis. In both departments we studied, this was often mentioned by the interviewed farmers as an incentive to report abortions. Additionally, these complementary analyses are often partially reimbursed by the GDS, provided that the abortion was reported to the veterinary services.

Similarities observed between departments

a. Veterinarians as key actors in the health network

Our analysis shows that veterinarians have a (quasi)monopoly on three key resources: 1) direct access to farmers and therefore to information about their practices and the health status of their herds for infectious and non-infectious diseases (Figure 1); 2) the sale of veterinary medicinal products, which makes them an indispensable source of treatments, particularly curative treatments, which no other actor can sell; and 3) expertise on veterinary acts, which means that veterinarians are essential to generate health information through screening or diagnosis (Figure 1). Veterinarians therefore play a central role in the network.

All the health actors depend directly on the veterinarians for their own activity in health surveillance. We observed that veterinary laboratories drew a large part of their income from their analysis requests, for diagnostic or screening purposes. Similarly, farmers depended on veterinarians to establish diagnoses and find suitable solutions to the zootechnical and health issues they were facing. The GDS also depends on veterinarians for close monitoring of the herd health situation of their members, access to non-member farms, and to implement their collective plans, as farmers most often follow their veterinarian's recommendations. Lastly, departmental veterinary services rely on veterinarians to apply official prophylaxis and control measures for the authorities.

> *"There are only twelve people [in our service] and [around] 6 000 farms [in the department]: this is just not enough! Our eyes and ears on the ground are the vets themselves." Departmental veterinary services*

b. Co-opetition between veterinarians and the GDS

We observed in Departments A and B that both veterinarians and the GDS aimed at being the farmers' reference regarding health issues and cattle follow-up for prevention and control measures. This aspect generated ambivalence in their relationship, which could be considered co-opetition, i.e. involving "cooperative competition" (Brandenburger and Nalebuff, 1996).

We observed collaboration between veterinarians and the GDS in the two studied departments, as the GDS had administrative software that was useful for veterinarians for the follow-up of herds.

339 Veterinarians did have software that monitored productivity and health indicators in their client herds,
340 but this software was not designed for individual follow-up of the animals and the veterinary acts
341 performed. The GDS used their management software to register for example their visit reports, the
342 referent clinic of each farm, the analytical results, and the health statuses of the individual animals and
343 herds for all diseases of interest in member-herds and for regulated diseases in all the herds in the
344 department. In both Departments A and B, most veterinarians could not organise the follow-up of their
345 client herds, because they lacked time and logistics. The GDS software enabled them to implement
346 long-term measures in the herds, such as repeated screening for a contagious disease in a given
347 period, or the vaccination or treatment of animals according to their health statuses and changes in
348 these statuses. For example, if targeted screening and treatment of a herd was needed, the GDS
349 could provide the veterinarian with the list of the bovines and their individual screening results before
350 each visit, indicating whether they were already treated or not. The GDS technicians also carried out
351 follow-up visits, but the number of technicians was limited compared to the number of member herds.
352 This is why the GDS also benefited from this collaboration: not only did the GDS benefit from
353 veterinarians' expertise in the implementation of their health plans, but it also benefited from their
354 proximity to the farms and their ability to ensure more regular follow-up visits.

355 As mentioned in the paragraph describing information flows, the GDS systematically received from the
356 veterinary laboratory a copy of all the analytical results of their member-herds. In both departments,
357 veterinarians were concerned with this broad access of the GDS to the health information of the herds,
358 which is a key resource for any actor who wishes to offer health consulting and follow-up to farmers.
359 This conflict zone was illustrated by situations where the GDS contacted farmers ahead of
360 veterinarians to set up a health plan in their cattle, after having received a copy of a positive result
361 from the veterinary laboratory.

362 Even though veterinarians were protecting their dominant position in the health network, this co-
363 opetition with the GDS did not lead to open conflicts. This was due to the strong interest that
364 veterinarians had in the transfer of competences they could operate with the GDS, for the
365 administrative follow-up of herds, and also for follow-up visits. In most clinics, these two activities were
366 not conceivable and not profitable. Likewise, our analysis showed that in the clinics organised around
367 consulting and prevention (which corresponded to larger clinics in Department A, and to clinics of the

368 contracted groups in Department B), veterinarians had a position of health referent that was more
369 established and stable on the farms, and less threatened by GDS activity. Therefore, we observed
370 less competition between these clinics and the GDS around the GDS health plans.

371 Despite the similarities observed in the two departments regarding the positions of veterinarians and
372 of the GDS, we noted key differences in the actor configurations. On the basis of our analysis of these
373 two configurations, we built two explanatory models.

374

375 ***Differences observed, highlighted by ideal-type models***

376 **a. Department A: pro-curative collective behaviour**

377 In Department A, there was high competition pressure on veterinary medicinal product sales and
378 health consulting because a large number of authorised APOs also offered these services to farmers
379 (Figure 2). One authorised APO in particular has developed into a large company, present in multiple
380 departments, and offers a wide range of services, which represented multiple different entry points to
381 find new clients. The preventive veterinary medicinal products that APOs may be authorised to sell
382 (French Ministry of Agriculture and Food, 2011) represent a large proportion of the sales volume of
383 veterinarians because they are often administered to a large number of animals. Examples include
384 antiparasitics and vaccines. This pressure resulted in reorganisation of veterinary clinics into larger
385 clinics, with collaboration between a larger number of veterinarians in the same clinic, and larger
386 groups of clinics, in other words a setting where clinics mutualised veterinary expertise and expenses.
387 This reorganisation enabled veterinarians not only to maintain competitive prices for the products, but
388 also to develop their offering in terms of herd follow-up, including reproduction follow-up, control plans
389 for calf diarrhoeal disorders, and cow lameness. They had more time for visits and developed logistics
390 to ensure administrative follow-up of the animals, and found ways to make this activity more profitable.
391 As a consequence, they became more independent of the GDS because, as explained above,
392 veterinarians' main interest in collaborating with the GDS is the transfer of competences on
393 administrative follow-up of herds and on follow-up visits.

