Elaboration d’un plan de sécurisation de la filière porcine vis-à-vis du risque lié au virus de l’hépatite E

PARTIE 4.1. Synthèse des mesures de maîtrise du virus de l'hépatite E envisageables dans la filière porcine

A partir des données récentes disponibles dans la littérature concernant le risque présenté par les produits porcins et l'épidémiologie du HEV dans les élevages de porcs, et des résultats obtenus au cours de la thèse, notamment en ce qui concerne l'influence des co-infections immunomodulatrices ainsi que la diffusion du virus dans la filière porcine, des **pistes d'action** ont été identifiées. Elles ont été **formulées sous forme de propositions**, soumises aux organisations publiques et privées gestionnaires du risque. L'ensemble du rapport est disponible en Annexe 8, seules les pistes d'action sont reprises ci-après :

Dix pistes d'action pour la maîtrise du risque HEV dans la filière porcine

AXE I - Lutte en élevage

Piste 1 : Accompagner les élevages (particulièrement ceux de grande taille ayant un mode de production intensif) vers des pratiques de biosécurité externe (sas sanitaire, quarantaine) et interne (limitation des adoptions et des mélanges, gestion des effluents) plus sûres.

Piste 2 : Soutenir la mise en place de programmes d'éradication des pathogènes immunomodulateurs, notamment du virus du SDRP.

Piste 3 : En collaboration avec les vétérinaires sanitaires, réaliser des dépistages HEV dans les élevages souhaitant s'engager dans un programme de maîtrise du HEV et assurer le suivi de leur situation sanitaire.

AXE II - Organisation de la filière

Piste 4 : Envisager la structuration d'une filière spécifique permettant aux élevages reconnus indemnes de HEV de fournir des foies sains pour la fabrication des produits à risque.

AXE III - Surveillance

Piste 5 : Inclure le HEV dans les prochains plans de surveillance et de contrôle annuels sur carcasses, abats et produits transformés.

AXE IV - Communication

Piste 6 : Réaliser une campagne d'information pour sensibiliser les acteurs de la filière porcine, notamment à l'échelon de l'élevage, à la problématique du HEV.

AXE V - Recherche

Piste 7 : Evaluer la faisabilité technique et l'acceptabilité sociale d'un plan de lutte par les différents acteurs de la filière.

Piste 8 : Réaliser une étude d'intervention en élevage permettant d'évaluer l'efficacité en conditions réelles des mesures de luttes proposées.

Piste 9 : Evaluer la prévalence de carcasses contaminées à l'abattage à partir d'un échantillonnage ciblé sur les facteurs de risque identifiés en élevage.

Piste 10 : Evaluer, à partir de viande de porcs infectés en conditions expérimentales, l'efficacité des process de séchage et de salaison utilisés dans les IAA sur la diminution de la charge virale dans les produits de charcuterie et salaison.

Ce qu'il faut retenir

Des mesures de maîtrise du HEV ont été identifiées, à l'échelle de l'élevage (structuration des élevages, mesures de biosécurité externe et interne, maîtrise de la situation sanitaire vis-à-vis des pathogènes intercurrents) et de la filière (organisation des échanges et de l'approvisionnement en matières premières pour les produits à risque). La mise en place d'un tel programme de lutte nécessiterait des changements de pratiques de la part des différents acteurs de la filière. Pour garantir l'application de ces mesures sur le terrain, il apparaît alors nécessaire d'étudier leur faisabilité technique et leur acceptabilité, c'est-à-dire les freins et motivations des acteurs à adopter de nouveaux comportements. C'est dans cet objectif que les sciences sociales ont été mobilisées dans la suite du projet.

Take home message

Measures to control HEV have been identified, at the farm level (farm structure, external and internal biosecurity measures, health management as regards intercurrent pathogens) and the production sector level (organisation of trade and of the supply in raw material for at-risk foodstuffs). The implementation of such a control programme would require changes in practices by the various actors in the sector. To ensure that these measures are applied in the field, it is then necessary to study their technical feasibility and acceptability, i.e. the obstacles and motivations of the actors to adopt new behaviours. It is with this objective in mind that the social sciences were mobilized in the rest of the project.

PARTIE 4.2. Retour vers le terrain : évaluation de la faisabilité d'un plan de lutte contre le virus de l'hépatite E dans la filière de production porcine

I. Enquête préliminaire : quelle connaissance les acteurs de la filière porcine ont-ils du virus de l'hépatite E ?

L'implication des acteurs de la filière dès la phase d'élaboration d'un programme de lutte contre un pathogène à l'échelle de l'élevage est la première garantie d'un plan de maîtrise effectivement mis en place sur le terrain. Entre autres choses, **l'engagement des parties prenantes dépend de la connaissance qu'elles ont du pathogène en question et de leur sensibilisation à l'importance de la problématique pour la filière**. L'importance de l'hépatite E, en tant qu'infection zoonotique émergente pour laquelle les cas sont difficiles à relier avec certitude avec la consommation de denrées alimentaires contaminées, est mésestimée, même parmi le monde médical et scientifique. En outre, le HEV circule dans les élevages de porcs sans causer aucun signe clinique ni perte de production. Pour toutes ces raisons, **le HEV est susceptible d'être méconnu des acteurs de la filière porcine**, notamment les éleveurs et les vétérinaires. Dans ce contexte, une **enquête préliminaire** a été conduite auprès des éleveurs de porcs et des vétérinaires du secteur porcin afin d'**évaluer leur niveau de connaissance du HEV et de déterminer les éléments nécessitant de renforcer les efforts de communication et de sensibilisation.**

Les questionnaires diffusés sont disponibles en ligne[26]. Ce travail a donné lieu à une publication dans le journal *Preventive Veterinary Medicine* (Salines *et al.*, 2018c) et à la création d'une brochure d'information à destination des éleveurs et vétérinaires (Annexe 9).

[26] Questionnaire à destination des éleveurs de porcs : https://forms.gle/qXMg6jxKZq4gVA8C8
Questionnaire à destination des vétérinaires en production porcine : https://forms.gle/pEKSFMTRg8wH2Eq47

Publication 10

Salines M., Andraud M., F. Terrade, Rose N., 2018. Are French pig farmers and veterinarians knowledgeable about emerging foodborne pathogens? The case of hepatitis E virus. *Preventive Veterinary Medicine* 156, 1-7.

Preventive Veterinary Medicine 156 (2018) 1–7

Contents lists available at ScienceDirect

Preventive Veterinary Medicine

journal homepage: www.elsevier.com/locate/prevetmed

Are French pig farmers and veterinarians knowledgeable about emerging foodborne pathogens? The case of hepatitis E virus

Morgane Salines[a,b,*], Mathieu Andraud[a,b], Florence Terrade[c], Nicolas Rose[a,b]

[a] ANSES, Ploufragan-Plouzané Laboratory, Swine Epidemiology and Welfare Research Unit, Ploufragan, France
[b] Université Bretagne-Loire, Rennes, France
[c] Université de Rennes 2, Laboratoire de Psychologie, Cognition, Comportement, Communication (LP3C), EA 1285, Rennes, France

ARTICLE INFO

Keywords:
Farmer
Foodborne zoonosis
Hepatitis E virus
Knowledge
Veterinarian

ABSTRACT

Hepatitis E virus (HEV) is an emerging zoonotic pathogen mainly transmitted via food in developed countries, and for which domestic pigs are recognised as the main reservoir. To implement an efficient HEV surveillance and control plan in the pig production sector, it is first necessary to assess the level of knowledge of pig-farming main actors about this pathogen. To this aim, an online survey was conducted between September and October 2017 to evaluate pig farmers' and veterinarians' knowledge about HEV epidemiology and its zoonotic potential. The questionnaire was filled in by 383 pig farmers and 46 pig veterinarians. Of this population, 77.8% of farmers and 8.7% of veterinarians had never heard of HEV. Our results highlight knowledge gaps among responding farmers, especially regarding the clinical and epidemiological features of HEV, while veterinarians appear to be well-informed about this pathogen. These findings indicate significant room for further improvement and the need for more information aimed at French pig farmers, with veterinarians acting as a priority channel through which information may be transferred from scientists to farmers. These educational efforts will facilitate farmers' involvement in future HEV surveillance and control plans.

1. Introduction

Food safety management used to be downstream-oriented, with a specific focus on the examination of food-processing operations and the control of finished products. However, in the last decades a significant turning point has been observed in the vision of food hygiene, with growing awareness of the importance of an integrated approach considering the whole food chain ("from farm to fork"). In this perspective, prevention and control measures have to be implemented at each production/processing/distribution stage, involving all stakeholders (Anonymous, 2002). In particular, for food of both animal and plant origins, special attention has been given to farming steps in order to avoid the introduction of foodborne pathogens on farms or limit their prevalence at the primary production level (European Food Safety, 2007, 2008). However, no surveillance or control programme at farm level can be effectively implemented without stakeholders' involvement, notably that of farmers and veterinarians. Among other things, their involvement primarily depends on their knowledge of the pathogen and their understanding of the importance of the issue. Several studies have evidenced major knowledge gaps among farmers regarding food safety topics, reducing their ability and/or their willingness to implement control programmes (Bahnson et al., 2001; Ellis-Iversen et al., 2010; Young et al., 2010a; Young et al., 2010b). For instance, a study led in the US showed that pork producers recognise their key role in pork food safety and express their willingness to participate, but also revealed that they need additional information and education about pathogens and control measures (Bahnson et al., 2001). Ellis-Iversen et al. (2010) also explored motivational factors for the implementation of zoonotic disease control programmes among English and Welsh cattle farmers; they showed that some farmers do not implement control programmes because of external barriers, including lack of knowledge. Fewer studies have investigated veterinarians' knowledge regarding food safety issues in industrialised countries. Marvin et al. (2010), for example, reported that veterinarians were more familiar with food safety issues than were other professional groups. Moreover, a number of publications noted that farmers considered private veterinarians as the most knowledgeable and trustworthy regarding animal diseases, zoonoses and antimicrobial use (Alarcon et al., 2014; Laanen et al., 2014; Marier et al., 2016; Mahon et al., 2017; Poizat et al., 2017). If sufficiently informed, veterinarians may therefore be an efficient channel through which to pass food safety fundamentals on to farmers.

The case of hepatitis E virus (HEV) is a challenging issue. Hepatitis E

* Corresponding author at: ANSES, Ploufragan-Plouzané Laboratory, Swine Epidemiology and Welfare Research Unit, Ploufragan, France.
E-mail addresses: morgane.salines@anses.fr (M. Salines), mathieu.andraud@anses.fr (M. Andraud), florence.terrade@univ-rennes2.fr (F. Terrade), nicolas.rose@anses.fr (N. Rose).

https://doi.org/10.1016/j.prevetmed.2018.04.015
Received 24 January 2018; Received in revised form 27 March 2018; Accepted 23 April 2018

is a worrying zoonosis mainly transmitted via food in developed countries and for which domestic pigs are recognised as the main reservoir (Dalton et al., 2008; Pavio et al., 2010; EFSA et al., 2017). Although the majority of human cases are asymptomatic, HEV can also cause acute, fulminant or chronic hepatitis that may be difficult to treat (Emerson and Purcell, 2003; Kamar et al., 2011). However, hepatitis E is a little-known disease even among medical doctors and scientists. It is considered as an emerging zoonosis in the sense that the number of reported cases has been constantly increasing these last few years in European countries (e.g. in France, only nine cases were reported in 2002, versus 2292 in 2016), but this is due more to a higher number of diagnostic tests than to an actual increase in the number of cases (CNR, 2017; EFSA et al., 2017). Although foodborne transmission from pork products is proven, few cases have actually been tied to the consumption of an HEV-contaminated pork product. For all these reasons, the knowledge of stakeholders in the pig farming sector about HEV may be imperfect. Moreover, HEV circulates on pig farms without causing any clinical signs in pigs or leading to financial losses. As Alarcon et al. (2014) showed that drivers for disease control by pig farmers were 'pig mortality', 'feeling of entering in an economically critical situation' and 'animal welfare', raising awareness about HEV may be problematic. To date, no HEV surveillance and control plan has ever been implemented in Europe (Salines et al., 2017a). However, articles on the risk of HEV related to the consumption of contaminated pork products have recently been published in the mass media after new scientific findings (for example following the paper by Said et al. (2017)). Thus, pig producer organisations are becoming increasingly aware of the risk of a crisis of confidence in the pork sector and are willing to control HEV on pig farms.

In this context, the aim of our study was to assess the level of knowledge of French pig farmers and veterinarians concerning HEV in order to raise actors' awareness of this issue and to involve them in future risk management strategies.

2. Material and methods

2.1. Survey design

Two similar questionnaires were developed to investigate pig farmers' and veterinarians' level of knowledge concerning HEV (see Supplementary File 1). Both were composed of 19 questions and the time needed to fill them in was estimated at 10 min. Most of the questions were closed to increase the comparability of respondents' answers. A short introduction briefly explained the context of the study, without going into too much detail to avoid helping respondents answer the questionnaire. Emphasis was placed on the anonymity of the answers and the shortness of the survey. The first question aimed to find out whether the responding farmers/veterinarians had ever heard of HEV. The main features of HEV were then addressed in the following questions, in particular regarding the overall situation of HEV in the French pig farming sector, clinical and epidemiological characteristics in pigs (clinical signs, treatment, vaccine, transmission routes between pigs and control measures) as well as HEV zoonotic transmission routes from pigs to humans. Veterinarians were also asked to rank the importance of the HEV issue at three levels: public health, economy of the pig production sector and risk of negative media exposure. Finally, the last part of the questionnaire was designed to collect general data on the respondent's characteristics: gender, age, type of farm or of veterinary practice. The final question was open-ended to allow respondents to express their comments, questions and concerns.

2.2. Data collection and analysis

The target populations were all pig farmers and pig veterinarians in metropolitan France. The questionnaires were developed as an online survey using Google Forms software (https://docs.google.com/forms).

Table 1
Main characteristics of questionnaire respondents (n = 383 farmers and 46 veterinarians).

Variable	Category	Farmer sample (n = 383) Number (percentage)	Veterinarian sample (n = 46) Number (percentage)
Gender	Male	307 (80.2%)	31 (67.4%)
	Female	76 (19.8%)	15 (32.6%)
Age	< 30 y/o	16 (4.2%)	2 (4.3%)
	30–39 y/o	78 (20.4%)	18 (39.1%)
	40–49 y/o	107 (27.9%)	15 (32.7%)
	50–59 y/o	155 (40.5%)	7 (15.2%)
	≥60 y/o	27 (7.0%)	4 (8.7%)
Type of farm	Nucleus	7 (1.8%)	–
	Multiplication	15 (3.9%)	–
	Farrowing	9 (2.4%)	–
	Farrowing Post-weaning	4 (1.1%)	–
	Farrowing-to-finishing	228 (59.5%)	–
	Post-weaning	2 (0.5%)	–
	Post-weaning Finishing	56 (14.6%)	–
	Finishing	40 (10.4%)	–
	Other[a]	22 (5.8%)	–
Type of veterinary practice[b]	Independent practitioner	–	22 (47.8%)
	Salaried practitioner	–	20 (43.4%)
	Academic, researcher, teacher	–	1 (2.2%)
	Pharmaceutical industrial	–	1 (2.2%)
	No answer	–	2 (4.4%)
Level of veterinarians' specialisation[b]	Pig farms as only clients	–	32 (69.5%)
	Pig farms as major clients	–	7 (15.2%)
	Pig farms as occasional clients	–	2 (4.4%)
	No answer / NA		5 (10.9%)

[a] The category "other" includes small farms (< 10 sows or < 10 finishing places) or owners of pet pigs.
[b] For practitioners only. NA: not applicable.

The survey was e-mailed to farmers by grading, weighing and marking bodies upon the request of the French Interprofessional Pork Council (INAPORC); and to veterinarians by the French Association for Pig Veterinary Medicine (AFMVP). Data were collected between 1st September and 15th October 2017.

