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Knowledge, attitudes and practices of Cambodian swine producers in relation to porcine reproductive and respiratory syndrome (PRRS)☆

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ABSTRACT

Porcine reproductive and respiratory syndrome (PRRS) was first detected in Cambodia in 2010. The disease was responsible for high morbidity and high mortality in adult pigs and the outbreak had a costly impact on those farmers affected. The aim of this study was to generate a better understanding of Cambodian swine producers' behaviour, in relation to PRRS and its control, in areas that have previously been affected by the disease. A survey of the knowledge, attitude and practices (KAPs) of pig owners with regard to PRRS was conducted in semi-commercial and backyard farms in Takeo province in southeast Cambodia. The survey was designed to assess knowledge of PRRS disease and its transmission, farmers' attitudes and practices related to preventive and control measures, knowledge on vaccination and perception towards local veterinary authority activities. Descriptive statistics were used to summarise qualitative data, while multivariate regression analyses were used to assess the association between selected outcomes and a number of hypothetical predictors. When presented with clinical signs typical of PRRS, most farmers identified an infectious disease as the most likely explanation for the listed clinical conditions. Farmers were also confident in recognising direct contact between pigs as one of the main ways of disease transmission; however, other viral transmission patterns typical of PRRS were mostly unknown or ignored. In general, male farmers and farmers with a higher level of education were more likely to have a better knowledge of transmission routes between pigs. In terms of attitude towards control measures, vaccination and disinfection were perceived as the most effective control practices. Farmers with a better knowledge of vaccine protocols were more likely to find vaccination effective. Village animal health workers (VAHWs) were generally in contact more with backyard farmers, while semi-commercial farmers were more prone to treat pigs themselves, raising the issue of easy and uncontrolled access to medication and vaccination. In general, farmers had a positive attitude towards local veterinarians, and lack of contact between farmers and the veterinary authority was associated more with logistic constraints than with farmers' mistrust towards the authority.

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1. Introduction

Cambodia experienced its first reported porcine reproductive and respiratory syndrome (PRRS) outbreak in July 2010 (Theary et al., 2011). The outbreak was characterised by high morbidity and mortality, particularly in adult pigs, and heavily impacted on the production output and the livelihoods of affected farmers (Theary et al., 2011). PRRS is caused by PRRS virus (PRRSV), a single stranded RNA virus, for which two genetically different strains are recognised: Type 1, initially isolated in Europe, and Type 2, initially isolated in North America (Murtaugh et al., 1995; Nelsen et al., 1999); both viral variants are now globally distributed. The virus is responsible for reproductive failure in sows, slow growth in adults pigs, and death in young pigs due to respiratory disease, often aggravated by secondary infection (Cho and Dee, 2006). Infected pigs shed the virus in saliva, nasal secretions, urine, semen and faeces, and the virus can be transmitted by intranasal, intramuscular, oral, intrauterine and vaginal routes (Zimmerman et al., 2006). Vertical transmission to the foetus results in foetal death, or the birth of infected pigs that are either weak or appear normal (Zimmerman et al., 2006). Shedding in saliva, urine and faeces also results in environmental contamination and creates the potential for transmission via fomites. Indirect transmission involves not only objects and living carriers, but also substances such as water and aerosols. Airborne spread and infection has been confirmed up to 120 m in distance during experimental studies, however different pathogenicity among viral isolates and meteorological conditions have proved to be important factors affecting aerosol transmission (Cho et al., 2007).

In 2006, a new highly pathogenic variant of the Type 2 strain emerged in China; since then it has devastated the pig population of China and Viet Nam, occurring also in Lao PDR, Thailand, and Indonesia (Hu et al., 2013). During the past six years there have been several PRRS epidemics characterised by high morbidity and high mortality, which transiently decimated pig populations in the region, and induced a sharp rise in pork price in the affected areas (Tong et al., 2007). The dynamics and impact of these epidemics might not only depend on the intrinsic characteristics of the pathogen or the host population, but also on farmers' preparedness and response to outbreaks, and the effectiveness of the veterinary authority in controlling them (Tiongco et al., 2012).