Despite this reorganisation of veterinary clinics, their economic sustainability still mainly depended on veterinary medicinal product sales and medical acts. Veterinarians were not able to find any form of contract with farmers that would ensure durability of the consulting service. They faced two challenges: 1) having sufficient consulting activity to ensure high income; and 2) finding a form of contract that was suitable for all farms with the same clientele, which can have very different profiles in terms of practices, production, and size. In addition, because of the pressure of competition on the sale of veterinary medicinal products, the proximity with farmers was important for veterinarians in order to keep their central position. This encouraged them to concentrate on their core activity: curative interventions on the farms.

> *"You're never happy when your major clients buy their medicinal products elsewhere. Especially as the current business model for farm animal practice is 80% medicinal product sales and 20% medical acts, or maybe 70/30. And this is how the business model works, so we also need to sell medicinal products. No problem saying that we need to sell consulting services, etc., but you'll never have the same income." Veterinarian*

For veterinarians, a curative approach is related to medical acts and curative veterinary medicinal product sales: two activities in which veterinarians have a monopoly. This monopoly ensures a privileged position for veterinarians through a curative approach on their client farms. Additionally, these two activities are more profitable to veterinarians than health consulting, which is more often related to a preventive approach. Therefore, in Department A, a curative approach was more advantageous to veterinarians than a preventive one. This was reinforced by the fact that the GDS in Department A had a limited membership rate (69% of farmers had subscribed the year before the sociological survey was carried out, versus 99% in Department B). Veterinarians therefore had an advantage over the GDS regarding their positioning as the farmers' health referents. Favouring individual curative interventions could maintain this advantage because the GDS does not cover this activity. It mainly implements collective preventive and control measures for infectious diseases.

In most cases, the exchange of information between veterinarians and farmers in Department A was limited to the classic framework of the singular colloquium (Figure 2). Veterinarians did not particularly encourage a transfer of competences to farmers, such as training them on primary care so that they could handle simple cases themselves, or informing them on which diseases are more common and

problematic locally, what their identification criteria are, or what behaviour farmers should adopt if they suspect a case in their cattle. In the singular colloquium built around a curative approach, farmers do not increase their competence for identifying the diseases of interest for health surveillance, and are not collectively encouraged to be responsive in detecting and handling suspected cases: they remain performers, in that they are not proactive in generating the information. The health information produced in such a context is limited and/or delayed: veterinarians mainly produce information after having intervened on a case, which includes the farmers' delay in detection and is limited to the case involved. If, after such an intervention, herd screening is carried out, the information generated is obtained later than if the disease is being screened before any serious case, i.e. in a preventive way, on the basis of the local health situation or early signs of alert detected by the farmer. Likewise, the information produced in this context does not enable an overview of the health situation at a local or departmental level. In short, veterinarians are field actors who convey resources (i.e. individual samples and diagnostic hypotheses) to veterinary laboratories for the production of collective information on the health status of animals, herds, and areas, which are transmitted to the other overview actors, including the GDS and departmental veterinary services (Figures 1 and 2). In the context of a curative approach, the priority of veterinarians and farmers is to treat the animals with clinical signs and not necessarily to arrive at a precise diagnosis, which would require multiple diagnostic analyses. The chain of information stops at the field level, without generating any collective information, which is the aim of health surveillance. This limited information also reinforces asymmetry of competences between veterinarians and farmers, which strengthens veterinarians' monopoly as farmers depend more on them.

As the curative approach was favoured in Department A, veterinarians not only produced less information, but also needed less collective information for their activity, which made them more independent of the overview actors. This could explain the distant relationships within the "health triad" for regulated diseases, formed by veterinarians, the GDS, and veterinary services (Figure 2). Overall, we also observed in Department A that there were few interactions between these three actors outside of crises, even though they had most often identified contacts in each organisation. This can also hinder information transfer or reduce its efficiency.

b. Department B: pro-preventive collective behaviour

In Department B, we observed a form of organisation that was not found in Department A: contracted veterinarian-farmer groups (called “contracted groups” in this article). Contracted groups are an association between one veterinary clinic and a collective of farmer clients. In contracted groups, veterinarians keep their private status, but their organisation enables collective interactions with their clientele, which is rare in classic private practice. Inside a contracted group, the clinic offers an annual package to the farmer collective, for an annual fee that is fixed per animal. Each year, the annual fee and the content of the package are decided jointly by the clinic and the farmer collective: this system is based on collaboration between veterinarians and farmers. Follow-up of the herds and preventive interventions, which constitute the main activities of contracted groups, are included in the annual package, as well as the most frequent and basic curative interventions. Sale of veterinary medicinal products and more complex and occasional curative interventions are charged as additional fees. There is also considerable transfer of competences from veterinarians to farmers inside a contracted group. This transfer consists essentially in training on primary care for simple cases, for example handling cases of mild diarrhoea or hyperthermia, the main physical parameters to check before calling a veterinarian when the condition of an animal deteriorates. The transfer also involves identifying major infectious and non-infectious diseases, and the behaviour to adopt for case suspicions. Contracted groups were created in a context of a population-based approach to animal diseases, and of strong collaboration between veterinarians and farmers. We found that contracted groups were drivers of the overall dynamics of health actors in Department B.