Respondents' characteristics and knowledge concerning HEV were quantitatively described. For ease of reading, most of the descriptive results in the following section are presented as colour-coded charts with the correct answers highlighted in green. A Chi-square test was performed to investigate any association between respondents' features (age, farm type) and their HEV knowledge.

3. Results

3.1. Study sample

The questionnaire was sent to 8075 pig farmers and 150 veterinarians having a pig practice. A total of 383 farmers and 46 veterinarians filled in the questionnaire, which corresponds to a response rate of approximately 4.7% and 30.7% respectively. The characteristics of respondents and farms/practices are summarised in Table 1. Most of the farmers had farrow-to-finish herds; most of the veterinarians were practitioners specialised in pigs.

3.2. Basic knowledge about HEV

Of the 383 farmers and 46 veterinarians, 77.8% and 8.7% respectively had never heard of HEV. For farmers, having heard of HEV was neither related to the type of farm nor to the respondents' age (p-value > 0.1). In the following sections, only the answers of the 85 farmers (22.2%) and of the 42 veterinarians (91.3%) having heard of HEV were analysed, considering that the others answered the questions randomly. Most farmers had heard about HEV through professional media or their veterinarian (as mentioned by 31 and 13 farmers respectively). Veterinarians had heard about HEV through veterinary schools or research institutes (as cited by 21 veterinarians), professional media (19), professional associations (18) or other veterinarians (14).

3.3. Situation of the French pig production sector regarding HEV

More than 68% of farmers and 92% of veterinarians were aware that HEV was present in France; 76% and 97.6% of them respectively knew that it can infect pigs. Only one out of the 85 farmers and five out of the 42 veterinarians knew that HEV was present on 61%–80% of farms (Rose et al., 2011). The majority of the respondents said that they did not know HEV prevalence in the French pig production sector or they underestimated it (Fig. 1).

3.4. Clinical and epidemiological features of HEV in pigs

3.4.1. Clinical signs, treatment and vaccination

More than 68% of the 85 farmers versus 14% of the 42 veterinarians wrongly thought that HEV caused clinical signs in pigs (Fig. 2). The following symptoms were cited: digestive disorders (27 farmers versus 1 veterinarian), production losses (20 vs. 0), mortality (13 farmers), neurological disorders (7 farmers), reproductive disorders (7 farmers) and respiratory disorders (6 farmers). Around 14% of the 85 farmers mistakenly thought that there was a treatment against HEV, most of them mentioning antibiotics (Fig. 2). More than 11% of farmers incorrectly thought that a vaccine against HEV existed (Fig. 2). Veterinarians knew that there was neither a treatment nor a vaccine against HEV (Fig. 2).

3.4.2. Transmission routes between pigs and control measures on pig farms

Direct and environmental within- and between-pen HEV transmission routes were rightly mentioned by 31, 43 and 39 farmers and by 23, 32 and 39 veterinarians respectively, whereas airborne transmission was wrongly mentioned by 3 farmers and 5 veterinarians (Fig. 3) (Kasorndorkbua et al., 2004; Bouwknegt et al., 2008; Andraud et al., 2013). The most frequently mentioned HEV control measures were the reinforcement of cleaning-disinfection protocols and an extension of fallowing periods (53 farmers and 35 veterinarians), strengthening of internal biosecurity measures (47 and 36), reduction of pig mingling (43 and 2), and checking of water quality (17 and 25) (Fig. 4) (Walachowski et al., 2014).

3.5. HEV as an issue

3.5.1. HEV's zoonotic potential

Among the 85 farmers and 42 veterinarians having heard of HEV, 80% and 100% of them respectively rightly thought that HEV can infect humans. These percentages dropped to 57% and 98% respectively when asking whether HEV transmission from pigs to humans was possible. Only 34%, 35% and 49% of the 85 farmers knew that HEV can be transmitted to humans through contact with soiled pigs, an accidental injection/cut with soiled equipment or the consumption of contaminated pork products, in that order (Fig. 5). These figures were higher for veterinarians: respectively 55%, 64% and 81% for the three aforementioned transmission routes, the major one being recognised as the consumption of contaminated pork products (Fig. 5) (Chaussade et al., 2013; Dalton and Izopet, 2018).

3.5.2. Concerns about HEV

A number of farmers expressed concern in the open comments section of the questionnaire and asked for a report on the answers to the survey. Of the 429 respondents, 292 farmers (76.2%) and 42 veterinarians (91.3%) wished to be provided with more information. Similarly, 227 farmers (59.3%) and 43 veterinarians (93.5%) said they were willing to participate in another survey on HEV. When asked about the importance of HEV in the pig production sector, veterinarians agreed that it is an important issue because of the risk of negative media exposure (87%), in terms of public health (74%) and from an economic

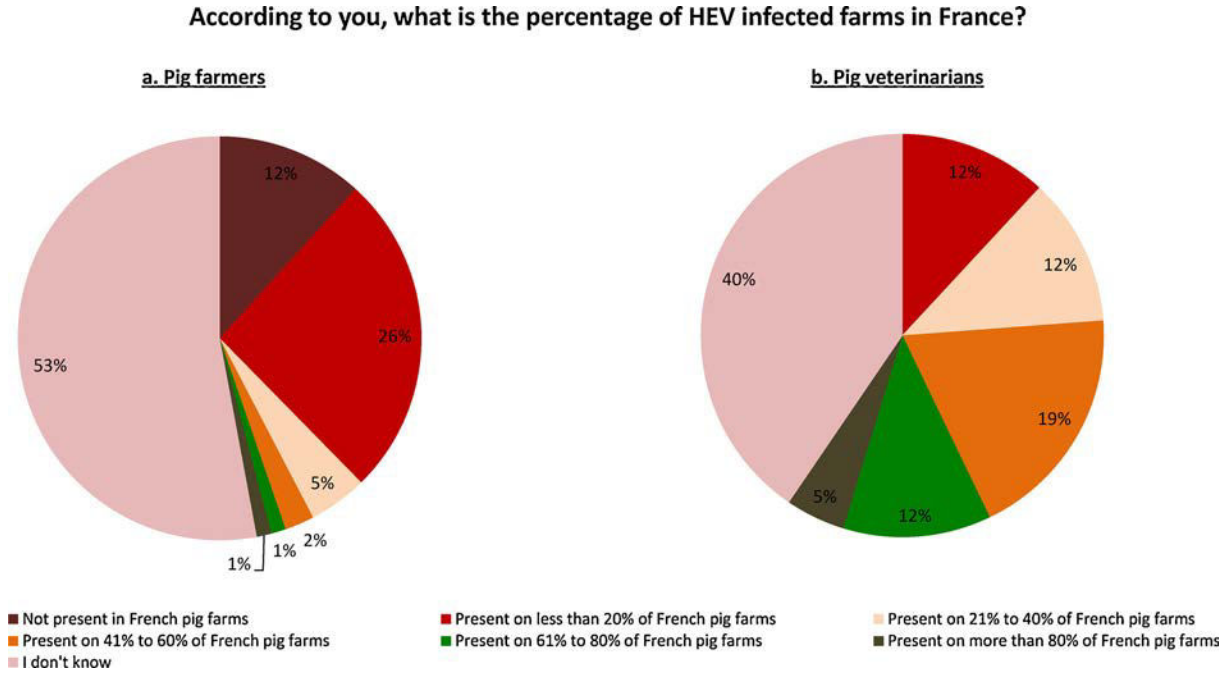

Fig. 1. Pig farmers' (a) and veterinarians' (b) opinion regarding HEV prevalence in the French pig production sector (85 farmers, 46 veterinarians).

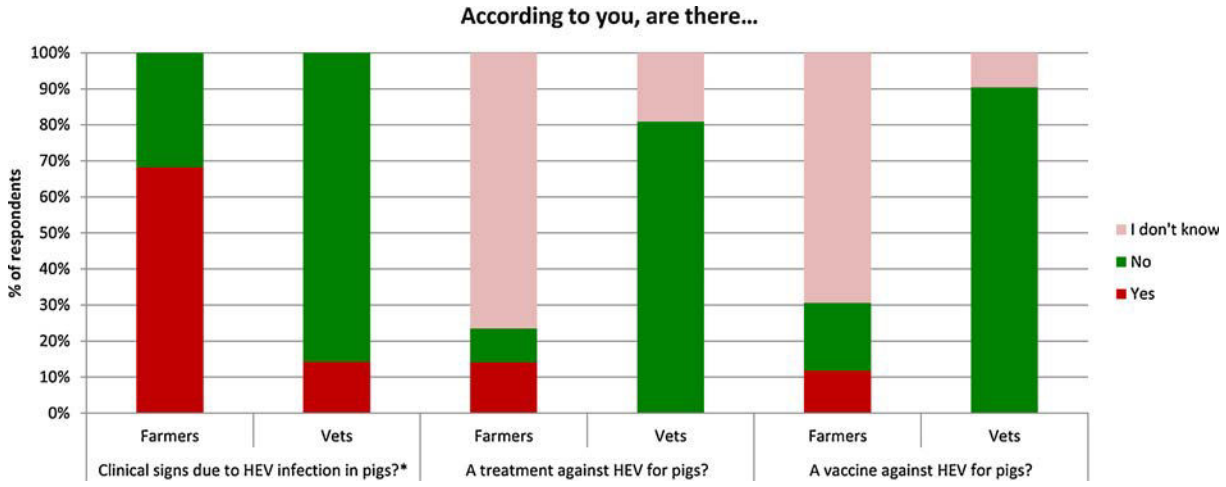

Fig. 2. Pig farmers' and veterinarians' opinion regarding clinical signs of HEV, treatment and vaccination (85 farmers, 46 veterinarians).
* the "I don't know" option was not proposed for this question.

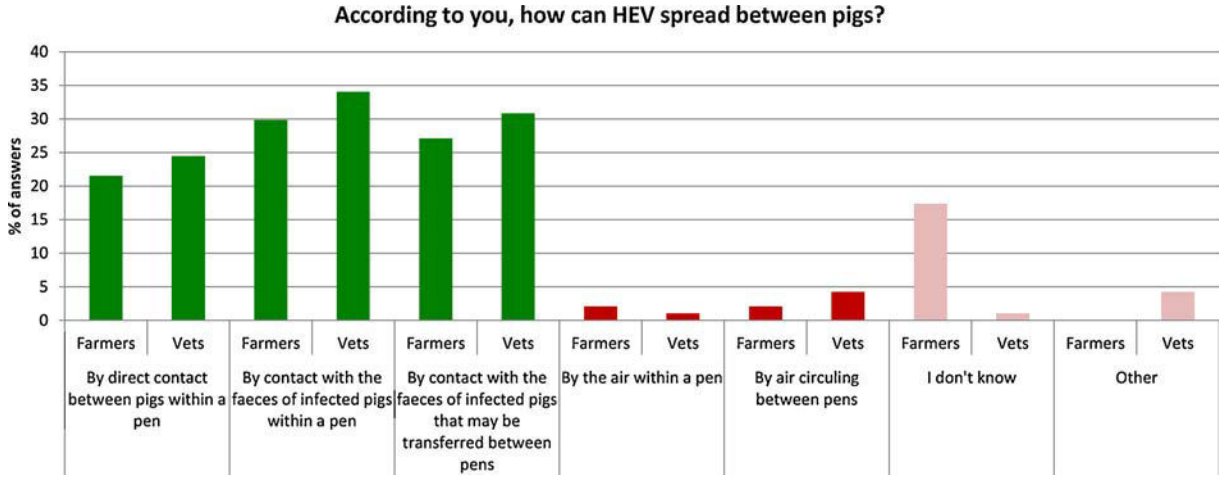

Fig. 3. Pig farmers' and veterinarians' opinion regarding HEV transmission routes between pigs (85 farmers, 144 answers from farmers; 46 veterinarians, 94 answers from veterinarians).

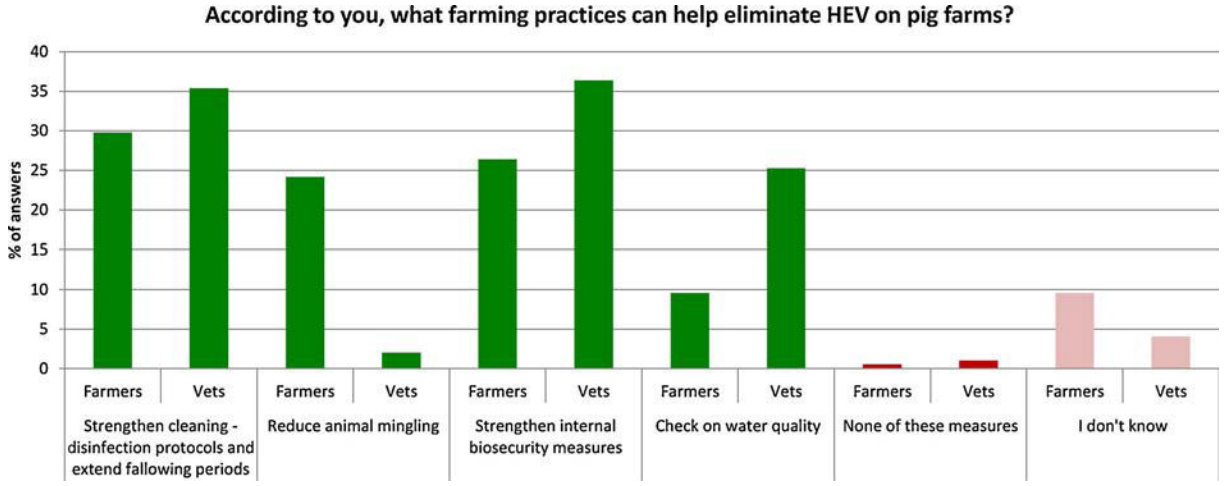

Fig. 4. Pig farmers' and veterinarians' opinion regarding possible HEV control measures (85 farmers, 178 answers from farmers; 46 veterinarians, 99 answers from veterinarians).

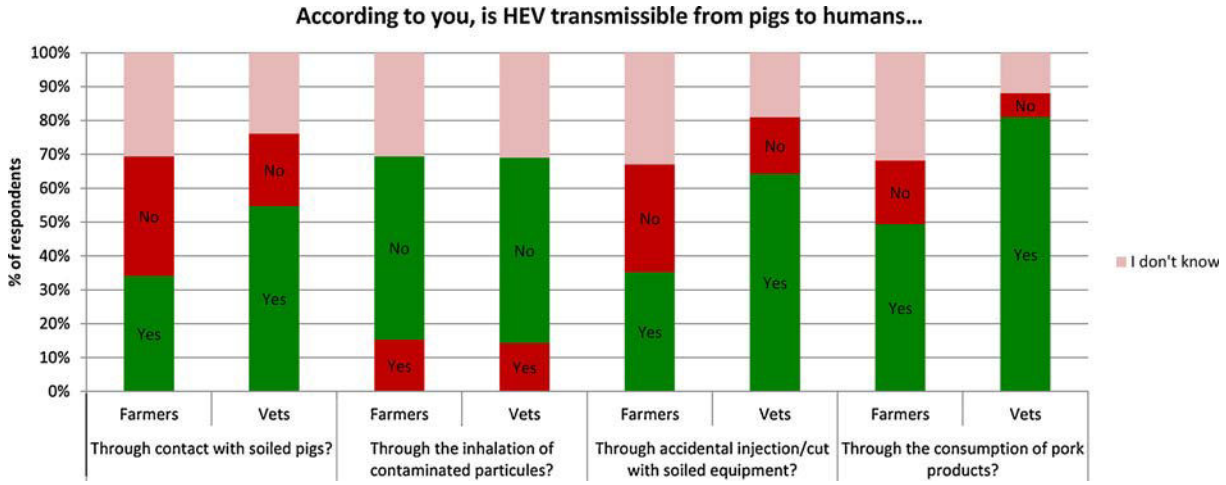

Fig. 5. Pig farmers' and veterinarians' opinion regarding zoonotic transmission routes of HEV from pigs to humans (85 farmers, 46 veterinarians).