In Cambodia, three distinct swine farming systems (typology) can be identified: commercial, semi-commercial and backyard, however, less than 1% of pig producers operate on a commercial level. The classification used by the Cambodian Veterinary Service considers a semi-commercial (SC) farm as "*any premise where pigs are reared in medium equipped sheds with more than one pen built either in concrete, bricks, wood fences or metal grid, with cement or tile floors and feeding and drainage facilities*"; these farmers derive their main form of income from pig raising (Sovann and Sorn, 2002). Backyard farms (BY) are defined as "*any premises in which farmers rear pigs which may be free ranging, tethered or maintained in very rudimental pens with no feeding and drainage facilities*"; these farmers typically generate most of their household income from rice cultivation and alongside this raise a small number of animals in order to meet the household meat demand (Sovann and Sorn, 2002).

These swine farming systems are characterised by almost non-existent bio-security and a lack of resources and information related to disease pathogenesis that renders disease control particularly difficult (Psilos, 2008; Chetra and Bourn, 2009; Tornimbene and Drew, 2012), with high mortality rates (35–50% average among non-assisted small producers) resulting from deficiencies in producer technical skill, misdiagnosis, inappropriate vaccinations, lack of access to or utilisation of basic veterinary care, poor quality of vaccines and veterinary medicines (Psilos, 2008). However, veterinarians often lack the training, experience, the logistical assistance, and/or the financial support to carry out formal surveys (Psilos, 2008; Chetra and Bourn, 2009; Tornimbene and Drew, 2012). As a result surveillance of animal disease in Cambodia is rudimentary and mainly passive and disease reporting lacks structure. No veterinary legislation has currently been put in place by the government (Chetra and Bourn, 2009; Wallberg, 2011; Tornimbene and Drew, 2012).

Given that different production systems are closely linked to the cultural and socio-economic backgrounds of the rural population (Sovann and Sorn, 2002); this might impact on farmers' knowledge and awareness of diseases and transmission, and on their likely actions in the event of animal diseases (Udeh et al., 2010). Such actions might also be associated with factors that have been shown to affect behaviours and decision-making: age, gender, education, experience, cognitive ability, household status, lifestyle attitude, and farmers' goals and values (Santoyo Rio, 2011; Toma et al., 2013). It is therefore important, when trying to understand PRRS epidemiology in the Cambodian Mekong lowland region, to explore behavioural differences among farmers.

A KAP (Knowledge, Attitude and Practice) survey is a representative study of a specific population to collect information on what is known, believed and acted on in relation to a particular topic (WHO, 2008). Such surveys are particularly helpful in evaluating a vulnerability to animal diseases in resource-scarce settings (Tiongco et al., 2012). In a system characterised by the absence of guidelines for both farmers and local veterinarians and by the absence of national strategies to control the introduction or spread of diseases, farmers' behaviour can have an important impact on the occurrence of disease epidemics. The evaluation and description of KAP for Cambodian farmers concerning swine diseases, their impact and their control, and their willingness to involve VAHWs and local veterinarians, might therefore help in the development of evidence-based disease prevention campaigns and efficient veterinary public health interventions. The aim of this study was to generate a better understanding of Cambodian swine producers' behaviour, in relation to PRRS and its control, in areas that have been previously affected by the disease.

2. Materials and methods

2.1. Study design and study area

A survey of the KAP of pig owners with regard to PRRS was carried out between March and April 2012 in a number of semi-commercial and backyard farms in the province of Takeo. Within Cambodia, Takeo province is an important pig producing area, containing mainly small and medium size farms (Chetra and Bourn, 2009). The province is located in the south-eastern part of the country, bordering Viet Nam, where multiple outbreaks of PRRS occurred between 2008 and 2010 (Feng et al., 2008; Le et al., 2012).

Semi-commercial farms were randomly selected from a list (obtained from the Cambodian National Veterinary Research Institute) containing all active semi-commercial farms in the province. Farms in the list were numbered and the "RAND" function in Microsoft Excel 2010 (Microsoft, Redmond, WA) was used to generate random entries. Lot quality assurance survey (LQAS) methodology was used to calculate a farm sample size ($n = 25$), with a sampling plan appropriate to classify the area as having PRRS herd prevalence <20% or >40% with 95% confidence (Brooker et al., 2005; Myatt et al., 2005). Twenty-five farms were visited in February 2010 and in a subsequent stage (June 2010) nine farms were added to replace farms that had stopped raising pigs. For this KAP survey all farms visited in February and June 2010 were recruited, for a total of 34 semi-commercial farms.