As farmers of contracted groups were not charged for each basic curative intervention (covered by the annual fee), they may have called on the veterinarian for this purpose more often than in classic practice, where the amount of time taken up by curative interventions already prevented veterinarians from organising time for preventive actions. Yet, no increase in demand for basic curative interventions was reported by veterinarians in Department B in the interviews. This trend was compensated for in three ways: 1) preventive interventions were also included in the annual fee; 2) farmers were trained throughout the year to adopt more preventive practices in their herds; and 3) farmers were also trained to handle simple cases on their own or with advice from the veterinarian by telephone. The interviews revealed that veterinarians in contracted groups were able to avoid both the

basic curative interventions, which are time-consuming because of their repetition, and the management of worsening health situations due to late handling of cases, which is also time-consuming because of difficulty in controlling the health situation once a certain threshold is reached. Veterinarians were also able to free up time for consulting and follow-up activities.

> *"The vet comes to our farm […] at least once every three weeks. Not [necessarily for] sick animals. Most often for reproduction follow-up, for discussions and so on. […] The good thing about contracted groups is that we don't hesitate to call [veterinarians]. If for example […] the mortality rate is a little bit higher than usual, we deal with it right away, without waiting. They will perform a necropsy or we'll do analyses […] pretty quickly, and if we can do something about it, we'll do it fast. We do appreciate [this responsiveness]." Contracted group farmer*

The collaboration and the transfer of competences between veterinarians and farmers of contracted groups favoured the production of collective and early health information on the farms, like their health status through preventive screening. This information, unlike the individual information produced by curative interventions, is directly usable by health actors outside of the farmer-veterinarian singular colloquium, i.e the overview actors. It is the type of information that is relevant for health surveillance. Concerning spontaneous reports of signs of alert, like abortions in the case of infectious abortive diseases, they were facilitated by a preventive approach and by the knowledge that farmers acquired on early identification of these signs of alert. Since most farm follow-up activities were reproduction follow-up, frequent visits were needed. Interestingly, veterinarians in contracted groups were twice to four times more present on the farms than in classic practice. As the farmers trusted the veterinarians, they easily talked with them about issues they encountered (e.g. cattle feed), that were not related to the visit's purpose. On the other hand, veterinarians were more inclined to give advice to the farmers based on elements they observed on their farms during the visit (e.g. the condition of animals or the farmer's practices for milking).

> *"When the vet comes to the farm, we talk about [the reason for his visit] but also about other things, more general problems. Because he is physically here during his visits, we get into more in-depth discussions, beyond the basics. As farmers, this makes us think differently." Contracted group farmer*

509 In Department B, three elements considerably reduced competition between veterinarians in
510 contracted groups and the GDS: 1) the limited threat concerning veterinary medicinal product sales
511 (due to the contracted groups business model, which depended less on these sales for their
512 sustainability), 2) the trust between farmers and veterinarians that placed the latter as the farmers'
513 health referent and produced individual information that stayed inside the singular colloquium (e.g.
514 preventive measures related to the farmer's technical practices, which were not associated with any
515 analysis or specific diagnosis); and 3) the independence of veterinarians from the GDS for their follow-
516 up competence, as contracted groups had both time and logistics organised around this activity. Even
517 though veterinarians of contracted groups were more independent of the GDS, they still benefited from
518 its overview of the local health situation. They also benefited from GDS support in promoting a
519 preventive approach on the farms. Here, the activity of the GDS was based on a preventive approach
520 and an insurance-like system, which means that their economic interests are aligned with those of the
521 contracted groups. The trust between farmers and veterinarians in the contracted groups also made
522 veterinarians less dependent on the health information held by the GDS, and less likely to not be
523 consulted when the GDS proposed to implement a control plan in a herd. In a situation where the
524 veterinarian reads the results with a delay compared to the GDS, they would have a higher probability
525 of being consulted early by the farmer, thanks to their strong partnership with them. This offered a
526 parallel way for veterinarians to access this information earlier. The competition between veterinarians
527 and the GDS for privileged access to health data was thus diminished in the contracted groups, and
528 their collaboration was reinforced as a consequence.

529 As the preventive approach was frequent in Department B, veterinarians produced herd-level
530 information and needed information about the local health situation for their activity. This need led to
531 intensified exchanges of information between veterinarians and the overview actors, who processed
532 and synthesised the collective information. For example, the GDS or the veterinary services could
533 inform veterinarians about the local level of risk for specific diseases, according to herd health status.
534 This could explain the relationships observed in Department B within the health triad (i.e.
535 veterinarians, the GDS, and veterinary services) (Figure 2). In Department B, these three actors
536 organised informal meetings every three months, regardless of the health situation. This enabled
537 exchange of information on the perception that each profession and the authorities had on specific
538 health or socio-economic issues and, if required, it also enabled an agreement on actions to

implement and on the way to implement them. This type of collaboration makes the transfer of information for surveillance easier or more efficient, both during and ahead of health crises. We can see from this observation that depending on the relationships between the actors in the health triad, they either limit themselves to the official rules or reinforce their interactions beyond the official rules. They may therefore go beyond performance of official health acts by mandated veterinarians and a meeting between the veterinary services, the GDS, and veterinarians before each annual testing season.

Discussion

Our in-depth study of the surveillance network in two departments illustrated the interdependence of the health actors within the network. All the health actors depend on farmers to provide field material, required to produce any information. They also depend on the veterinarians for their expertise and as the initial producers of formalised information. To summarise on the key role of veterinarians, although they are not a prerequisite for accessing information on farm status for infectious diseases, they are a prerequisite: 1) for the production of formalised information (together with farmers who call veterinarians and accept to pay for the investigation of diseases in their cattle); 2) for access to supplementary information on farmer practices; 3) for access to health information on non-infectious diseases and health situations that were not associated with the analyses; and 4) for implementation of any health measures or investigations on farms. Therefore, veterinarians are a type of nodal point in the surveillance network. Key information and actions circulate through these actors. This central position means that the actions of veterinarians largely influence the other actors' behaviours regarding bovine health surveillance in general, and regulated infectious diseases in particular.