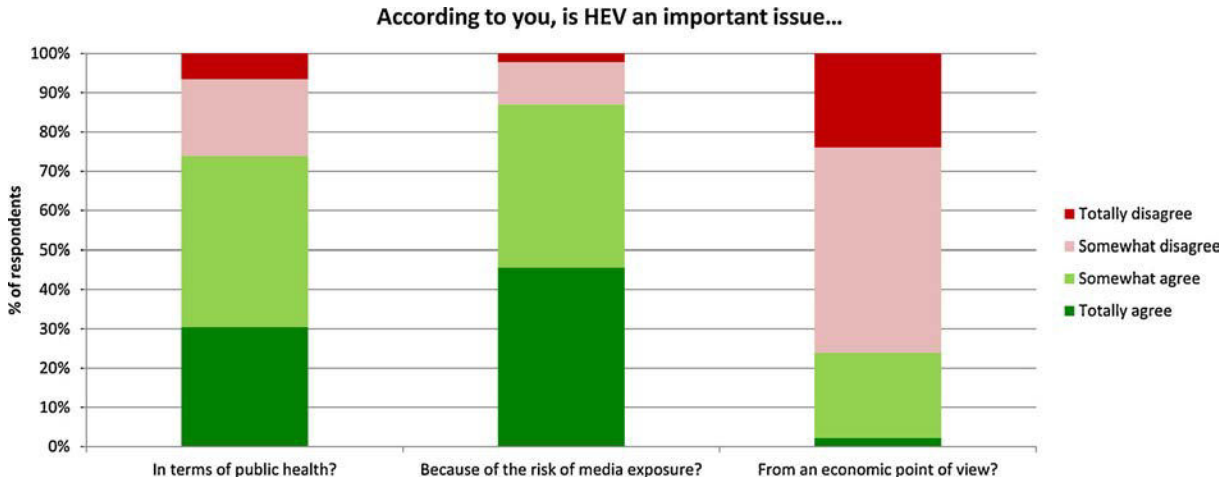

Fig. 6. Pig veterinarians' opinion regarding the importance of the HEV issue in the pig production sector (n = 46).

point of view (24%) (Fig. 6).

4. Discussion

The very first step in raising the awareness of stakeholders and involving them in a disease control plan is to ensure that they are well-informed about the pathogen in question. The primary interest of our study lies in providing baseline data about pig farmers' and veterinarians' knowledge concerning HEV. As far as we are aware, this is the first study on this topic. Many studies have investigated farmers' level of knowledge about non-zoonotic animal diseases (Jansen et al., 2010; Guinat et al., 2016; Jones et al., 2016). Other studies have addressed farmers' and/or veterinarians' knowledge concerning on-farm biosecurity measures (Kristensen and Jakobsen, 2011; Racicot et al., 2012; Simon-Grife et al., 2013; Laanen et al., 2014) or resistance to antimicrobials (Jones et al., 2015). However, fewer studies have addressed the particular case of farmers' and veterinarians' knowledge about zoonotic diseases, and most of these have been oriented towards zoonotic risks for professionals (Dowd et al., 2013; Robin et al., 2017). Moreover, these publications have generally reported data on stakeholders' attitudes towards and perceptions of a disease, with no specific focus on their knowledge.

Assuming that pig farmers and veterinarians would be the two major actors involved in the implementation of a future on-farm HEV surveillance and control plan, our study was designed as a two-level survey targeting farmers and veterinarians similarly and simultaneously. E-mail contact was chosen as a way to reach the largest population. However, the response rates observed in published publications having used the same communication channel are quite low (Guinat et al., 2016). In comparison, our survey has satisfactory response rates, especially as regards veterinarians. For veterinarians, the absolute number of respondents also makes sense, since the total population of swine practitioners is small. Because of the low response rate in the farmer population, the results of this survey have to be interpreted with caution. Our study sample shows great diversity in terms of type of farming activity and of veterinary practice. The distribution between the different types of farming (breeders, farrowers-to-finishers, finishers, etc.) from our survey is close to the results of the last official French agricultural census (Agreste, 2013), but comparison with more recent data (Salines et al., 2017b) evidences an over-representation of farrow-to-finish pig farms. No published data have been found to assess the representativeness of the veterinary sample. It is likely that the responding farmers and veterinarians are a biased sample, as they may be the most involved in their work or the most interested in this issue. Farrow-to-finish farmers, for instance, may be more interested in the safety of the end product they are marketing than other types of farmer.

Despite these biases, the results from this survey led to a number of noteworthy conclusions as regards the level of knowledge of pig farming stakeholders concerning HEV. Our study revealed HEV knowledge gaps among pig farmers. Only a minority of them had ever heard of HEV, but of those who had, a majority was aware of possible HEV transmission from pigs to humans, half of them knowing that the

virus could be transmitted through the consumption of pork products. However, their knowledge on the clinical and epidemiological aspects of HEV in pigs was poor. Several papers have already shown that farmers' knowledge of zoonoses is low. For instance, Mahon et al. (2017) recently reported that two-thirds of Irish farmers were unaware that a zoonosis is a disease a person gets from an animal, and that 90% did not know that apparently healthy animals may be a source of infection for humans. Bahnson et al. (2001) also evidenced knowledge gaps among American pork producers, e.g. regarding the zoonotic potential of *Salmonella*, *Trichinella* and *Campylobacter* to pass from pigs to humans. Canadian dairy producers also showed knowledge gaps regarding zoonotic risks linked to *Brucella* and *Cryptosporidium* (Young et al., 2010a). Similarly to what Marvin et al. (2010) reported regarding knowledge of zoonoses in the American pig production sector, the veterinarians in our survey were better-informed about HEV than farmers. Such an outcome was expected, mainly because veterinarians have better access to continuous training programmes and updated scientific information. Still, around 15% of veterinarians wrongly thought that HEV causes clinical signs. On a similar point, Marvin et al. (2010) also interestingly reported that *Yersinia enterocolitica* — a pathogen that does not have any clinical impact on pig health — was the least familiar hazard to all the respondents to their survey, including veterinarians, only one third of respondents being concerned about the transmission of *Y. enterocolitica* from pigs or pork to people. Thus, one of the critical points limiting farmers' and veterinarians' knowledge concerning HEV may be the absence of clinical signs of the disease in pigs. Moreover, scientific knowledge about HEV is constantly evolving and some HEV features are still poorly documented, e.g. the efficiency of control measures (Salines et al., 2017a). Informing stakeholders about these points may therefore be challenging.

A few studies have concluded that producers recognise the need to control foodborne pathogens, that they are aware of their role in food safety and that they are willing to adopt better practices to improve it (Bahnson et al., 2001; Ellis-Iversen et al., 2010; Marier et al., 2016). However, our findings suggest that pig farmers' knowledge related to HEV may reduce their ability to participate in future HEV control and surveillance plans. The possibility of improving production practices to decrease HEV prevalence as needed will depend in part on farmers having a solid knowledge base. Thus, additional farmer education on the clinical and epidemiological features of HEV is needed. Since veterinarians have been shown to be the best placed for passing food safety knowledge on to farmers (Bahnson et al., 2001; Marvin et al., 2010), and as they seem to have satisfactory knowledge about HEV, they could act as a knowledge transfer channel between researchers and farmers. However, veterinarians and farmers are generally federated within specifically clustered groups and their respective representatives therefore need to consider how to formalise information transfer between these groups. In France, for example, there are specific continuous training organisations for veterinarians, but they address questions very specific to veterinarians, and knowledge transfer to farmers is not a priority. Farmer organisations also have their own objectives, with a strong emphasis on the economic resilience of the system. Further improvements should be considered in the future to facilitate communication and knowledge transfer between veterinary and farmer organisations and prevent conflicts of interest between both parties. Because HEV is still little-known and research projects are currently underway to better understand its spread and persistence in the pig production sector, farmers and veterinarians should also be regularly provided with updated information from the scientific field. To this aim, an initial factsheet on HEV features has been designed and will be sent to the 8075 pig farmers that were contacted for this survey. Moreover, stakeholders' behaviour towards a given pathogen does not only depend on their knowledge but also on various factors that could be classified into three categories: *(i)* attitude towards the behaviour (i.e. the individual's degree of attractiveness or repulsion towards the particular behaviour), *(ii)* subjective norm (i.e. an individual's perception about the particular behavior, which is influenced by the judgment of significant others), and *(iii)* perceived behavioural control (i.e. an individual's perceived ease or difficulty of performing the particular behaviour) (Ajzen, 1991). These key factors themselves depend on external features such as demographical factors (age, gender, religion, origin, etc.), global dispositions (personality, general attitude, self-esteem, emotions, etc.) and education (experience, knowledge, access to media, etc.). Further studies would therefore be required to determinate whether farmers and veterinarians are willing and able to implement control and surveillance plans of HEV in the pig production sector.

5. Conclusions

Our baseline study highlighted HEV knowledge gaps among pig farming stakeholders that have to be filled. Targeted educational efforts need to be made in an attempt to raise the awareness of farmers and veterinarians concerning HEV. Before initiating an HEV risk mitigation plan, further studies are needed to investigate the barriers to controlling the pathogen as perceived by farmers, as well as their preferred motivators. This kind of data would help risk managers facilitate surveillance and control implementation by steering efforts to remove specific obstacles and thereby create favourable conditions for HEV control on pig farms.

Author contributions

MS, FT, MA and NR designed the questionnaires. MS analysed the data and drafted the manuscript. NR initiated and coordinated the project. All the co-authors revised the manuscript and approved the final submitted version.

Acknowledgements

This work was supported by the French Ministry of Agriculture and Food, and by the French Interprofessional Pork Council (INAPORC). The authors are very grateful to all the pig farmers and veterinarians who answered the survey. They would also like to thank INAPORC, the grading, weighing and marking bodies, and the AFMVP for distributing the questionnaires to farmers and veterinarians.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.prevetmed.2018.04.015.

References

Agreste, 2013. Les élevages de porcs en France métropolitaine en 2010. 11 500 élevages porcins détiennent la quasi-totalité du cheptel national. Agreste Primeur 300, 8. .
Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50, 179–211.
Alarcon, P., Wieland, B., Mateus, A.L., Dewberry, C., 2014. Pig farmers' perceptions, attitudes, influences and management of information in the decision-making process for disease control. Prev. Vet. Med. 116, 223–242.
Andraud, M., Dumarest, M., Cariolet, R., Aylaj, B., Barnaud, E., Eono, F., Pavio, N., Rose, N., 2013. Direct contact and environmental contaminations are responsible for HEV transmission in pigs. Vet. Res. 44, 102.
Anonymous, 2002. Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European food safety authority and laying down procedures in matters of food safety. Off. J. L31, 1–24.
Bahnson, P.B., Michalak, M.M., Miller, G.Y., 2001. Pork producers' attitudes, knowledge, and production practices that relate to on-farm food safety. J. Food Prot. 64, 1967–1972.
Bouwknegt, M., Frankena, K., Rutjes, S.A., Wellenberg, G.J., de Roda Husman, A.M., van der Poel, W.H., de Jong, M.C., 2008. Estimation of hepatitis E virus transmission among pigs due to contact-exposure. Vet. Res. 39, 40.
Chaussade, H., Rigaud, E., Allix, A., Carpentier, A., Touze, A., Delzescaux, D., Choutet, P., Garcia-Bonnet, N., Coursaget, P., 2013. Hepatitis E virus seroprevalence and risk

factors for individuals in working contact with animals. J. Clin. Virol. 58, 504–508.
CNR, 2017. Plan du rapport annuel d'activité. Centre National des Références, Virus des hépatites à transmission entérique.
Dalton, H.R., Bendall, R., Ijaz, S., Banks, M., 2008. Hepatitis E: an emerging infection in developed countries. Lancet. Infect. Dis. 8, 698–709.
Dalton, H.R., Izopet, J., 2018. Transmission and epidemiology of Hepatitis E virus genotype 3 and 4 infections. Cold Spring Harb. Persp. Med. http://dx.doi.org/10.1101/cshperspect.a032144. in press.
Dowd, K., Taylor, M., Toribio, J.A., Hooker, C., Dhand, N.K., 2013. Zoonotic disease risk perceptions and infection control practices of Australian veterinarians: call for change in work culture. Prev. Vet. Med. 111, 17–24.
EFSA, B.P., Ricci, A., Allende, A., Bolton, D., Chemaly, M., Davies, R., Fernandez Escamez, P.S., Herman, L., Koutsoumanis, K., Lindqvist, R., Nørrung, B., Robertson, L., Ru, G., Sanaa, M., Simmons, M., Skandamis, P., Snary, E., Speybroeck, N., Ter Kuile, B., Threlfall, J., Wahlström, H., Di Bartolo, I., Johne, R., Pavio, N., Rutjes, S., van der Poel, W., Vasickova, P., Hempen, M., Messens, W., Rizzi, V., Latronico, F., Girones, R., 2017. Public health risks associated with Hepatitis E virus (HEV) as a food-borne pathogen. EFSA J. 15 e04886-n/a.
Ellis-Iversen, J., Cook, A.J., Watson, E., Nielen, M., Larkin, L., Wooldridge, M., Hogeveen, H., 2010. Perceptions, circumstances and motivators that influence implementation of zoonotic control programs on cattle farms. Prev. Vet. Med. 93, 276–285.
Emerson, S.U., Purcell, R.H., 2003. Hepatitis E virus. Rev. Med. Virol. 13, 145–154.
European Food Safety, A., 2007. Report of the task force on zoonoses data collection on the analysis of the baseline survey on the prevalence of salmonella in broiler flocks of gallus gallus, in the EU, 2005–2006 - Part B: factors related to salmonella flock prevalence, distribution of salmonella serovars, and antimicrobial resistance patterns. EFSA J. 5 101r-n/a.
European Food Safety, A., 2008. Report of the task force on zoonoses data collection on the analysis of the baseline survey on the prevalence of salmonella in slaughter pigs, in the EU, 2006–2007 - Part A: salmonella prevalence estimates. EFSA J. 6 135r-n/a.
Guinat, C., Wall, B., Dixon, L., Pfeiffer, D.U., 2016. English pig farmers' knowledge and behaviour towards African swine fever suspicion and reporting. PloS One 11, e0161431.
Jansen, J., van Schaik, G., Renes, R.J., Lam, T.J., 2010. The effect of a national mastitis control program on the attitudes, knowledge, and behavior of farmers in the Netherlands. J. Dairy Sci. 93, 5737–5747.
Jones, P.J., Marier, E.A., Tranter, R.B., Wu, G., Watson, E., Teale, C.J., 2015. Factors affecting dairy farmers' attitudes towards antimicrobial medicine usage in cattle in England and Wales. Prev. Vet. Med. 121, 30–40.
Jones, P.J., Sok, J., Tranter, R.B., Blanco-Penedo, I., Fall, N., Fourichon, C., Hogeveen, H., Krieger, M.C., Sundrum, A., 2016. Assessing, and understanding, European organic dairy farmers' intentions to improve herd health. Prev. Vet. Med. 133, 84–96.
Kamar, N., Garrouste, C., Haagsma, E.B., Garrigue, V., Pischke, S., Chauvet, C., Dumortier, J., Cannesson, A., Cassuto-Viguier, E., Thervet, E., Conti, F., Lebray, P., Dalton, H.R., Santella, R., Kanaan, N., Essig, M., Mousson, C., Radenne, S., Roque-Afonso, A.M., Izopet, J., Rostaing, L., 2011. Factors associated with chronic hepatitis in patients with Hepatitis E virus infection who have received solid organ transplants. Gastroenterology 140, 1481–1489.
Kasorndorkbua, C., Guenette, D.K., Huang, F.F., Thomas, P.J., Meng, X.J., Halbur, P.G., 2004. Routes of transmission of swine Hepatitis E virus in pigs. J. Clin. Microbiol. 42, 5047–5052.
Kristensen, E., Jakobsen, E.B., 2011. Danish dairy farmers' perception of biosecurity. Prev. Vet. Med. 99, 122–129.
Laanen, M., Maes, D., Hendriksen, C., Gelaude, P., De Vliegher, S., Rosseel, Y., Dewulf, J., 2014. Pig, cattle and poultry farmers with a known interest in research have comparable perspectives on disease prevention and on-farm biosecurity. Prev. Vet. Med. 115, 1–9.
Mahon, M.M., Sheehan, M.C., Kelleher, P.F., Johnson, A.J., Doyle, S.M., 2017. An assessment of Irish farmers' knowledge of the risk of spread of infection from animals to humans and their transmission prevention practices. Epidemiol. Infect. 145, 2424–2435.
Marier, E., Piers Smith, R., Ellis-Iversen, J., Watson, E., Armstrong, D., Hogeveen, H., Cook, A.J., 2016. Changes in perceptions and motivators that influence the implementation of on-farm salmonella control measures by pig farmers in England. Prev. Vet. Med. 133, 22–30.
Marvin, D.M., Dewey, C.E., Rajic, A., Poljak, Z., Young, B., 2010. Knowledge of zoonoses among those affiliated with the ontario swine industry: a questionnaire administered to selected producers, allied personnel, and veterinarians. Foodborne Pathog. Dis. 7, 159–166.
Pavio, N., Meng, X.J., Renou, C., 2010. Zoonotic Hepatitis E: animal reservoirs and emerging risks. Vet. Res. 41, 46.
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.
Racicot, M., Venne, D., Durivage, A., Vaillancourt, J.P., 2012. Evaluation of the relationship between personality traits, experience, education and biosecurity compliance on poultry farms in Quebec, Canada. Prev. Vet. Med. 103, 201–207.
Robin, C., Bettridge, J., McMaster, F., 2017. Zoonotic disease risk perceptions in the British veterinary profession. Prev. Vet. Med. 136, 39–48.
Rose, N., Lunazzi, A., Dorenlor, V., Merbah, T., Eono, F., Eloit, M., Madec, F., Pavio, N., 2011. High prevalence of Hepatitis E virus in French domestic pigs. Comp. Immunol. Microbiol. Infect. Dis. 34, 419–427.
Said, B., Usdin, M., Warburton, F., Ijaz, S., Tedder, R.S., Morgan, D., 2017. Pork products associated with human infection caused by an emerging phylotype of Hepatitis E virus in England and Wales. Epidemiol. Infect. 145, 2417–2423.
Salines, M., Andraud, M., Rose, N., 2017a. From the epidemiology of Hepatitis E virus (HEV) within the swine reservoir to public health risk mitigation strategies: a comprehensive review. Vet. Res. 48, 31.
Salines, M., Andraud, M., Rose, N., 2017b. Pig movements in France: designing network models fitting the transmission route of pathogens. PloS One 12, e0185858.
Simon-Grife, M., Martin-Valls, G.E., Vilar-Ares, M.J., Garcia-Bocanegra, I., Martin, M., Mateu, E., Casal, J., 2013. Biosecurity practices in Spanish pig herds: perceptions of farmers and veterinarians of the most important biosecurity measures. Prev. Vet. Med. 110, 223–231.
Walachowski, S., Dorenlor, V., Lefevre, J., Lunazzi, A., Eono, F., Merbah, T., Eveno, E., Pavio, N., Rose, N., 2014. Risk factors associated with the presence of Hepatitis E virus in livers and seroprevalence in slaughter-age pigs: a retrospective study of 90 swine farms in France. Epidemiol. Infect. 142, 1934–1944.
Young, I., Hendrick, S., Parker, S., Rajic, A., McClure, J.T., Sanchez, J., McEwen, S.A., 2010a. Knowledge and attitudes towards food safety among Canadian dairy producers. Prev. Vet. Med. 94, 65–76.
Young, I., Rajic, A., Letellier, A., Cox, B., Leslie, M., Sanei, B., McEwen, S.A., 2010b. Knowledge and attitudes toward food safety and use of good production practices among Canadian broiler chicken producers. J. Food Prot. 73, 1278–1287.