The selection of backyard farms was carried out as follows: two villages were randomly selected from all villages located within 2 km of 12 of the 25 initially selected semi-commercial farms. Within each of the 24 selected villages, a list of all backyard farms actively rearing pigs was obtained with the assistance of the village chief and/or village animal health worker. Farms were then randomly selected from the list (using a smart-phone random number generator application); three or four backyard farms were visited in each village, for a total of 78 backyard farms. The number of backyard farms to be sampled within each village was calculated in order to detect the disease with 95% confidence for expected prevalence among farms of at least 60%.

2.2. Survey methodology

A standardised, structured questionnaire (English version available as electronic supplementary material) was used to collect information on demographics (gender, age, education and profession), farm characteristics, and farmers KAP towards PRRS. A list of clinical signs typical of PRRS circulating in Asia (depression, anorexia, dyspnoea, cough, nasal discharge, sitting dog position, facial and/or eye oedema, lameness, high fever, tremors, skin lesions, cyanosis of ears and/or thighs, and/or perineal areas) was presented to the participants and the following KAPs were investigated (Tian et al., 2007):

1. Knowledge of PRRS and its transmission patterns.
2. Farmers' attitudes towards PRRS and its prevention and/or control in four different disease scenarios (absence of disease and outbreak events at three different levels: own farm, other farms in same village, other farms in different villages in the same district).
3. Farmers' practices related to PRRS control once the disease is present in the farm.
4. Knowledge and perception towards vaccination.
5. Perception towards VAHWs and local veterinarians' effectiveness.

Table 1 summarises the questionnaire contents in relation to KAPs explored. Closed and open format questions were used, together with Likert-scale items to assess the level of agreement of the interviewee with a number of knowledge queries or to assess the frequency of events (WHO, 2008). Ranking cards were also used to measure the effectiveness of suggested control measures. Specifically, 13 cards were used, each card presenting a preventive/control practice. Four different disease scenarios (no disease, disease present in their district, disease present in their village, disease present in their farm) were described to survey participants. Participants were then asked to rate the effectiveness of each control measure suggested on the cards for each disease scenario, by ordering the cards from the most effective practice to the least.

Questionnaires were drafted in English language and translated into the Khmer language by a professional translator. Two interviewers in charge of interviewing the participant and filling the questionnaire were trained in KAP survey methodology. The Khmer version of the questionnaire was reverse translated into English by the project interviewers to check for discrepancies. The final version presented questions and responses in both Khmer and English languages so as to allow the main author to read the material. The questionnaire was piloted in six farms in Kandal province, in proximity to the capital Phnom Penh, and the final version modified according to interviewers' feedback.

Upon arrival at a farm the family member responsible for pig rearing (i.e. buying piglets/gilts, feeding the pigs, cleaning the pen, treating pigs if sick, and trading) was selected for the interview; if different members of the family were in charge of different activities, the family was asked to select the person that was generally taking the most important decisions about pig rearing. A brief description of the aim and objectives of the project was read to the candidate. Upon agreement to take part in the survey, the selected person was taken to an area of the farm where he/she could be completely alone to avoid external influences to his/her responses. No one else was allowed to participate in the interview.

Interviews were carried out in the Khmer language by the interviewers using a dialogue-based format; the interviewers went through each question without prompting any responses, and recorded all the information/responses of the participant in English. At the end of each day, interviewers and the main author double-checked all the responses, to clarify possible translation errors between Khmer and English.

2.3. Data analysis

Data from the questionnaire were compiled in Microsoft Excel 2010 (Microsoft, Redmond, WA) by one of the authors

Table 1
Description and format of questions used to gather information on KAPs with regard to PRRS and its control utilised in the survey of 112 semi-commercial and backyard farms in Takeo province, Cambodia (2012).