It is important to consider the influence of veterinarians on the nature of the information exchanged in the network, which underlines the importance of unravelling the interactions and resource flows between local actors in health surveillance. This enables us to better understand the production and dissemination of information for health surveillance.

Key resources as the basis of the system of action

Veterinarians were found to have a quasi-monopoly on three key resources, which made them the key actors in the network. Their decisions were oriented towards maintaining this central role. They more specifically looked to preserve their monopoly regarding the two key resources for which they could encounter competition from other actors in the system: sale of veterinary medicinal products, and privileged access to farmers. This explains why in Department B, where the veterinarian's role as a key partner to farmers was well established and stable, they relied more easily on the GDS's competence for their follow-up activities. In this favourable context, the business model of contracted groups was able to develop and persist. The veterinarians we interviewed in contracted groups stated that in this form of clinical practice, the preventive approach was more profitable than the curative approach and annual income was more stable, which is supported by the literature (Dumas and Sulpice, 2017). In contracted groups, the income of veterinarians was secured by the annual fee. Farmers paid this annual fee to maintain the good health status of their animals. In other words, farmers paid veterinarians to prevent curative veterinary interventions, just like they would do for an insurance policy. In such a system, healthy animals are just as profitable for veterinarians as sick ones, as opposed to the classic clinics (that were the dominant business model in Department A), where most income is associated with sick animals. By favouring a preventive approach, the veterinarians of contracted groups produced more collective and early information that could circulate outside of the singular colloquium between the farmer and the veterinarian, and this information was useful in health surveillance. This socio-economic context and these mechanisms of information production and transmission are shown in the pro-preventive model (Figure 2), where the power games between the actors are favourable for health surveillance.

One third of the clinics in Department B were part of a contracted group and among the other clinics, several had individual contracts with farmers among their clientele, with an annual fee related to the number of animals in their herds. Moreover, veterinarians in contracted groups often had responsibilities as representatives of their profession in local veterinary associations (i.e. chairperson or member of a specific committee). These associations organise continuing education training for veterinarians and farmers, and carry the voice of veterinarians for technical issues related to their profession. They are also a framework for veterinary group debate on the main local or national health

595 issues. Through these roles, they could promote pro-preventive behaviour outside of their clientele, in
596 the rest of the department.

597 By contrast, in Department A where veterinarians experienced competition on the two key resources
598 from authorised APOs, they were more protective of their position as the farmers' health referent,
599 disputed with the GDS. Even though veterinarians and the GDS still collaborated because of their
600 mutual interest in the resources exchanged (veterinary expertise, follow-up logistics, etc.),
601 veterinarians were attentive to the conflict zone with the GDS around access to farm health
602 information. In this unfavourable context, veterinarians produced more individual and delayed
603 information through a mainly curative approach, generally more profitable than the preventive
604 approach for the business model established in the department (classic clinical practice). Health
605 information did not circulate systematically outside of the singular colloquium and could not easily be
606 used for surveillance. Overview actors had to pass through veterinarians to access this information.
607 This socio-economic context and these mechanisms are shown in the pro-curative model (Figure 2),
608 where the power games between the actors are unfavourable to health surveillance.

609

610 ***Power games determining the flow of health information***

611 Understanding the power games in place between the actors in the health network is essential to
612 evaluate the production and dissemination of information for health surveillance. Characteristics that
613 may be seen as the result of how a health risk is perceived by veterinarians and farmers, under the
614 influence of individual factors (Bronner et al., 2014), are in fact the result of behaviour that is shaped
615 by the local configuration, either pro-preventive or pro-curative. Cognitive factors may have an
616 influence on the actors' behaviours, but these behaviours are strongly determined by resource
617 availability within the system they belong to, and the power games constructed around these
618 resources between the system actors. Veterinarians and farmers, although important actors in the
619 production of health information, are only one part of the information chain. The production and
620 dissemination of information for health surveillance (e.g. abortion reporting for the surveillance of
621 bovine brucellosis) cannot be understood without a larger understanding of the system of actors within
622 which veterinarians and farmers interact. In particular, in the two local orders studied, we observed a
623 difference in the importance that veterinarians give to the sale of veterinary medicinal products,

624 depending on the resources available to them. Our models highlighted a link between the level of
625 competition experienced by veterinarians in this activity and the overall contribution of the actors'
626 system to health surveillance. A high level of competition regarding the sale of veterinary medicinal
627 products leads to collective pro-curative behaviour, and a low level of competition to collective pro-
628 preventive behaviour. These findings call for additional studies to further characterise the link between
629 competition in the sale of veterinary medicinal products and the contribution of the actor system to
630 health surveillance, and to verify whether this link is also found in other local orders.

631 Our study showed that professional issues were of high importance in health surveillance, as well as
632 health and epidemiological issues, which are not always a priority for the actors. For example, the
633 ambivalent cooperation between the GDS and veterinarians that we observed in the field can be
634 pushed to one extreme or the other, according to the economic context, thus generating and
635 disseminating more or less information for surveillance. If veterinarians experience high levels of
636 competition on veterinary medicinal product sales and health consulting by the authorised APOs, they
637 may need to affirm themselves more strongly as the health referent of their client farms, to the
638 detriment of the GDS. This phenomenon may also be intensified in a situation where the GDS is
639 already weak (with a low membership rate), as in Department A. Likewise, as the GDS is mostly
640 involved in surveillance and prevention measures, higher competition between this actor and
641 veterinarians may mechanically lower the production of data for health surveillance for two reasons: 1)
642 if they collaborate less, the membership rate of the GDS may decrease as more farmers will rely
643 exclusively on their veterinarians to implement health plans. Therefore, monitoring of the department's
644 health status by the GDS (through monitoring of the members' status) may be reduced; and 2) this
645 may encourage veterinarians to favour the curative approach or smaller preventive measures that can
646 be handled without the intervention of the GDS, which would favour interventions that produce less
647 information for surveillance.