II. Evaluation de la faisabilité technique et de l'acceptabilité d'un plan de maîtrise du virus de l'hépatite E dans la filière porcine

Le bon fonctionnement de la chaîne de l'innovation suppose que des chercheurs, enseignants et étudiants de tous niveaux connaissent intimement la pratique, ses conditions, ses contraintes et ses besoins. Faute de quoi, beaucoup de nouveautés sont inadéquates et rejetées […]. En définitive, la science et la technique « proposent », mais ce sont la pratique et l'économie qui « disposent ». […] Ce sont les agriculteurs eux-mêmes […] qui mettent au point les systèmes de production les plus avantageux, en fonction de leurs conditions de milieu et de prix, et en fonction des contraintes de superficie, de main-d'œuvre et de financement de leurs exploitations.

Mazoyer M., Roudart L., 2002. *Histoire des agricultures du monde : Du néolithique à la crise contemporaine*. Ed. Seuil, 705 p.

L'étude menée auprès des éleveurs et des vétérinaires a révélé des trous de connaissance et une faible sensibilisation des éleveurs à la problématique du HEV, mais aussi le potentiel pour les vétérinaires d'agir comme courroie de transmission d'informations et comme accompagnateurs des éleveurs. C'est à partir de ce constat qu'il a été choisi d'**évaluer la faisabilité technique et l'acceptabilité de mesures de maîtrise du HEV auprès des éleveurs et de leur environnement professionnel direct : vétérinaires et conseillers d'élevage**. Une enquête visant à étudier les **freins et motivations à d'éventuels changements de pratiques** en élevage de porcs a ainsi été conduite sous la forme d'**entretiens semi-directifs** auprès de ces trois catégories d'acteurs. Cette étude donnera lieu à une publication dont le projet est présenté ci-après et un résumé a été accepté pour un poster aux *Journées Recherche Porcine* 2020.

En parallèle, une **réunion de concertation des organisations publiques et privées** potentiellement impliquées dans la gestion du risque lié au HEV a été organisée. Les objectifs étaient d'une part de fournir un **point d'information** sur les données et travaux récents sur le HEV dans la filière porcine, d'autre part de **susciter réflexions et échanges** sur les stratégies pouvant être mises en place. Les participants ont reçu en amont un document de synthèse (Annexe 8) et un compte-rendu, inclus ci-après, a été rédigé à l'issue de cette réunion.

Publication 11 (Draft)

Teixeira-Costa C., Andraud M., Rose N., **Salines M.** Controlling hepatitis E virus in the pig production sector: assessment of the technical and behavioural feasibility of on-farm risk mitigation strategies. In prep.

Controlling hepatitis E virus in the pig production sector: assessment of the technical and behavioural feasibility of on-farm risk mitigation strategies

Charlotte Teixeira-Costa[1], Mathieu Andraud[1], Nicolas Rose[1,*], Morgane Salines[1]

[1]ANSES, French Agency for Food, Environmental and Occupational Health & Safety, Ploufragan-Plouzané-Niort Laboratory, 22440 Ploufragan, France

* corresponding author: nicolas.rose@anses.fr

Abstract: Hepatitis E virus is a zoonotic agent whose main reservoir in industrialised countries is pigs. Recent studies conducted on pig farms, in experimental situations, or through modelling approaches have led to a better understanding of the spread of HEV on pig farms and to a set of measures to reduce its prevalence and the risk of marketing contaminated products. The objective of this study was to assess the feasibility of a set of HEV control strategies on pig farms. Individual semi-structured interviews were conducted with farmers, veterinarians and farming advisors to collect general data, their level of knowledge of HEV, their opinion on the technical feasibility of some changes in practices, their perception of the respective responsibilities of the different actors and their feelings about the importance of the issue, following the framework of the theory of planned behaviour. The interviews made it possible to highlight potential barriers (lack of knowledge, scientific gaps, perceived inability to control HEV, low perception of the importance of the issue) and preferred motivators (professional satisfaction, family recognition, opportunity to achieve higher quality standards) for the implementation of on-farm risk mitigation strategies. Three clusters of stakeholders were also evidenced, with a group of leaders who could help unlock reluctance and disseminate innovations. This kind of behavioural approach appeared useful to help risk managers facilitate zoonotic control on pig farms.

Keywords: decision-making process; disease control; foodborne zoonosis; hepatitis E virus; pig production sector; theory of planned behaviour

Highlights

- An interview-based study was led to assess the feasibility of HEV on-farm control.
- Farmers, advisors and veterinarians were all willing to participate in HEV control.
- Lack of knowledge, scientific gaps, inability to control HEV would be barriers.
- Family recognition, opportunity for higher quality standards would be motivators.
- A cluster of potential leaders would help engage stakeholders in such a programme.

1. Introduction

Hepatitis E virus (HEV) is a non-enveloped single-stranded RNA virus that can cause acute or chronic hepatitis (Emerson and Purcell, 2003; Kamar et al., 2011; Choi et al., 2018). In many industrialised countries, a number of locally acquired cases have been linked to the consumption of raw or undercooked pork products, especially those containing liver in high proportion (Moal et al., 2012; Renou et al., 2014; Guillois et al., 2016; Pavio et al., 2017). Several risk factors of HEV presence in the liver of slaughtered pigs have been evidenced at the individual or the farm scale through field studies, experimental trials or modelling approaches. They are related to the farms' size, the type of production (e.g. free-ranged or organic versus conventional farming), the batch management system (e.g. one week versus three week between-batch interval), biosecurity measures (e.g. absence of an hygiene lock, no quarantine sector), farming practices (e.g. cross-fostering and mingling practices), farms' health status regarding intercurrent pathogens affecting pigs' immunity (e.g. porcine circovirus type 2 (PCV2) and porcine respiratory and reproductive syndrome virus (PRRSV)) (Li et al., 2009; Jinshan et al., 2010; Hinjoy et al., 2013; Walachowski et al., 2014; Lopez-Lopez et al., 2018; Salines et al., 2019a; Salines et al., 2019b; Salines et al., 2019c). To our knowledge, no HEV systematic control or surveillance programme is implemented in the European pig production sector yet (Salines et al., 2017a). Potential control measures could be drawn from these recent findings in order to design a risk mitigation plan limiting HEV on-farm spread and persistence and thus HEV presence in foodstuffs. However, the effective implementation of these upstream measures would rely on the stakeholders' involvement, primarily the one of farmers, but also of their direct professional environment, i.e. farming advisors and veterinarians. Their commitment would depend on a combination of several external and internal factors that is crucial to understand for motivating them to change. Literature extensively reports on factors influencing

farmers' decision-making, particularly about animal or public health issues and that are not only based on policies, economics or rational judgments (Edwards-Jones, 2006; Ritter et al., 2017). First, individual characteristics such as age, sex, education, personality, previous experiences, routines, family influences etc. can affect farmers' opinions on animal health, prevention and control strategies and their decision-making (Racicot et al., 2012; Wilson et al., 2015; Frössling and Nöremark, 2016). Farmers also need to have sufficient knowledge about the disease and management strategies to make effective changes (Benjamin et al., 2010; Ellis-Iversen et al., 2010; Racicot et al., 2012; Ritter et al., 2015). In the specific case of HEV, farmers' knowledge has been shown to be quite low according to the results of our previous survey (Salines et al., 2018). The impact of the disease on animal health and/or on the farm's economic performances can also motivate farmers to take steps toward disease control and prevention (Alarcon et al., 2014). HEV spreads on pig farms without leading to any clinical signs in pigs or causing financial losses, meaning that the problem awareness among farmers may be low. Another interesting point is that the threshold at which an issue becomes an actual problem depends on the farmers' frame of reference, itself often influenced by farmers' descriptive and injunctive norms and previous experiences (Jansen et al., 2010; Jansen et al., 2016). It has also been shown that the farmers' evaluation of a problem is not performed according to an absolute scale but in relation to other issues that also require their efforts (Leach et al., 2010a; Bruijnis et al., 2013; Horseman et al., 2014). Global farming context is therefore an important factor to consider (laws and regulations, market prices, consumer demands, cues and nudges, etc.) (Ritter et al., 2017). Farmers' perception of their own responsibility in dealing with the problem has been evidenced as a key factor in their motivation as well, especially for zoonotic pathogens raising concerns about consumer health or consumer perception of the production sector quality (Sorge et al., 2010; Nielsen, 2011; Toma et al., 2015). Other internal incentives can include professional satisfaction, reputation, family recognition, etc. (Leach et al., 2010b; Bruijnis et al., 2013; Alarcon et al., 2014; Roche et al., 2015). The efficacy and the cost-effectiveness of recommended strategies, as well as their feasibility and practicality, are also known to be strong drivers for farmers to adopt recommended disease prevention and control measures (Gunn et al., 2008; Valeeva et al., 2011; Garforth et al., 2013; Alarcon et al., 2014; Toma et al., 2015). Regarding the farmers' professional environment, several studies have shown that veterinarians and farming advisors play a significant role in spreading information and motivating farmers to adopt best management practices (Alarcon et al., 2014; Laanen et al., 2014; Marier et al., 2016; Mahon et al., 2017; Poizat et al., 2017). However, their own mindset, opinion (e.g. on the effectiveness of control and prevention measures) and self-efficacy (i.e. their belief to their

ability to perform a behaviour and obtain a desired outcome (Bandura, 1977)) have only been scarcely explored yet (Ritter et al., 2017; Hidano et al., 2018).

In this context, and with the goal of providing risk managers with tangible and pragmatic elements for decision-making, the aim of our study was to evaluate the technical and behavioural feasibility of on-farm HEV control measures from the perspective of pig farmers, advisors and veterinarians through semi-directed interviews.

2. Materials and methods

2.1. Survey design

2.1.1. Survey methodology

The three categories of stakeholders (farmers, veterinarians and advisors) were interviewed using semi-structured questionnaires designed with a similar framework. First, several questions were asked to gather general data and, for farmers, a Mindmap was used as a support to collect the farm's characteristics. Then, the conversation was directed to address three key points. The two first ones were the level of knowledge of the interviewees regarding HEV and their practices and their possible modifications. For the latter, the interviewees were first asked to describe the structure and the management of their farm or of their clients' farms, then if it would be possible to change some of their practices and why/why not. Several practices' modifications were assessed: type of housing facilities for gestating sows, cross-fostering practices at farrowing, mingling practices at weaning, management of intercurrent pathogens (PRRSV, PCV2), HEV screening of the herd and of slaughtered pigs, potential HEV vaccination in case one was available. The third key point was their attitude towards HEV issue in the pig production sector: their opinion in terms of control measures, their willingness to pay for them and their perception about the responsibility of the stakeholders in addressing the problem. The interview was concluded with general questions about the individual's characteristics (e.g. age, sex, education, personality, previous experiences etc.). Throughout the interview, open-ended questions alternated with several types of closed-ended questions (binary questions, graduated questions with Lickert scale, multiple-choice questions) according to a

logical and consistent process. Eight questions were part of the framework of the Theory of Planned Behaviour, which stated that intention to adopt a behaviour depends on the perceived behavioural control, the norms and the attitude (Ajzen, 1991) (Figure 1). Moreover, brief information on HEV was also provided to enable interviewees to answer the questions in an informed way.

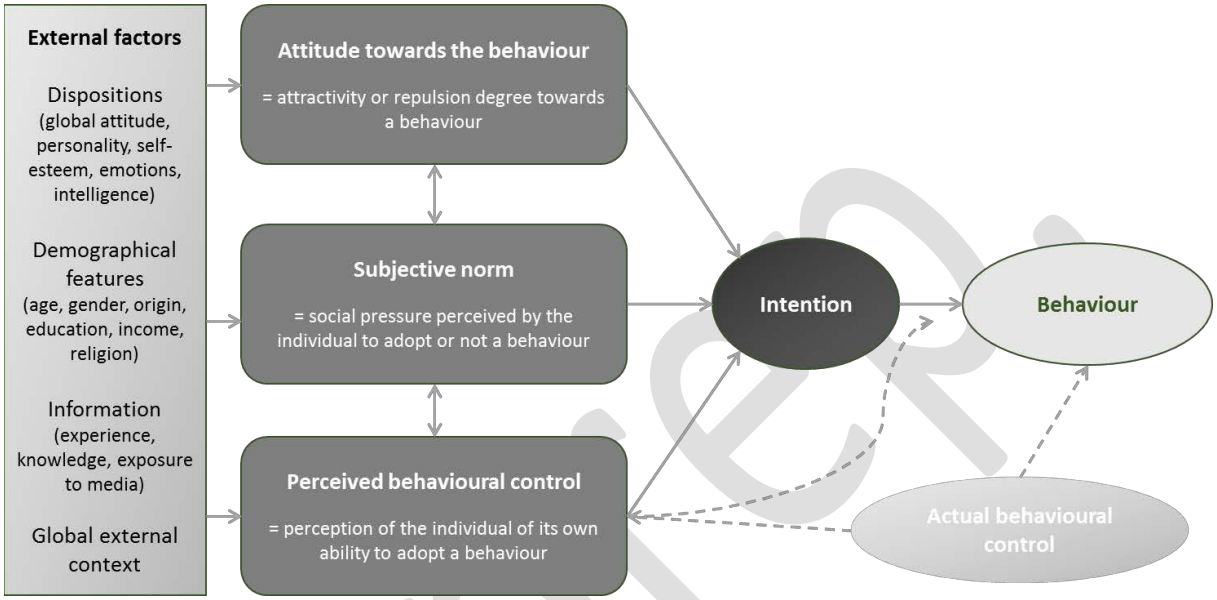

Figure 1: Framework of the Theory of Planned Behaviour (Ajzen, 1991)

2.1.2. Sample selection

Stakeholders were sampled as follows: *(i)* First, producers' organisations and veterinarians were asked to provide a list of farmers representing different types of farms (e.g. multiplication farms, nucleus, farrow-to-finish farms, etc.) and following several kind of quality charts. All sampled farmers were located in the Western part of France, corresponding to main major pig production area. *(ii)* Then, farming advisors were selected in the main producers' groups in Western France. *(iii)* Finally, veterinarians specialised in pig health and who practiced as liberal practitioners or employees of different companies were sampled. Finally, 59 farmers, 12 farming advisors and 26 veterinarians were included in the contact list.

2.1.3. On-site interviews

Interviews were held from April to June 2019. They were grouped, as far as possible, by geographical area. The appointments were made by email or by phone. The interviews were

preferably led face to face, but some were carried out by phone for practical reasons. The questionnaire was not sent to the participants prior to the interview and all professionals were investigated in the same way. With the participants' agreement, the conversations were recorded while notes were taken. All the interviews were conducted by the same interviewer which allowed answers to be compared and avoided information bias.

2.2. Data analysis

The interviews were transcribed in order to carry out a qualitative analysis of the interviewees' comments and to include verbatim in the results. The quantitative data from the interviews were recorded in an Access database. The distribution of the responses to graduated questions was represented by boxplots. As part of the application of the theory of planned behaviour, the effect of seven explanatory variables on the outcome variable 'behavioural intention' (question: "Would you be willing to participate in an HEV control programme?") was analysed by Spearman correlation tests (univariate analysis) and a principal component analysis (PCA, multivariate analysis) followed by hierarchical clustering (HC). The seven explanatory variables were divided into three groups: (1) variables representing attitude towards the behaviour ("Would controlling HEV be satisfactory?", "Do you feel directly concerned by this issue?", How do you perceive that better managing pig health would mitigate the risks for human health?"), (2) those describing the effect of subjective norms ("Would your relatives want you to participate in an HEV control programme?", "Is hepatitis E an important issue for human health?", "Is hepatitis E an important issue for the pig production sector?"), (3) and those related to perceived behavioural control ("Do you feel able to control HEV?"). The statistical analyses were carried out using the R software (R 3.5.1).

3. Results

3.1. Features of the study sample

A total of 11 veterinarians, 10 farming advisors and nine farmers agreed to participate in the study (Table 1). Of the 30 interviews, five were conducted by phone. The majority of the

189 interviewees were men, with large age range. All interviewees were specialised in pig
190 production only. The respondants were mainly located in the North-Western France, except
191 three veterinarians working in the North and South-West regions of the country. The interviews
192 lasted on average an hour with a maximum to 2h24.
193
194 **Table 1. Interviewees' and interviews' characteristics**

	Farmers	Farming advisors	Veterinarians
Number of interviews (of which phone interviews)	9 (1)	10 (0)	11 (4)
Average age [range]	47 [29-57]	41 [26-55]	47 [36-56]
Sex ratio (men/women)	8/1	8/2	10/1
Average duration (min) [range]	62 [45-90]	60 [45-75]	81 [45-144]

195
196 The farmer sample included two multiplication farms, four production farrow-to-finish farms,
197 two farrowing farms and one post-weaning farrowing farm. These farms were managed
198 according to a 4-, 5-, 7- or 10- batch management system. The number of sows ranged from 85
199 to 600 (mean: 283) and the number of fattening pigs ranged from 560 to 5,000 (mean: 2,350).
200
201 When asked about several potentially worrying aspects of pig farming, farmers gave a particular
202 importance to human resources, explaining that they experienced difficulties in recruiting
203 skilled employees, which was confirmed by veterinarians (Figure 2). Farming advisors and
204 veterinarians attributed high score to animal health and external health threats.
205

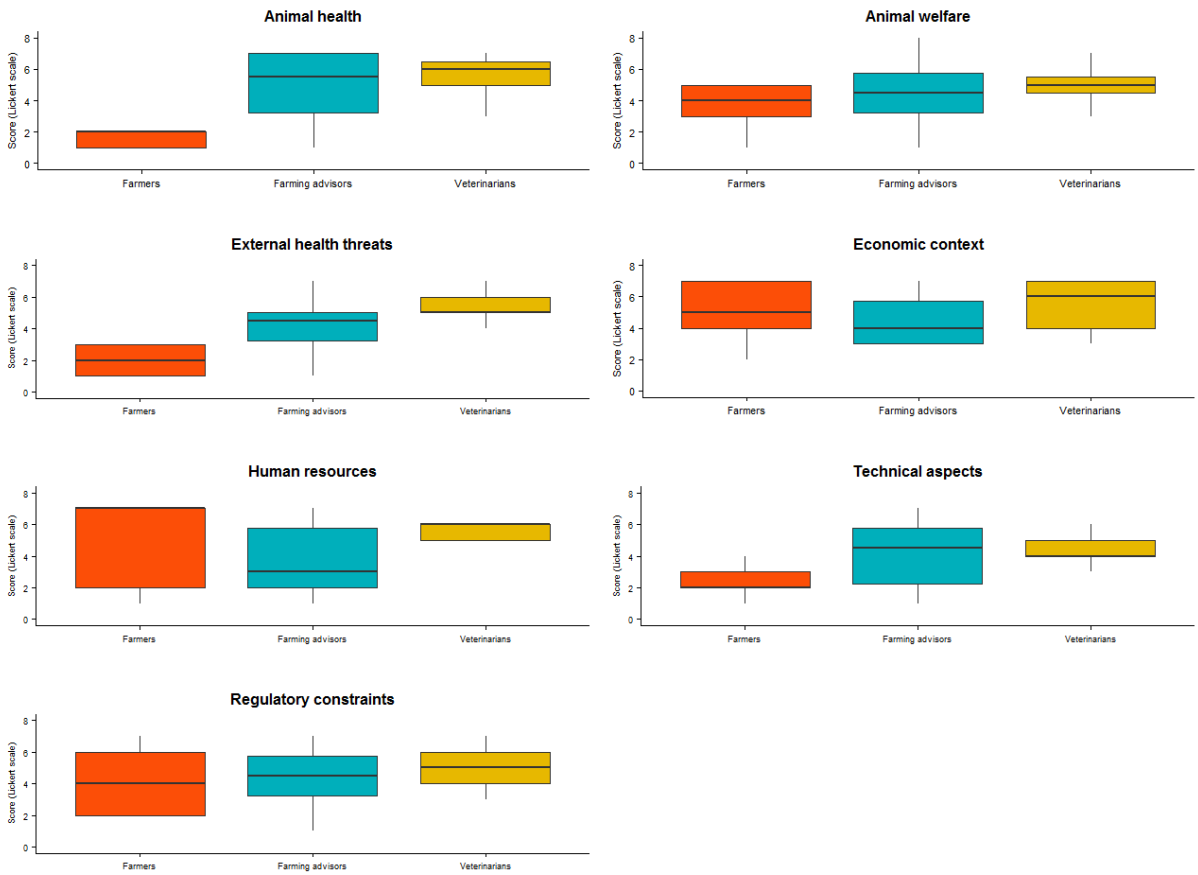

Figure 2. Distributions of the interviewees' scores attributed to potentially worrying aspects of pig farming

Regarding the interviewees' knowledge of HEV, a high within- and between-group diversity was observed. All surveyed veterinarians, half of the interviewed farming advisors and one farmer had ever heard of HEV but their knowledge about it was variable.

3.2. Would it be feasible to…

3.2.1. … house gestating sows in smaller groups?

Three of the nine surveyed farmers housed their gestating sows in large pens (more than 15 sows per pen) and stated that changing this housing system to a more segregated one would be impossible. Indeed, it would require significant structural changes that would be too costly. A veterinarian also explained: "*There are many of them and in particular on the largest farms, where the size of the groups is much larger and reviewing the management of these farms by*

moving from large groups to small groups is probably totally unthinkable given the constraints of the buildings". Moreover, some farmers explained that they recently changed this structure to meet welfare requirements. Veterinarians and farming advisors had various opinions regarding welfare criteria for gestating sows: for some of them, housing sows in smaller groups would help reduce competition thanks to a more quickly established hierarchy and would improve food and health monitoring. For the others, large pens would reduce locomotor disorders and decrease competition thanks to increased escape possibilities.

3.2.2. … have safer mingling practices?

All the veterinarians and farming advisors interviewed stated that they already recommend farmers to reduce cross-fostering and mingling of weaned piglets for the beneficial effect of these practices on other diseases. They therefore believed that improving these practices to reduce the risk of HEV would be feasible in the medium to long term. However, they explained that limiting cross-fostering could be sometimes delicate given the genetic evolution towards increasingly prolific sows: "*Five to six years ago, we were weaning between 11.5 and 12 piglets; today, I see farms with 15 or more weaned pigs. At some point, with this level of prolificacy, they have to homogenate the litter sizes*" said one veterinarian. Farmers, for their part, claimed to limit these practices already, even if a 10% cross-fostering threshold would be difficult to meet because of the need to maintain the technical and economic performances of the farm. Regarding mingling practices of weaned pigs, the farmers interviewed housed on average 28 [14-34] pigs per nursery pen; four of them housed more than 30 pigs per pen. When these farmers were asked whether it would be possible for them to make smaller nursery pens, half would agree to do so.

3.2.3. … improve management of intercurrent pathogens?

Only one veterinarian believed that the fact that co-infection with PRRSV and/or PCV2 increases the risk of HEV would encourage farmers to take action to better manage these pathogens: "*Farmers feel responsible. They want to feed people safely, so it's an argument that could be presented to them, it would only increase their motivation*", explained this veterinarian. Half of the farming advisors also thought that this could be an additional argument to convince farmers to take action against PRRSV and/or PCV2. One of them said: "*Yes, it can be another argument to convince them to take action if they have not already done so, but it is up to us to*

communicate on this too". The other veterinarians and farming advisors did not consider it necessary to specifically increase the management efforts already undertaken for intercurrent pathogens for the sole reason of HEV control. According to them, controlling HEV would not be sufficient incentive to motivate farmers: if farmers take measures to better manage PRRSV/PCV2, it would be for their direct technical and economic consequences, not for their impact on HEV dynamics.

3.2.4. … look for HEV on the farms and on slaughtered pigs?

If there were a readily available routine test, six out of 11 veterinarians and seven out of 10 farming advisors would be interested in accessing it. Five of the interested veterinarians and all advisors would encourage farmers to test their animals. However, opinions regarding the type of farms which should be tested in priority differed. One of the veterinarians explained that "*the most sensitive part will be the part that is directly related to human consumption, so it is the fattened pigs, meaning we should test farrow-to-finish farms or finishing farms or post-weaning finishing farms, as long as they sell finished pigs*". Nevertheless, the majority of them stressed the importance of starting at the top of the pyramid, i.e. of testing nucleus farms and multipliers: "*I would start by cleaning up the top of the pyramid, you see, nucleus, multipliers, if we want to try to limit the introduction of shedders, [...] because it is true that they are the most at-risk of disseminating HEV*". Seven out of nine farmers would be interested in testing their farm for HEV in order to know their status. Nevertheless, all of them said they would like this test to be free of charge. The two farmers who did not wish to know the status of their farm mentioned the fear of diagnosing a new pathology on their animals they could not treat: "*By searching, we always end up finding*", highlighted one of them.

The majority of the interviewees did not support screening of animals entering a farm for various reasons: *(i)* the objectives of such screening were still unclear for them, as one advisors stated: "*if the farm is positive, it may not change much and since it is a healthy carrying all farms are equally likely to be positive*", *(ii)* the cost may be charged on farmers instead of on slaughterhouses, *(iii)* and these screenings could only be considered in the case of a collective approach, otherwise some farmers would not be able to sell their positive animals.

Seven out of 11 veterinarians and eight out of 10 farming advisors would recommend screening livers at slaughter: "*According to me, an important control point would be to screen for the presence of the virus on livers that are intended for human consumption*", said one veterinarian. Four out of nine farmers also highlighted the fact that it would probably be interesting to test

the livers and sort them before processing, which would limit the constraints for farmers. The other farmers considered that they are not directly concerned by this question since it is related to the downstream part of the chain; they even explained that they do not know what the future of the livers of their animals is.

3.2.5. … vaccinate pigs against HEV?

If a vaccine against HEV were available for pigs, four out of 11 veterinarians and eight out of 10 farming advisors think that farmers might be ready to vaccinate their animals because it is a human health issue: "*the interest is for the pork sector and for public health, so […] they would be ready to vaccinate if they are told to vaccinate*" explained a veterinarian. Developing a multivalent vaccine would also facilitate vaccination implementation, as well as a financial support for the vaccine. According to these respondents, vaccination should also be part of a "*collective approach*", with for example the development of a sub-sector providing HEV-free livers for liver-based products, and better payment for the farmers involved in this kind of production. On the contrary, the others considered vaccination unthinkable, particularly because of the asymptomatic nature of the infection in pigs: "*Honestly, I think [farmers] will only do so if it becomes compulsory, if it is part of a public health or other approach*", said one farming advisor. Nevertheless, four out of nine farmers said they would be willing to vaccinate despite the fact that there are no symptoms in pigs because this is a human health issue. For the other five, vaccination against HEV would not be feasible given the cost of vaccines, the additional workload involved and the unseen consequences of the infection on animals.

3.2.6. … create a specific chain dedicated to the production of liver-based products?

Unanimously, the veterinarians were in favour of organising such a sub-sector, provided that farmers derive added value from it: "*It could probably be another type of outlet […], it is true that today the marketing of livers is null or almost null [...], it would certainly be an economic plus*", said a veterinarian. The opinion of advisors was similar, only one seemed reluctant to this idea because, according to him, it would not be of interest to the farmer: "*it would be more the responsibility of the slaughterhouse to sort the livers and to notify them as HEV-free*". All veterinarians and farmers stressed that it would be necessary to better pay farmers who would move towards this free status, otherwise they would not be interested in. All the interviewed farmers were interested in this HEV-free qualification for various reasons: high interest in

taking part in HEV control, new outlet, market diversification, professional development. All but one confirmed, however, that better remuneration would be necessary. One farming advisor explained that producing HEV-free pigs would be a relevant marketing differentiation factor for the French market opposed to other big producers. However, five farmers out of nine feared competitive distortion in the case of new norms or regulatory constraints forcing them to adopt more expensive farming practices.