648

649 ***Observed organisations as the result of department history***

650 In Department A, the technical and health aspects of animal husbandry remained partitioned, which
651 had two consequences: 1) the relationship between veterinarians and farmers stayed aligned with the
652 classic model: a singular colloquium between a veterinarian and a farmer with strong asymmetry of

competences, and individual and curative medicine practiced on the farms; and 2) APOs had a strong role as technical advisors and developed follow-up of the technical performances of farms. In contrast, in Department B, these two aspects were considered to be closely related, which had two consequences, opposed to those observed in Department A: 1) the relationshiop between veterinarians and farmers moved away from the classic model, towards a collective organisation, where veterinarians had an interest in increasing the health competence of farmers, thus reducing their asymmetry of competences and favouring population-based and preventive medicine on the farms; and 2) veterinarians played a central role as farmers' advisors and were already ensuring long-term follow-up on the farms: APOs did not have broad scope to develop their service offering. As a consequence, in Department B, unlike Department A, very few authorised APOs were established at the time of our study. Therefore, veterinary clinics had little competition on both veterinary medicinal product sales and health consulting.

In both Departments A and B, local socio-political history seems to have largely influenced the nature of relationships between veterinarians and farmers, and as a consequence, between all the health actors. Bearing in mind this historical context, we can better understand why the veterinary clinics adopted different forms of organisation in the two departments. The two observed configurations seem to result from opposed organisational strategies adopted by veterinarians and farmers at the end of the 20th century, oriented by opposing considerations about the technical and health aspects of animal husbandry. In Department B, contracted groups are the result of specific local history. In the 1980s, the national representatives of important agricultural political organisations aimed to improve the overall health status of farms, which had generally worsened with the intensification of agriculture after the Second World War. Together with the local referents in farm animal veterinary practice and research, they strongly favoured a collective approach to animal health on farms, inspired by the epidemiological approach that had succeeded in improving health situations in other contexts. Through this local process, the network of actors received enough support from the authorities and territorial organisations to be able to institutionalise the system and conduct research directly on the farms. Farmers and veterinarians strongly contributed to study design and conduct, and to the development of practical solutions based on the study results.

682 ***Specificity and limitations of our study***

683 The two models in this study are entirely based on the field material collected during our sociological
684 survey. They are the result of a series of interpretations originating from the interview content and the
685 grey literature. Our approach was inductive and consisted of continuous alignments and adjustments
686 between the models and our field observations.

687 Our study sample was voluntarily limited to two departments. Representativeness was not an
688 objective because our aim was to understand existing mechanisms and to explore their heterogeneity.
689 We did not aim to infer a single model for all departments in France. For our purposes, contrasting and
690 common patterns between the two fields of study were the important characteristics we needed to
691 help us understand the power games and interaction rules of the system in our analysis. Now that we
692 have built two ideal-type models, it would be interesting to test their robustness in other departments,
693 to determine: 1) how we can improve these models by comparing them to similar configurations (pro-
694 preventive/pro-curative) in other systems of action, and 2) whether these models can explain other
695 configurations or if other models need to be defined. For example, in other pro-preventive
696 configurations, would we observe the same kinds of collaboration and transfer of competences? In
697 other pro-curative configurations, would we observe a larger proportion of preventive actions due to
698 the organisation of veterinarians into large clinics and groups of clinics? In configurations that differ
699 from both the pro-preventive and pro-curative models, would we identify new key resources or local
700 actors who might influence the ratios of power between the health actors in a different way?

701 We focused on understanding how the studied configurations differed in the two departments, and we
702 did not attempt to explain how these situations were reached. Therefore, we aimed at identifying the
703 variables of the models that influenced the configurations, and not the factors that could explain their
704 establishment. Nevertheless, as we highlighted in the description of the pro-preventive model, local
705 socio-political history has a strong influence on the creation of certain forms of organisation, like the
706 contracted groups in Department B. Assessing our ideal-type models with regard to other departments
707 with a different socio-political background should enable us to identify whether this parameter actually
708 plays a role as a variable in the observed configurations, or only explains the appearance of certain
709 forms of organisation without explaining their persistence in the present system of action.

There are many different cattle farming profiles and veterinary structures, which could influence the behaviour of the actors, as well as the sociological context in which they evolve. Our analysis focused on the influence of the local order observed on the contribution of actors to health surveillance, rather than on the influence of the actors' profiles in the field, which had been analysed in part in a previous study (Bronner et al., 2014). We chose the departmental level for our analysis because, although it tends to smooth out the diversity of these field actors, it seemed to be the best-suited level for understanding the functioning of the local systems of action in health surveillance. Additionally, the department is the smallest administrative level for managing health monitoring of infectious, regulated and non-regulated diseases. For example, the smallest management area of veterinary services and the GDS is the department. Due to a lack of time and resources, we were unable to interview a large number of field actors (farmers and veterinarians) from each profile, nor could we cover all existing profiles. Nevertheless, in each department we were able to interview veterinarians from structures among the dominant business models, and farmers among the profiles most involved in health surveillance. Certain production types – not included in the analysis – have derogations for the monitoring of regulated diseases as their practices present less risk of contamination by these diseases or their spread. Concerning the overview and peripheral actors, there was a low number of key contacts for our study in each organisation, and we were able to meet most of them.

Improvement levers for passive surveillance

Analysing health surveillance systems "from bottom to top" helps us to understand the origin and nature of the data that are collected in relation to the interests of the actors who produce these data. We highlighted three characteristics that help to identify the configuration of a system of action: 1) the pressure of competition exerted on veterinarian activities; 2) the dominant business model and form of organisation of the veterinary clinics; and 3) the frequency of interactions between the main surveillance actors outside of crises. The first two characteristics affect the local contribution to data reporting for surveillance, and the third characteristic affects network responsiveness in a health crisis.

As demonstrated in other sociological studies, the social and practical conditions of data production largely influence the efficiency of health surveillance systems (Fortané, 2015; Fortané and Keck, 2015). In our study, the pro-preventive model describes a configuration of actors where the risk of

spread of diseases is likely lower, as their early detection based on suspicion reporting is more effective. This configuration is more suited to the needs of health surveillance. Hence the closer departments are to this configuration, the more effective national surveillance should be. Our ideal-type models help to understand how a system of action could tend towards one configuration or the other if the structure of the social interactions was modified, thus changing the power relationships between actors and consequently affecting their behaviours. This provides insights on potential levers to improve passive surveillance. For example, if the contribution of veterinarians to GDS control plans was made systematic, and formalised so that they could be paid for this service, they could position themselves as the co-referent for health follow-up of herds with the GDS. In this way, veterinarians would protect their privileged access to farmers. This type of collaboration would also enable veterinarians to gradually increase the proportion of their income associated with consulting, and decrease their economic dependence on the sale of veterinary medicinal products. This would mechanically encourage pro-preventive behaviour and thus greater disease suspicion reporting for surveillance. When our sociological survey was carried out, this kind of collaboration was being set up in Department A, and was already in place in other departments.

Conclusion

In this study, we aimed to understand the influence of the organisation of local actors on their contribution to passive health surveillance. An important finding was the central position of veterinarians within the system of actors, and the major influence they had on health surveillance, depending on the evolution of their profession towards more or less economic independence from the sale of veterinary medicinal products, particularly through the development of new resources, such as health consulting and herd health monitoring. Similarly, our study highlighted that a surveillance network with a pro-preventive configuration contributed more to health surveillance than a pro-curative configuration, as it mainly produced collective and early health information that circulated more largely between actors. As a result, one could expect passive surveillance of infectious diseases to be easier to implement in any local order corresponding to the pro-preventive configuration, compared to a local order with a pro-curative

767 configuration. Nonetheless, other variables, such as the profile of the farms and the health history of
768 their neighbourhood, may also influence the behaviour of the actors at the farm level.

769

770

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782 References

783 Brandenburger, A.M., Nalebuff, B.J., 1996. Co-opetition, Doubleday Business. ed., pp. 304.

784 Bronner, A., Hénaux, V., Fortané, N., Hendrikx, P., Calavas, D., 2014. Why do farmers and
785 veterinarians not report all bovine abortions, as requested by the clinical brucellosis surveillance
786 system in France? BMC Vet. Res. 10, 93-104. https://doi.org/10.1186/1746-6148-10-93

787 Bronner, A., Gay, E., Fortané, N., Palussière, M., Hendrikx, P., Hénaux, V., Calavas, D., 2015.
788 Quantitative and qualitative assessment of the bovine abortion surveillance system in France. Prev.
789 Vet. Med. 120(1), 62-69. https://doi.org/10.1016/j.prevetmed.2015.02.019

790 Carpenter, D., 2010. Reputation and Power: Organisational Image and Pharmaceutical regulation at
791 the FDA, Princeton University Press, Princeton, pp. 856.

792 Dedieu, F., Jouzel, J.-N., Prete, G., 2015. Governing by Ignoring: The Production and the Function of
793 the Under-reporting of Farm-workers' Pesticide Poisoning in French and Californian Regulations,
794 in: Matthias Gross et Linsey McGoey (Eds), Handbook of Ignorance Studies, Routledge, London, 297-
795 307.

796 Delabouglise, A., Antoine-Moussiaux, N., Phan, T.D., Dao, D.C., Nguyen, T.T., Truong, B.D., Nguyen,
797 X.N.T., Vu, T.D., Nguyen, K.V., Le, H.T., Salem, G., Peyre, M., 2016. The Perceived Value of Passive
798 Animal Health Surveillance: The Case of Highly Pathogenic Avian Influenza in Vietnam. Zoonoses
799 Public Health 63, 112–128. https://doi.org/10.1111/zph.12212

800 Dumas, P.-L., Sulpice, P., 2017. Success stories : La convention : Pour contractualiser l'activité
801 vétérinaire en collectif. Comparatif convention / libéral. *[Success stories : Contracted groups : to*
802 *contractualise the veterinary activity in groups. Comparison contracted/private practice].* Presented at
803 the Journée nationale des Groupements techniques vétérinaires (GTV) *[Veterinary technical group*
804 *(GTV) National day]*, Reims, France, pp. 10.

805 Fensterbank, R., 1987. Some aspects of experimental bovine brucellosis. Annales de Recherches
806 Vétérinaires. 18, 421-428.

807 Food and Agriculture Organisation of the United Nations (FAO), 2011. Challenges of animal health
808 information systems and surveillance for animal diseases and zoonoses (Proceedings of the
809 international workshop organized by FAO, 23-26 November 2010, Rome, Italy.).

810 Fortané, N., 2015. La surveillance comme dispositif-frontière. *[Surveillance as a boundary-system].*
811 Revue d'anthropologie des connaissances. 9(2), 265-290. DOI: 10.3917/rac.027.0265

812 Fortané, N., Keck, F., 2015. Ce que fait la biosécurité à la surveillance des animaux. *[What biosecurity*
813 *does to animal surveillance].* Revue d'anthropologie des connaissances 9(2), 125-137. DOI:
814 10.3917/rac.027.0125

French Ministry of Agriculture and Food, Arrêté du 28 juin 2011 fixant la liste des médicaments vétérinaires prévue au deuxième alinéa de l'article L. 5143-6 du code de la santé publique. Official journal 0157, July 8th 2011, page 11865, text 33. https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000024323639&categorieLien=id

Friedberg, E., 1993. Le pouvoir et la règle. Dynamiques de l'action organisée. *[The power and the rule. Dynamics of the organised action]*, ed. Le Seuil, Paris.