3.3. Assessment of factors affecting interviewees' willingness to participate in an HEV control programme

3.3.1. Descriptive results (Figure 3)

Overall, the interviewees stated their intention to participate in an HEV control programme, provided they would not act alone, as stated a veterinarian: "*Yes, as part of a collective control plan*". The willingness to participate seemed higher for veterinarians (average score: 5.8/7) than for the other groups (farmers' score: 4.6/7; advisors' score: 4.5/7). High within-group variability was evidenced regarding the actors' ability to participate in an HEV control plan with average scores of 4.3, 3.8 and 3.9 for farmers, advisors and veterinarians, respectively. The main reason for which the interviewees would not feel able to participate to an HEV control programme was the lack of detailed and confirmed data and of concrete proofs of the efficacy of the suggested control measures. When veterinarians and advisors were asked if, in their opinion, farmers would be able to control HEV, their answers were highly heterogeneous. Some of the interviewees believed that farmers would not be able to do this because they are unaware of the existence of this disease and have other more important concerns. Others, on the other hand, believed that farmers could be able to do so if good explanations are provided. Overall, the question related to the influence of the relatives' opinions obtained high scores, with average scores of 5, 4 and 4 for farmers, advisors and veterinarians, respectively. Farmers and veterinarians said they feel directly concerned about this issue (average scores: 5 and 5.6, respectively), more than advisors (average score: 3.6). With average scores of 6 in all categories, the benefits of better managing pig health to reduce risks for human health appeared highly interesting for all interviewees. Regarding the importance of the issue for human health and for the pig production sector, answers were greatly variable and, on average, around the

middle score, essentially in relation with the quite low number of hepatitis E human cases. Farmers attributed higher scores to these two questions than the other interviewee categories.

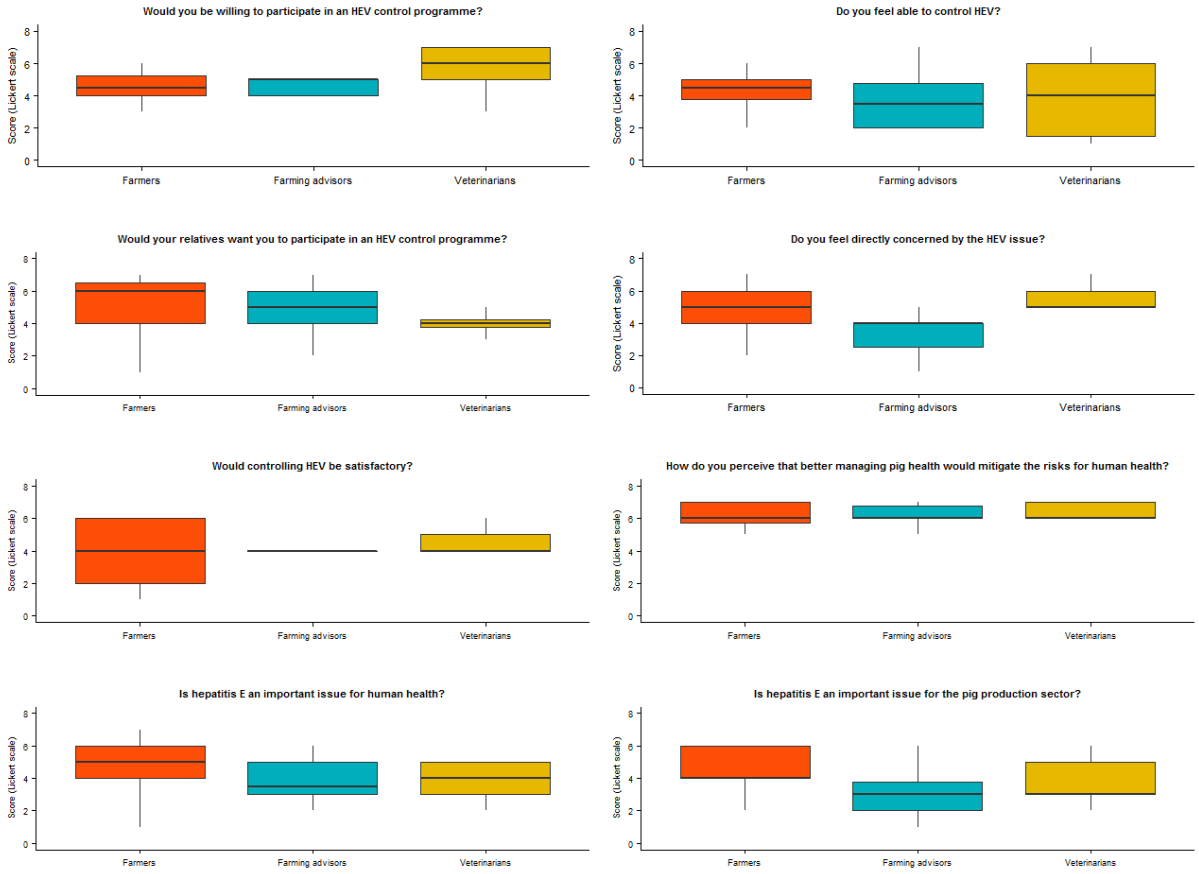

Figure 3. Distributions of the interviewees' answers to eight questions included in the framework of the theory of planned behaviour

If some veterinarians thought that it is important not to "*turn a blind eye*" but to "*remain attentive*" because "*it is a matter of consumer health, [one] cannot ignore it*", others highlighted the risk of being too precautious and of stigmatizing pig farms in an already touchy social, economic and political context: "*I mean, we're in a context where we're already pointing fingers at the animal sectors, so waving a small hepatitis E flag would be quite anxious without [hepatitis E] being really potentially serious for humans, we'll say*". This risk of a media crisis was addressed by the interviewees from two opposite angles: for some of them, the fear of a media crisis would be a positive incentive argument, which could push farmers to take an interest in the issue, while for others it would affect the entire sector negatively and lead to a crisis in consumer confidence. Among the barriers highlighted by the interviewees, the cost of implementing control measures (depending on the individual characteristics of each farm) was

the major one: "*The economic aspect remains the only obstacle that often prevents us from being positive and 100% committed to control plans*", said one of the farmers surveyed. Financial incentives could then be considered, according to some of the surveyed persons. However, all questions related to the willingness to pay to a control programme were found hardly answerable by the interviewees and no outcomes could be drawn because of too much missing data. Unanimously, veterinarians considered themselves as the privileged interlocutors to provide advice and information on this topic during farm visits. They highlighted the annual sanitary check-up, meetings, documents and social network as good opportunities to talk about this issue. All farmers and advisors also appointed the veterinarian as their main contact person.

3.3.2. Statistical analysis

The univariate analysis showed a positive association between the willingness of veterinarians to participate in an HEV control programme and the influence of their relatives' opinion (Spearman correlation coefficient = 0.75, p-value < 0.05) (Table 2). The same tendency was observed for farming advisors (CC = 0.60, p-value < 0.10). There was also a tendency of association between veterinarians' intention to control HEV and the value they give to improve pig health in order to reduce the risks for human health (CC = 0.60, p-value < 0.10).

Table 2. Correlation between the interviewees' willingness to participate in an HEV control programme and seven explanatory variables fitting to the framework of the theory of planned behaviour

CC: Spearman correlation coefficient

	Farmers		Farming advisors		Veterinarians	
	CC	**p-value**	**CC**	**p-value**	**CC**	**p-value**
Do you feel able to control HEV?	- 0.15	p > 0.10	0.33	p > 0.10	0.45	p > 0.10
Would your relatives want you to participate in an HEV control programme?	0.56	p > 0.10	**0.60**	**p < 0.10**	**0.75**	**p < 0.05**
Do you feel directly concerned by the HEV issue?	0.08	p > 0.10	0.44	p > 0.10	0.28	p > 0.10
Would controlling HEV be satisfactory?	- 0.25	p > 0.10	0.61	p > 0.10	0.28	p > 0.10
How do you perceive that better managing pig health would mitigate the risks for human health?	0.53	p > 0.10	0.67	p > 0.10	**0.60**	**p < 0.10**
Is hepatitis E an important issue for human health?	- 0.19	p > 0.10	0.24	p > 0.10	0.08	p > 0.10

Is hepatitis E an important issue for the pig production sector?	0.02	p > 0.10	0.42	p > 0.10	0.13	p > 0.10

The multivariate analysis (PCA followed by HC) made it possible to evidence three clusters (Figure 4). The first axis was mainly represented by var4 ("Do you feel directly concerned by the HEV issue?"); the second axis was mainly represented by var6 ("How do you perceive that better managing pig health would mitigate the risks for human health?") and var7 ("Is hepatitis E an important issue for human health?"). Var6 and var7 appeared orthogonal, thus independent.

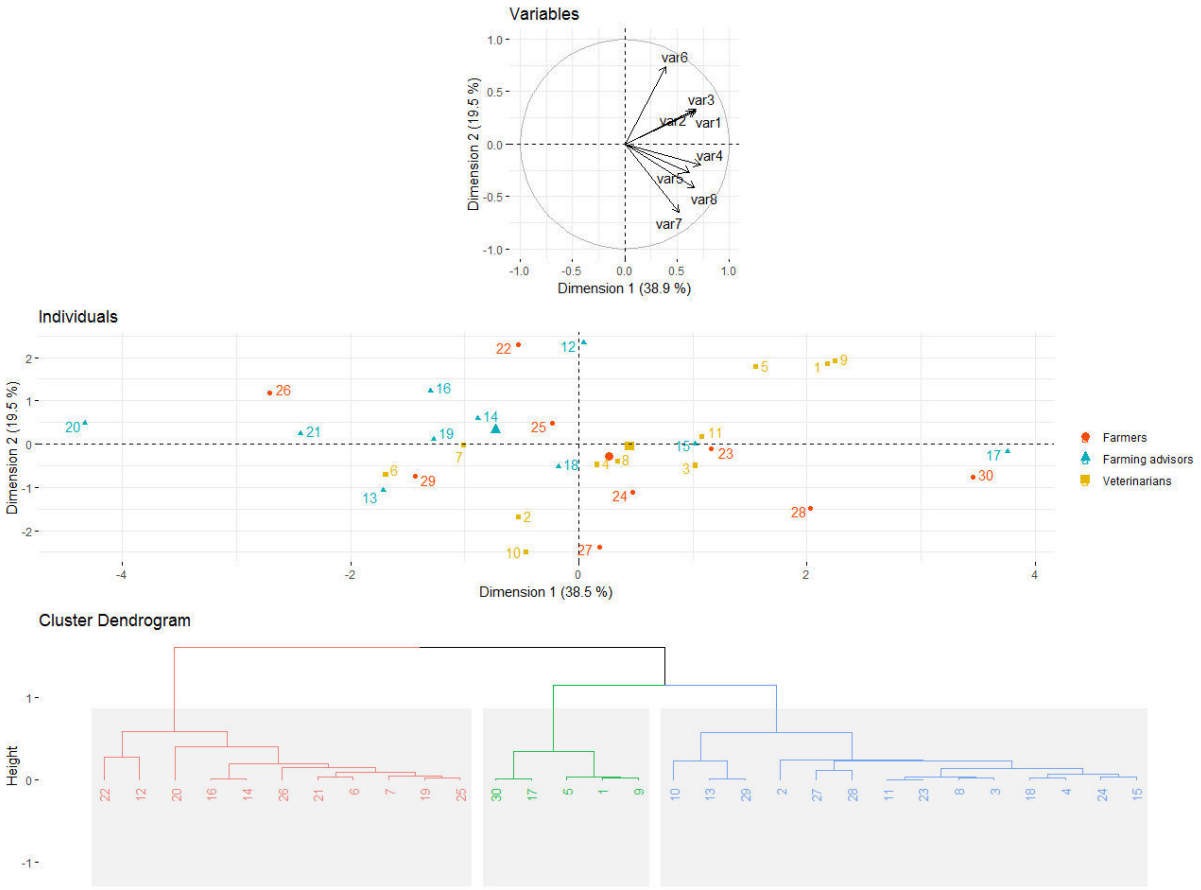

Figure 4. Interviewees' characteristics regarding behavioural determinants, as represented thanks to a principal component analysis followed by hierarchical clustering

Var1: Would you be willing to participate in an HEV control programme? Var2: Do you feel able to control HEV? Var3: Would your relatives want you to participate in an HEV control programme? Var4: Do you feel directly concerned by the HEV issue? Var5: Would controlling HEV be satisfactory? Var6: How do you perceive that better managing pig health would mitigate the risks for human health? Var7: Is hepatitis E an important issue for human health? Var8: Is hepatitis E an important issue for the pig production sector?

The smallest cluster (cluster 1) contains one farmer, one farming advisor and three veterinarians. With high scores to the eight questions, these interviewees were highly motivated by taking part in an HEV control programme and felt directly concerned by the issue (Figure 5). The second one gathers three farmers, six advisors and two veterinarians. They had the lowest scores to all but one questions, especially to those regarding their ability to control HEV and the importance of the issue for human health and the pig production sector. However, they found particularly interesting the fact that better pig health management would help reduce risks for human health. The last one (cluster 3) hosts five farmers, three advisors and six veterinarians who had middle scores to most questions and a low score concerning their ability to participate in an HEV control programme.

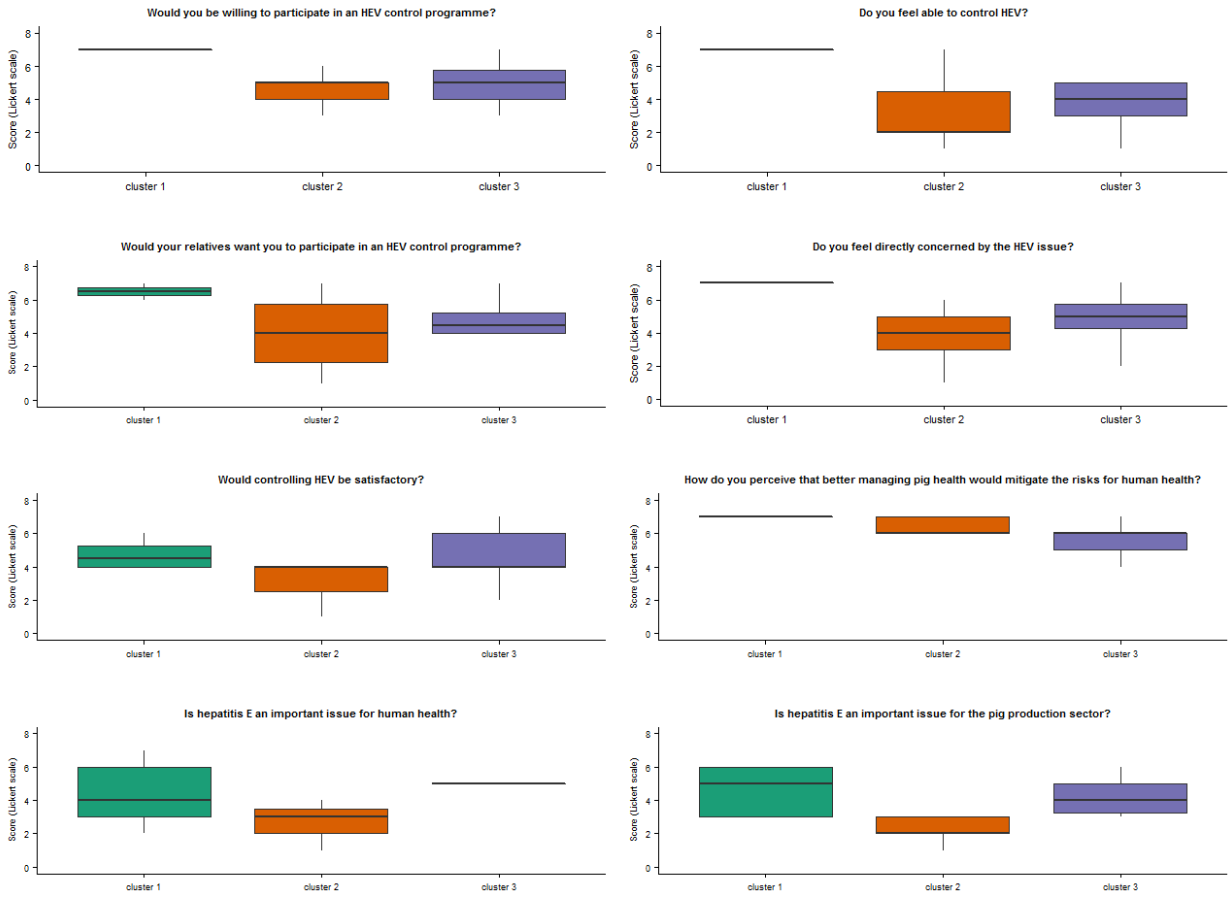

Figure 5. Distributions of interviewees' answers to eight questions included in the framework of the theory of planned behaviour depending on the cluster they belong to

4. Discussion and conclusion

The primary interest of our study lies in the in-depth exploration of the potential barriers and challenges that would arise from the implementation of an HEV control programme and in the suggestion of levers favouring the stakeholders' involvement in HEV management strategies. Assuming that pig farmers would be the major actors involved in the implementation of a future on-farm HEV control plan, our study was designed as a three-level survey targeting similarly farmers and their direct collaborators, i.e. farming advisors and veterinarians. This approach made it possible to cross-reference the views of three categories of complementary actors, working together on several technical and health issues of pig production. In this study, we decided to focus on up-stream stakeholders only, but downstream surveys would be needed to investigate the possibility of control plans at the slaughterhouse and/or processing plant levels. The sample size was deliberately small to allow for a more detailed discussion of the topics covered, hence increasing the validity of the investigation compared to short interviews which would have been necessary to achieve a larger sample size (Crouch and McKenzie, 2006; Alarcon et al., 2014). The surveyed sample cannot be considered as representative because of the non-random selection procedure. Indeed, diverse interviewees' profiles were purposely looked for, for instance to ensure that different farm types and the three major French producer organisations were represented in the study. The interviewees were not nationally distributed but mainly located in North-Western France, which is the biggest pig production area of the country (Agreste, 2013; Salines et al., 2017b). It is therefore worth mentioning that the sample composition is not adequate to extrapolate findings to the overall French pig farmer, advisor and veterinarian population. Indeed, the respondents were voluntary to participate in the study, thus suggesting that they are more involved in animal and public health issues. It is very likely that a true random sample of interviewees would have yielded few or no people with intent to be part of an HEV control programme and thereby not have been able to inform our study about extrinsic and intrinsic barriers.