Hénaux, V., Bronner, A., Perrin, J.-B., Touratier, A., Calavas, D., 2015. Evaluation du coût global du dispositif de surveillance de la brucellose bovine en France en 2013. *[Costing out of the surveillance system of bovine brucellosis in France in 2013].* Bulletin épidémiologique, santé animale et alimentation 69, 28-35.

Hoinville, L., 2013. Animal Health Surveillance Terminology Final Report from Pre-ICAHS Workshop, pp. 27.

Merton, R. K., 1968. Social Theory and Social Structure, ed. Free Press, New York, pp. 702.

Olsen, S.C., Johnson, C., 2011. Comparison of abortion and infection after experimental challenge of pregnant bison and cattle with *Brucella abortus* strain 2308. Clinical and Vaccine Immunology, 2075-2078. DOI: 10.1128/CVI.05383-11

Prete, G., 2008. Surveiller en éradiquant : l'importance des « médiateurs de la surveillance » et des réseaux informels dans la surveillance des risques sanitaires et environnementaux. *[Monitoring while eradicating: the importance of "surveillance mediators" and of informal networks in the monitoring of health and environmental risks"].* 50, 489–504. https://doi.org/10.4000/sdt.19890

Sala, C., Vinard, J.-L., Perrin, J.-B., 2019. Cattle herd typology for epidemiology, surveillance, and animal welfare: Method and applications in France. Prev. Vet. Med. 167, 108–112. https://doi.org/10.1016/j.prevetmed.2019.04.003

Weber, M., 1919. Gesammlte Aufsaetze zur Wissenschaftslehre *[Essays on the theory of science]*, ed. Mohr, Tübingen. *(French Translation: Freund, J., 1965. Essais sur la théorie de la science. Recherches en Sciences humaines, 19.), pp. 351.*

Figure captions

Figure 1. *Information and resource flows between the eight categories of actors involved in bovine health surveillance at the departmental level (GDS: Departmental health-support association; APOs: Agricultural professional organisations)*

Figure 2*. Schemas of the interactions and resource flows between local actors in health surveillance in the two socio-economic models in the study*

Pro-curative model: *Strong competition imposed on independent farm animal veterinarians regarding veterinary medicinal product sales and health consulting, associated with a mainly pro-curative approach on health issues. The information produced is more often individual and delayed. This information stays inside the farmer-veterinarian singular colloquium, and hence has limited utility in health surveillance.*

Pro-preventive model: *Little competition imposed on independent farm animal veterinarians, associated with a mainly pro-preventive approach on health issues. The information produced is more often collective and early. It can be diffused outside of the farmer-veterinarian singular colloquium, to the overview health actors (veterinary laboratories, veterinary services, and the GDS), and hence has greater utility in health surveillance.*

Key variables of the models:

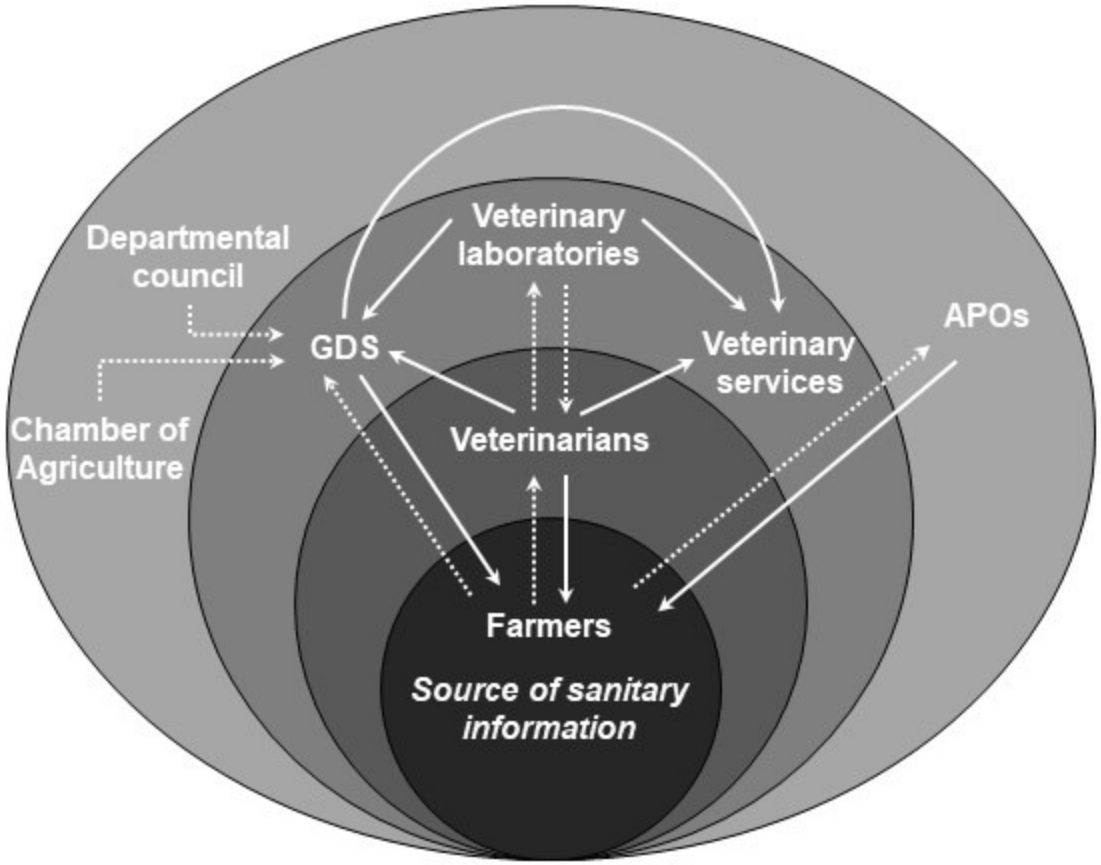
(1) Competition imposed by authorised agricultural professional organisations (APOs) on veterinary medicinal product sales and health consulting;

(2) Form of organisation of the independent farm animal veterinarians that has an influence on the practices of professionals regarding health issues in the department.

Acronyms and abbreviations used in Figure 2:

DVS	*Departmental veterinary services*
GDS	*Departmental health-support association*
VL	*Veterinary laboratory (private: attached to a clinic; public: departmental VL)*
Authorised APOs	*Agricultural professional organisations authorised to sell preventive veterinary medicinal products*

Figure 1

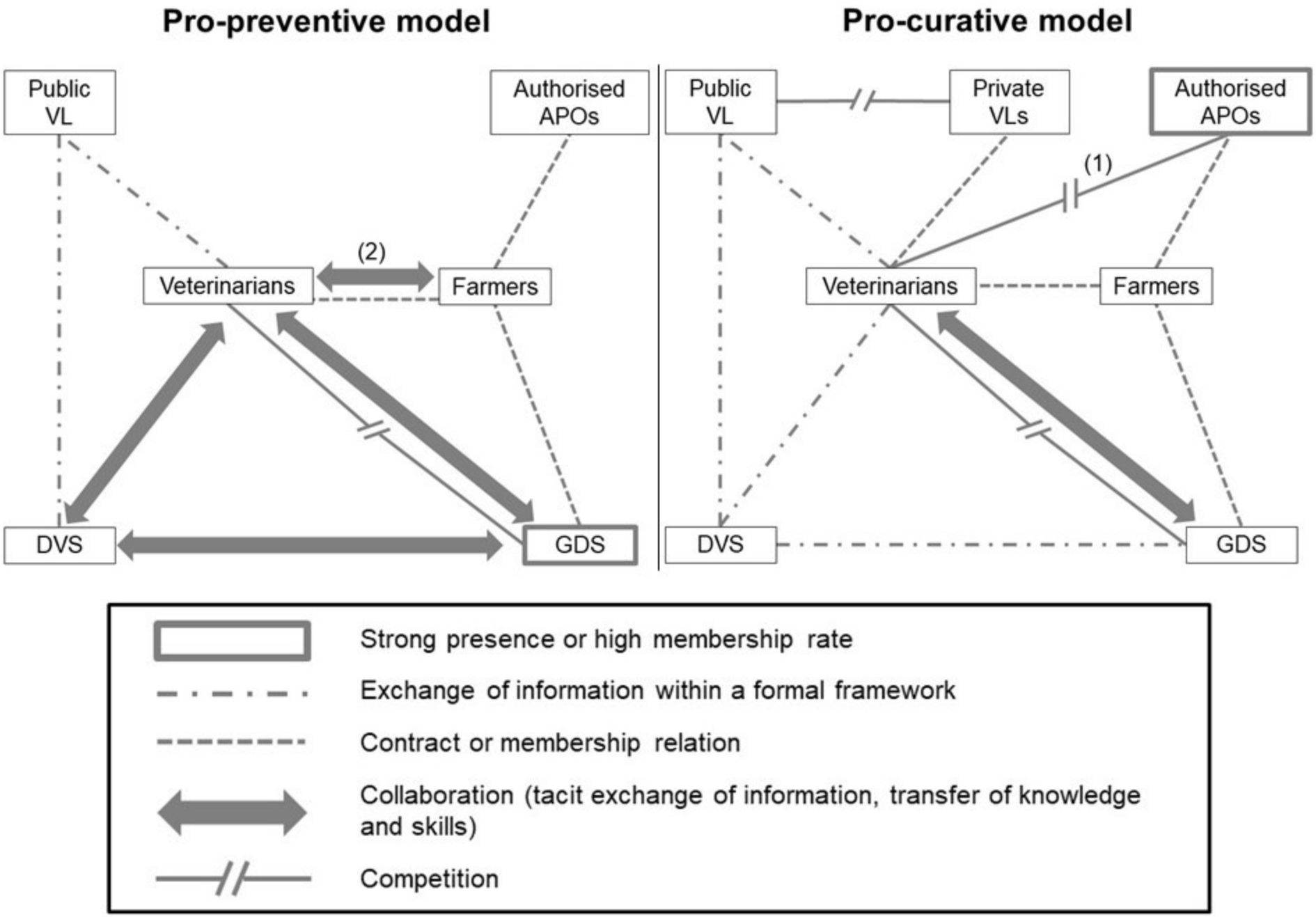


Flow of resources (e.g. samples, analysis results (for veterinarians), information on farmers' practices and farm situations, subsidies, traceability information)

Flow of information on farm sanitary status concerning infectious diseases (e.g. analysis results, diagnoses)

Proximity to the source of sanitary information *(the darker the discs are, the more frequent the interactions with farmers for sanitary purposes are)*

Figure 2


Pro-preventive model
Public VL
Authorised APOs
(2)
Veterinarians
Farmers
DVS
GDS
Pro-curative model
Public VL
Private VLs
Authorised APOs
(1)
Veterinarians
Farmers
DVS
GDS
Strong presence or high membership rate
Exchange of information within a formal framework
Contract or membership relation
Collaboration (tacit exchange of information, transfer of knowledge and skills)
Competition