The interview template was designed in a way that the interviewees were first asked to give their opinion on technical questions, which were considered easy, comfortable and non-personal, before being led to broader considerations needing personal thinking. By doing so, the interviews were conducted in a fluid manner and the questions were overall well understood. Including information points during the interview appeared also relevant. Indeed, it made

possible for the interviewees to give their opinion in an informed way and to ask for clarifications if needed. Moreover, it helped to raise their awareness on the issue and, by starting with such small-scale awareness-raising operations, one could hope information and knowledge to be disseminated through spill-over effects. The theory of planned behaviour was used as a framework for the purpose of describing the decision-making process involved on the control of HEV by farmers, advisors and veterinarians (Ajzen, 1991). This model presents several limitations, notably the fact that it assumes that peoples' behaviour fits to a rational and systematic decision-making process, which might not always be the case in real situations. Nevertheless, this concept has already been used in several other studies dealing with risk management in animal production sectors (Gunn et al., 2008; Ellis-Iversen et al., 2010; Alarcon et al., 2014) and has enabled to evidence barriers to and/or drivers for disease control. In the present case, our study was designed to identify and accurately understand behaviour's determinants through stakeholders' own perceptions. Finally, combining qualitative and quantitative analysis by alternating open- and closed-ended questions allowed for a more comprehensive assessment of the stakeholders' opinions and behaviour.

The results from this study led to a number of noteworthy conclusions as regards barriers to and drivers for the potential implementation of an HEV control programme by pig farming stakeholders. One of the major outcomes of our survey is that most participants did not appear reluctant to help tackle the HEV issue, with high scores concerning their willingness to participate to an HEV control plan (86% of answers being above the mean score). This intent to adopt HEV control measures was found affected by both extrinsic **(1)** and intrinsic **(2)** factors.

(1) First of all, like in the large-scale survey we have previously conducted (Salines et al., 2018), the present study highlighted the lack of knowledge of and about HEV in all stakeholder categories. As veterinarians have been identified as the main referent by the other actors, they could act as a knowledge transfer channel. Other studies have shown that this lack of knowledge was one of the reasons affecting people's decision-making process, e.g. explaining why farmers did not implement biosecurity measures, some control programmes or adopt new technologies on their farms (Gunn et al., 2008; Benjamin et al., 2010; Ellis-Iversen et al., 2010; Alarcon et al., 2014; Ritter et al., 2015). However, if these studies alerted to the lack of awareness by producers on current scientific research, the case of HEV appeared more complex to interpret. Indeed, if all participants admitted their lack of knowledge about HEV, they also stressed the numerous gaps in scientific knowledge that prevent them from considering disease control in

concrete terms. They would appreciate the effectiveness of the presented control strategies to be confirmed with more solid data, for instance on-farm tested measures. Moreover, the absence of any clinical signs or performance losses due to HEV infection of pigs was recognized as a factor that would hinder the interviewees to implement on-farm risk mitigation strategies, as evidenced in other studies (Alarcon et al., 2014). Regarding the technical aspects, they were found closely related to the individual situation of farmers. For some of them, the required changes in their farming practices would be marginal and would not necessitate much effort from them. For the others, whose farm facilities appeared to be risky regarding HEV infection, major investments would be needed and farmers seemed reluctant to make them, as it was confirmed by veterinarians and advisors. Besides, if knowing farms' and livers' HEV status sounded as a relevant option, the participants were not in favour of systematically testing all traded live animals, this kind of highly restrictive measure being considered far-fetched and impractical. Moreover, human resources were mentioned by the interviewees as a critical point in farmers' business, meaning that these latter would have trouble with affording additional labour (e.g. for an extra vaccination) or recruiting new employees. As shown in other publications, the farmers' evaluation of a problem is generally performed in relation to other hot topics or areas of focus which could overshadow other problems (Leach et al., 2010a; Bruijnis et al., 2013; Horseman et al., 2014); this is currently the case e.g. with the external threat linked to the African swine fever virus. Economics was also one of the major themes identified consistently throughout the template, alternatively in a negative or positive manner. Indeed, against the backdrop of global competition between markets and trading systems, farmers also expressed concern that new standards or regulations would be imposed on them, thereby distorting competition in comparison with foreign markets. For others, losing consumer confidence in the product, e.g. due to a media scare, would have far-reaching consequences. They also wish to overcome potential obstacles by turning challenges into opportunities: to their mind, being involved in an HEV control programme would be a positive differentiating factor on the market, like other labels, which would help them and the whole production sector to move towards higher quality standards that could be financially valued. Financial incentives could then be effective to stimulate producers' enrollment in such programmes. As whished by the survey's participants, reducing external pressure would also be achievable through a collective approach. It would mitigate the sense of isolation often felt by farmers, as described in Alarcon et al. (2014), and provide them with collective support. Being part of an organized and well-considered strategy would also help reduce potential mistrust and skepticism of stakeholders, as well as the financial and technical burden. Most of the interviewees were in

favor of dedicating specific HEV-free farms for the production of liver-based products. This kind of collective but targeted approach would make it possible to secure the sector without impacting too many producers. The interviewees also would need organisational and institutional support that would facilitate recommended changes and they mentioned other organized systems existing for the control of zoonotic pathogens, such as *Salmonella* and *Trichinella*. Interviewing actors from the downstream part of the production chain would be highly relevant to discuss this risk mitigation strategy. Segmenting slaughter and process chains to guarantee livers' traceability would probably be the major obstacles to this kind of specific HEV-free production chain.

(2) The interviews also made it possible to highlight several intrinsic barriers to or, on the contrary, motivators for HEV control. In the multivariate analysis, the most discriminant variables were the ones related to the feeling of being directly concerned by the issue, to the influence of better pig health management on the reduction of the risk for human health, and to the importance of the issue for human health. This analysis made it possible to separate three clusters of individuals. *(i)* One cluster gathers interviewees who did not feel able to participate in HEV control, did not attach particular importance to their relatives' opinions and did not consider HEV as an important issue, either for human health or for the pig production sector. It highlights the fact that, despite the probably high number of HEV infections in industrialised countries (Van Cauteren et al., 2017), the low number of actually reported cases leads to underestimating the importance of the disease. However, they were highly interested in the fact that better managing pig farms would help mitigate the risk of HEV for human health. This cluster hosts mainly farming advisors and farmers. They can be considered as the most reluctant group of people who would be probably the last to embrace the change. *(ii)* Another cluster contains individuals who gave middle scores to almost all questions but who felt particularly unable to participate in HEV control. This group gathers mainly veterinarians and farmers. One could say that these people would not be either reluctant to or proactive in fighting HEV. They would probably adopt a wait-and-see posture and would be willing to participate in HEV control once the efficacy of the mentioned strategies would have been proven. *(iii)* Finally, the smallest cluster contains individuals with high scores to all questions, with high motivation and self-efficacy for an HEV control plan. In particular, helping tackle the HEV issue would give them professional satisfaction and family recognition. This cluster gathers mostly veterinarians. It could be considered as a group of leaders, who will take initiatives and stimulate change. This clustering process allowed to identify where in the pathway to pathogen control a person – or a

group of persons – is. If information and awareness campaigns would be useful for all stakeholders, one could say that involvement efforts should be focused on people being in the pre-contemplation, contemplation or preparation stage of the transtheoretical model of change (Prochaska and Di Clemente, 1982; Bamberg, 2013), corresponding to the two last clusters described. Indeed, a control programme for such a non-regulated pathogen would need to be incrementally set up, using the theories of increasing adoption rates (Vanloqueren and Baret, 2009). Leaders, for instance duos of highly engaged veterinarians and farmers, would help unlock reluctance, disseminate innovations and better agricultural practices to the followers (Rogers, 2003). They should be supported in their involvement, for instance if they get committed to a niche market delivering HEV-free livers for liver-based products. Interfaces between leaders and other producers should also be encouraged, in order for these local innovations to be compatible with the dominating model (Geels and Schot, 2007; Bidaud, 2013).

In conclusion, collecting and analysing opinions from stakeholders before proposing HEV control strategies was of major importance to guarantee the proper implementation of such a plan. Our interview-based research has proven to be relevant for capturing the high variation of opinions and perceptions amongst farmers, advisors and veterinarians but also for identifying shared ideas and define three stakeholder clusters. From our results, potential hurdles (lack of knowledge, scientific gaps, perceived inability to control HEV, low perception of the importance of the issue) and preferred motivators (professional satisfaction, family recognition, opportunity to achieve higher quality standards) have been highlighted. The importance of these intrinsic and extrinsic circumstances highlights the need for socio-ecological behavioral models, which acknowledge and incorporate the influences of external and internal factors on someone's decision-making process. From a practical point of view, these outcomes are also likely to help risk managers facilitate the implementation of an HEV control programme by steering efforts to remove specific barriers and thereby creating favorable conditions for zoonotic control on pig farms.

Authors' contributions

NR, MA and MS initiated and coordinated the project. CT and MS designed the questionnaires. CT contacted the study participants, conducted the interviews, recorded and analysed the data. CT and MS drafted the manuscript. All the co-authors revised the manuscript and approved the final submitted version.

Funding and acknowledgments

This work was supported by the French Ministry of Agriculture and Food, and by the French Interprofessional Pork Council (INAPORC). The authors are very grateful to all the pig farmers, advisors and veterinarians who participated in the study.

Competing interests

The authors declare that they have no competing interests.

References

Agreste, 2013. Les élevages de porcs en France métropolitaine en 2010. 11 500 élevages porcins détiennent la quasi-totalité du cheptel national. Agreste Primeur 300, 8.

Ajzen, I., 1991. The theory of planned behavior. Organizational behavior and human decision processes 50, 179-211.

Alarcon, P., Wieland, B., Mateus, A.L.P., Dewberry, C., 2014. Pig farmers' perceptions, attitudes, influences and management of information in the decision-making process for disease control. Preventive veterinary medicine 116, 223-242.

Bamberg, S., 2013. Processes of change. In: Steg, L., Van den Berg, A., De Groot, J. (Eds.), Environmental psychology. An introduction. BPS Blackwell, Oxford, 268-279.

Bandura, A., 1977. Self-efficacy: toward a unifying theory of behavioral change. Psychological review 84, 191-215.

Benjamin, L.A., Fosgate, G.T., Ward, M.P., Roussel, A.J., Feagin, R.A., Schwartz, A.L., 2010. Attitudes towards biosecurity practices relevant to Johne's disease control on beef cattle farms. Preventive veterinary medicine 94, 222-230.

Bidaud, F., 2013. Transitions vers la double performance : quelques approches sociologiques de la diffusion des pratiques agroécologiques. Centre d'Etudes et de Prospective du Ministère de l'Agriculture, de l'Agroalimentaire et de la Forêt 63, 1-8.

Bruijnis, M., Hogeveen, H., Garforth, C., Stassen, E., 2013. Dairy farmers' attitudes and intentions towards improving dairy cow foot health. Livestock Science 155, 103-113.

Choi, M., Hofmann, J., Kohler, A., Wang, B., Bock, C.T., Schott, E., Reinke, P., Nickel, P., 2018. Prevalence and Clinical Correlates of Chronic Hepatitis E Infection in German Renal Transplant Recipients With Elevated Liver Enzymes. Transplantation direct 4, e341.

Crouch, M., McKenzie, H., 2006. The logic of small samples in interview-based qualitative research. Social Science Information 45, 483-499.

637 Edwards-Jones, G., 2006. Modelling farmer decision-making: concepts, progress and challenges.
638 Animal Science 82, 783-790.
639 Ellis-Iversen, J., Cook, A.J.C., Watson, E., Nielen, M., Larkin, L., Wooldridge, M., Hogeveen, H., 2010.
640 Perceptions, circumstances and motivators that influence implementation of zoonotic
641 control programs on cattle farms. Preventive veterinary medicine 93, 276-285.
642 Emerson, S.U., Purcell, R.H., 2003. Hepatitis E virus. Reviews in medical virology 13, 145-154.
643 Frössling, J., Nöremark, M., 2016. Differing perceptions – Swedish farmers' views of infectious
644 disease control. Veterinary Medicine and Science 2, 54-68.
645 Garforth, C.J., Bailey, A.P., Tranter, R.B., 2013. Farmers' attitudes to disease risk management in
646 England: A comparative analysis of sheep and pig farmers. Preventive veterinary medicine
647 110, 456-466.
648 Geels, F.W., Schot, J., 2007. Typology of socio-technical transition pathways. Research Policy, 399-
649 417.
650 Guillois, Y., Abravanel, F., Miura, T., Pavio, N., Vaillant, V., Lhomme, S., Le Guyader, F.S., Rose, N., Le
651 Saux, J.C., King, L.A., Izopet, J., Couturier, E., 2016. High Proportion of Asymptomatic
652 Infections in an Outbreak of Hepatitis E Associated With a Spit-Roasted Piglet, France, 2013.
653 Clinical infectious diseases : an official publication of the Infectious Diseases Society of
654 America 62, 351-357.
655 Gunn, G.J., Heffernan, C., Hall, M., McLeod, A., Hovi, M., 2008. Measuring and comparing constraints
656 to improved biosecurity amongst GB farmers, veterinarians and the auxiliary industries.
657 Preventive veterinary medicine 84, 310-323.
658 Hidano, A., Enticott, G., Christley, R.M., Gates, M.C., 2018. Modeling Dynamic Human Behavioral
659 Changes in Animal Disease Models: Challenges and Opportunities for Addressing Bias.
660 Frontiers in veterinary science 5, 137.
661 Hinjoy, S., Nelson, K.E., Gibbons, R.V., Jarman, R.G., Chinnawirotpisan, P., Fernandez, S., Tablerk, P.,
662 Labrique, A.B., Patchanee, P., 2013. A cross-sectional study of hepatitis E virus infection in
663 pigs in different-sized farms in northern Thailand. Foodborne pathogens and disease 10, 698-
664 704.
665 Horseman, S., Roe, E., Huxley, J., Bell, N., Mason, C., Whay, H., 2014. The use of in-depth interviews
666 to understand the process of treating lame dairy cows from the farmers' perspective. Animal
667 Welfare 23, 157-165.
668 Jansen, J., van Schaik, G., Renes, R.J., Lam, T.J.G.M., 2010. The effect of a national mastitis control
669 program on the attitudes, knowledge, and behavior of farmers in the Netherlands. Journal of
670 Dairy Science 93, 5737-5747.
671 Jansen, J., Wessels, R.J., Lam, T., 2016. Understanding the mastitis mindset: applying social
672 psychology in practice. In, Proc. National Mastitis Council 55th Annual Meeting, Glendale, AZ,
673 5-15.
674 Jinshan, Jirintai, Manglai, D., Takahashi, M., Nagashima, S., Okamoto, H., 2010. Molecular and
675 serological survey of hepatitis E virus infection among domestic pigs in Inner Mongolia,
676 China. Archives of virology 155, 1217-1226.
677 Kamar, N., Garrouste, C., Haagsma, E.B., Garrigue, V., Pischke, S., Chauvet, C., Dumortier, J.,
678 Cannesson, A., Cassuto-Viguier, E., Thervet, E., Conti, F., Lebray, P., Dalton, H.R., Santella, R.,
679 Kanaan, N., Essig, M., Mousson, C., Radenne, S., Roque-Afonso, A.M., Izopet, J., Rostaing, L.,
680 2011. Factors associated with chronic hepatitis in patients with hepatitis E virus infection
681 who have received solid organ transplants. Gastroenterology 140, 1481-1489.
682 Laanen, M., Maes, D., Hendriksen, C., Gelaude, P., De Vliegher, S., Rosseel, Y., Dewulf, J., 2014. Pig,
683 cattle and poultry farmers with a known interest in research have comparable perspectives
684 on disease prevention and on-farm biosecurity. Preventive veterinary medicine 115, 1-9.
685 Leach, K.A., Whay, H.R., Maggs, C.M., Barker, Z.E., Paul, E.S., Bell, A.K., Main, D.C.J., 2010a. Working
686 towards a reduction in cattle lameness: 1. Understanding barriers to lameness control on
687 dairy farms. Research in veterinary science 89, 311-317.

Leach, K.A., Whay, H.R., Maggs, C.M., Barker, Z.E., Paul, E.S., Bell, A.K., Main, D.C.J., 2010b. Working towards a reduction in cattle lameness: 2. Understanding dairy farmers' motivations. Research in veterinary science 89, 318-323.

Li, W., She, R., Wei, H., Zhao, J., Wang, Y., Sun, Q., Zhang, Y., Wang, D., Li, R., 2009. Prevalence of hepatitis E virus in swine under different breeding environment and abattoir in Beijing, China. Veterinary microbiology 133, 75-83.

Lopez-Lopez, P., Risalde, M.L.A., Frias, M., Garcia-Bocanegra, I., Brieva, T., Caballero-Gomez, J., Camacho, A., Fernandez-Molera, V., Machuca, I., Gomez-Villamandos, J.C., Rivero, A., Rivero-Juarez, A., 2018. Risk factors associated with hepatitis E virus in pigs from different production systems. Veterinary microbiology 224, 88-92.

Mahon, M.M., Sheehan, M.C., Kelleher, P.F., Johnson, A.J., Doyle, S.M., 2017. An assessment of Irish farmers' knowledge of the risk of spread of infection from animals to humans and their transmission prevention practices. Epidemiology and infection 145, 2424-2435.

Marier, E., Piers Smith, R., Ellis-Iversen, J., Watson, E., Armstrong, D., Hogeveen, H., Cook, A.J.C., 2016. Changes in perceptions and motivators that influence the implementation of on-farm Salmonella control measures by pig farmers in England. Preventive veterinary medicine 133, 22-30.

Moal, V., Gerolami, R., Colson, P., 2012. First human case of co-infection with two different subtypes of hepatitis E virus. Intervirology 55, 484-487.

Nielsen, S.S., 2011. Dairy farmers' reasons for participation in the Danish control programme on bovine paratuberculosis. Preventive veterinary medicine 98, 279-283.

Pavio, N., Doceul, V., Bagdassarian, E., Johne, R., 2017. Recent knowledge on hepatitis E virus in Suidae reservoirs and transmission routes to human. Veterinary research 48, 78.

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. Preventive veterinary medicine 146, 61-72.

Prochaska, J.O., Di Clemente, C.C., 1982. Transtheoretical therapy toward a more integrative model of change. Psychotherapy: Theory, Research and Practice 19(3), 276-287.

Racicot, M., Venne, D., Durivage, A., Vaillancourt, J.-P., 2012. Evaluation of the relationship between personality traits, experience, education and biosecurity compliance on poultry farms in Québec, Canada. Preventive veterinary medicine 103, 201-207.

Renou, C., Roque-Afonso, A.M., Pavio, N., 2014. Foodborne transmission of hepatitis E virus from raw pork liver sausage, France. Emerging infectious diseases 20, 1945-1947.

Ritter, C., Jansen, J., Roche, S., Kelton, D.F., Adams, C.L., Orsel, K., Erskine, R.J., Benedictus, G., Lam, T.J.G.M., Barkema, H.W., 2017. Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. Journal of Dairy Science 100, 3329-3347.

Ritter, C., Kwong, G.P.S., Wolf, R., Pickel, C., Slomp, M., Flaig, J., Mason, S., Adams, C.L., Kelton, D.F., Jansen, J., De Buck, J., Barkema, H.W., 2015. Factors associated with participation of Alberta dairy farmers in a voluntary, management-based Johne's disease control program. Journal of Dairy Science 98, 7831-7845.

Roche, S.M., Jones-Bitton, A., Meehan, M., Von Massow, M., Kelton, D.F., 2015. Evaluating the effect of Focus Farms on Ontario dairy producers' knowledge, attitudes, and behavior toward control of Johne's disease. Journal of Dairy Science 98, 5222-5240.

Rogers, E., 2003. Diffusion of innovations. Free Press, 5e ed.

Salines, M., Andraud, M., Pellerin, M., Bernard, C., Grasland, B., Pavio, N., Rose, N., 2019a. Impact of porcine circovirus type 2 (PCV2) on hepatitis E virus (HEV) infection and transmission under experimental conditions. Veterinary microbiology 234, 1-7.

Salines, M., Andraud, M., Rose, N., 2017a. From the epidemiology of hepatitis E virus (HEV) within the swine reservoir to public health risk mitigation strategies: a comprehensive review. Veterinary research 48, 31.

739 Salines, M., Andraud, M., Rose, N., 2017b. Pig movements in France: Designing network models
740 fitting the transmission route of pathogens. PLoS One 12, e0185858.
741 Salines, M., Andraud, M., Terrade, F., Rose, N., 2018. Are French pig farmers and veterinarians
742 knowledgeable about emerging foodborne pathogens? The case of hepatitis E virus.
743 Preventive veterinary medicine 156, 1-7.
744 Salines, M., Dumarest, M., Andraud, M., Mahé, S., Barnaud, E., Cineux, M., Eveno, E., Eono, F.,
745 Dorenlor, V., Grasland, B., Bourry, O., Pavio, N., Rose, N., 2019b. Natural viral co-infections in
746 pig herds affect hepatitis E virus (HEV) infection dynamics and increase the risk of
747 contaminated livers at slaughter. Transboundary and emerging diseases.
748 Salines, M., Rose, N., Andraud, M., 2019c. Tackling hepatitis E virus spread and persistence on
749 farrow-to-finish pig farms: insights from a stochastic individual-based multi-pathogen model.
750 Epidemics (Submitted).
751 Sorge, U., Kelton, D., Lissemore, K., Godkin, A., Hendrick, S., Wells, S., 2010. Attitudes of Canadian
752 dairy farmers toward a voluntary Johne's disease control program. Journal of Dairy Science
753 93, 1491-1499.
754 Toma, L., Low, J.C., Vosough Ahmadi, B., Matthews, L., Stott, A.W., 2015. An analysis of cattle
755 farmers' perceptions of drivers and barriers to on-farm control of Escherichia coli O157.
756 Epidemiology and infection 143, 2355-2366.
757 Valeeva, N.I., van Asseldonk, M.A.P.M., Backus, G.B.C., 2011. Perceived risk and strategy efficacy as
758 motivators of risk management strategy adoption to prevent animal diseases in pig farming.
759 Preventive veterinary medicine 102, 284-295.
760 Van Cauteren, D., Le Strat, Y., Sommen, C., Bruyand, M., Tourdjman, M., Da Silva, N.J., Couturier, E.,
761 Fournet, N., de Valk, H., Desenclos, J.C., 2017. Estimated Annual Numbers of Foodborne
762 Pathogen-Associated Illnesses, Hospitalizations, and Deaths, France, 2008-2013. Emerging
763 infectious diseases 23, 1486-1492.
764 Vanloqueren, G., Baret, P., 2009. How agricultural research systems shape a technological regime
765 that develops genetic engineering but locks out agroecological innovations. Research Policy,
766 971-983.
767 Walachowski, S., Dorenlor, V., Lefevre, J., Lunazzi, A., Eono, F., Merbah, T., Eveno, E., Pavio, N., Rose,
768 N., 2014. Risk factors associated with the presence of hepatitis E virus in livers and
769 seroprevalence in slaughter-age pigs: a retrospective study of 90 swine farms in France.
770 Epidemiology and infection 142, 1934-1944.
771 Wilson, L., Rhodes, A.P., Dodunski, G., 2015. Parasite management extension – challenging traditional
772 practice through adoption of a systems approach. New Zealand Veterinary Journal 63, 292-
773 300.

774

Compte-rendu

Le virus de l'hépatite E dans la filière porcine. Compte rendu de la réunion d'information et d'échanges du 25/06/2019

Le virus de l'hépatite E dans la filière porcine

Compte rendu de la réunion d'information et d'échanges du 25/06/2019

Objectifs de la réunion

Les objectifs de la réunion étaient d'une part de fournir un point d'information sur les données et travaux récents sur le VHE dans la filière porcine, d'autre part de susciter réflexions et échanges sur les stratégies pouvant être mises en place par les acteurs de la filière porcine.

Déroulé de la réunion

La réunion s'est tenue le 25 juin 2019, de 9h30 à 13h, dans les locaux de la Direction Générale de l'Alimentation à Paris. En amont de la réunion, les participants avaient reçu un rapport préliminaire synthétisant *(i)* les données récentes disponibles dans la littérature concernant le risque présenté par les produits porcins et l'épidémiologie du VHE dans les élevages de porcs ; *(ii)* les résultats du projet de recherche sus-cité, notamment en ce qui concerne l'influence des co-infections immunomodulatrices ainsi que la diffusion du virus dans la filière porcine. Le document s'accompagnait d'une synthèse des pistes d'action identifiées, formulées sous la forme de propositions à discuter avec les organisations publiques et privées gestionnaires du risque. La réunion s'est déroulée en deux phases : une première phase de présentation, suivie d'une discussion autour de trois thèmes : *(i)* quelle gestion possible du VHE dans l'amont de la filière porcine ? *(ii)* quelle gestion possible du VHE dans l'aval de la filière porcine ? *(iii)* quels futurs besoins de recherche ? La réunion a été co-animée par Morgane Salines, Nicolas Rose et Charlotte Teixeira-Costa, de l'unité de recherche en Epidémiologie, Santé et Bien-Être du laboratoire de l'Anses de Ploufragan/Plouzané/Niort.

Participants

La réunion a regroupé 38 participants. Les représentants de plusieurs organisations étaient présents : l'Anses, Santé Publique France (SPF), la Direction Générale de l'Alimentation (DGAl), la Direction Générale de la Santé (DGS), le Centre National de Référence (CNR) des virus hépatiques à transmission entérique, la Fédération française des Industriels Charcutiers Traiteurs (FICT), la Confédération Nationale des Charcutiers Traiteurs (CNCT), la

Confédération Française de la Boucherie, Charcuterie, Traiteurs (CFBCT), Coop de France, l'Interprofession Nationale Porcine (INAPORC), l'Association Nationale Sanitaire Porcine (ANSP), la Fédération Nationale Porcine (FNP), la Fédération du Commerce et de la Distribution (FCD), le Syndicat National de l'Industrie de la Nutrition Animale (SNIA), Cirhyo, Tradival.

Première partie : Présentation

Une version papier de la présentation a été remise aux participants en début de réunion. La présentation a porté sur *(i)* les caractéristiques de l'hépatite E chez l'homme, *(ii)* les voies de transmission zoonotique du VHE, et en particulier le risque posé par les produits à base de foie de porc et les autres produits à base de porc, *(iii)* les caractéristiques épidémiologiques du VHE dans les élevages de porcs (voie de transmission, prévalence, facteurs de risque, *(iv)* les pistes de maîtrise possibles du VHE en élevage déterminées, entre autres, par des approches de modélisation, *(v)* les premiers retours des acteurs de terrain (éleveurs, vétérinaires praticiens, conseillers d'élevage) quant à la mise en place pratique de ces mesures dans les élevages. Les diapositives ont été envoyées par courriel à l'issue de la réunion.

Seconde partie : Discussion des mesures de gestion possibles dans la filière porcine et des futurs besoins de recherche

Axe I : Possibilités de maîtrise du VHE dans l'amont de la filière

Les pistes d'action suivantes ont retenu toute l'attention des participants :

- ✓ Sensibiliser les éleveurs à la problématique et aux possibilités de réduction du risque de propagation et de persistance du VHE dans leur élevage.
- ✓ En ce sens, retenir le VHE (éventuellement en complément d'autres pathogènes zoonotiques) comme thème de sensibilisation lors de la prochaine campagne de visite sanitaire porcine.
- ✓ Accompagner les élevages (particulièrement ceux de grande taille ayant un mode de production intensif) vers des pratiques de biosécurité externe (sas sanitaire, quarantaine) et interne (compartimentation, gestion des flux) et de conduite (limitation des adoptions et des mélanges, gestion des effluents) plus sûres.
- ✓ Soutenir la mise en place de programmes d'éradication des pathogènes immunomodulateurs, notamment du virus du SDRP.

Axe II : Possibilités de maîtrise du VHE dans l'aval de la filière

Les éléments suivants ont été jugés prioritaires pour la gestion du VHE dans les produits :

- ✓ Envisager la qualification d'élevages indemnes de VHE qui pourraient approvisionner en foies le marché des produits à base de foie susceptibles d'être consommés crus.

- ✓ Inclure le VHE dans les prochains plans de surveillance et plans de contrôle, en utilisant les facteurs de risque identifiés dans la littérature.
- ✓ En ce sens, inclure le VHE comme future thématique d'intérêt pour la plateforme de Surveillance de la Chaîne Alimentaire.
- ✓ Renforcer *(i)* le contrôle de l'étiquetage des produits à risque et de l'information des consommateurs et *(ii)* la sensibilisation des personnes à risque.

Axe III : Futurs besoins de recherche sur la thématique du VHE

Nombreux ont été les besoins de recherche dans la filière porcine identifiés par les participants :

- ✓ Réaliser une étude d'intervention en élevage pour tester l'efficacité en conditions réelles des mesures identifiées.
- ✓ Explorer la situation sanitaire des élevages dits alternatifs (non-conventionnels) et identifier les facteurs de risque associés à ces modes de production.
- ✓ Investiguer la situation sanitaire des élevages de sélection et de multiplication.
- ✓ Identifier les génotypes circulant actuellement dans la population porcine pour les comparer avec ceux circulant dans la population humaine.
- ✓ Poursuivre les travaux de recherche relatifs à la présence du VHE dans les muscles, le sang, et autres tissus de porcs ainsi que dans les produits à base de porc ne contenant pas de foie.
- ✓ Poursuivre les travaux concernant l'efficacité et la faisabilité de possibles traitements assainissants des produits finis, notamment la pascalisation, le séchage et la salaison.
- ✓ Concevoir un plan d'échantillonnage pour la recherche du VHE dans les foies destinés à la fabrication de produits crus.

Au bilan, la réunion a été jugée satisfaisante par l'ensemble des participants. Il est souhaitable que ce type d'initiative soit régulièrement renouvelé pour une information et une concertation efficaces de tous les acteurs de la filière porcine et de la santé humaine.