Topic	Description	Questions format
1.		
Knowledge of cause of PRRS clinical signs	Participants were asked to list potential causes for the manifestation of the following clinical signs in their pigs: high fever, dyspnoea, cough, nasal discharge, sitting dog position, facial and/or eye oedema, lameness, skin lesions, cyanosis of ears and/or thighs and/or perineal areas	Open question
Knowledge of PRRS transmission	Participants were asked to describe possible transmission routes of the disease (PRRS) from pig to pig, farm to farm, village to village	Open question
Knowledge of PRRS transmission routes	Participants were asked to express their agreement on six statements with regards to PRRS transmission: through direct contact between infected animals, aerosol, contaminated fomites, contaminated dung, venereal transmission (boar to sow and sow to boar) between infected and not infected host. Although transmission through live cover it is also a direct contact transmission, question were formulated separately to investigate the knowledge of participants in relation to venereal transmission, in view of a possible future introduction of artificial insemination as reproductive practice	Likert-scale (yes, confident; yes, not confident; I do not know; no, not confident; no, confident)
2.		
Attitude towards preventive and control measures	Participants were given four potential disease scenarios – no disease, disease in the district, disease in the village, disease in the farm- and asked to list what they perceived the most effective preventive and control measures for each scenario	Open question and ranking cards
3.		
Practices during disease outbreak	Participants were asked to describe actions they undertake during disease outbreaks with sick and healthy pigs	Open question
4.		
Attitude towards vaccine usage	Participants were asked to list reasons, if existing, for not using vaccination	Open question
Perception of vaccine effectiveness	Participants were asked to explain the effect of vaccine on their pigs	Open question; Likert-scale for participant response "protection from diseases" (always, sometimes, rarely)
Knowledge of vaccine action	Participants were asked to indicate how many diseases one vaccine type protects from	Closed question
5.		
Attitude towards local veterinary authority	Participants were asked to list reasons for not calling the VAHW or the local veterinarian in case of disease in the farm	Open question
Attitude towards local veterinary authority	Participants were asked to define the likelihood of calling the VAHW or the local veterinarian in case of disease in the farm	Likert-scale (Always, Sometimes, Rarely/Never)
Perception of local authority effectiveness	Participants were asked how effective they thought the VAHW or the local veterinarian was in treating sick pigs	Likert-scale (confident all pig will get better, confident some pig will get better, confident no pigs will get better, not confident but all pig will get better, not confident but some pig will get better, not confident but no pigs will get better, I do not know)

and quality was controlled for entry errors by the main author. Data were summarised in order to assess differences in KAP between semi-commercial and backyard farms. Only the responses of the ranking cards placed by the farmers in the first four positions were considered; responses for each scenario were added and percentages for each different response calculated.

Regression models were used to analyse the association between seven independent variables and a number of different outcomes (dependent variables): knowledge of viral transmission, use of vaccine, and farmers' attitude towards the veterinary service (VAHWs and public veterinarians). Dependent variables analysed and their indicators are presented in Table 2.

Independent variables (Table 3) considered and included in all models were: gender of the respondent, years of formal schooling, duties in relation to pig rearing, farming system (breeder, farrow to finish and breeder, farrow to finish, farrow to finish and fattener, fattener), herd size, previous experience of PRRS during the 2010 outbreak, and whether or not participants had identified an infectious disease as the cause of listed

Table 2
Description of dependent variables used for the eleven statistical models designed to analyse the association between recorded KAPs and a number of independent variables, and their corresponding indicators.

Outcomes	Variables	Statement	Description	Variable type
Knowledge of viral transmission	Transmission index	General knowledge of PRRS transmission pig to pig	Likert-scale responses for variables *n*. 2–7 were scored (4 = yes confident; 3 = yes not confident; 2 = don't know; 1 = no not confident; 0 = no confident). Scores of variables *n*. 2–7 were then added up to generate a continuous variable (transmission index)	Ordinal (the transmission index was divided into quartiles)
	Direct contact	Knowledge of PRRS transmission pig to pig through direct contact	0 = I don't know/no, not confident/no, confident; 1 = yes, confident/yes, not confident	Dichotomous
	Aerosol	Knowledge of PRRS transmission pig to pig through aerosol	0 = I don't know/no, not confident/no, confident; 1 = yes, confident/yes, not confident	Dichotomous
	Fomites	Knowledge of PRRS transmission pig to pig through fomites	0 = I don't know/no, not confident/no, confident; 1 = yes, confident/yes, not confident	Dichotomous
	Dung	Knowledge of PRRS transmission pig to pig through contaminated dung	0 = I don't know/no, not confident/no, confident; 1 = yes, confident/yes, not confident	Dichotomous
	Boar to sow	Knowledge of PRRSV venereal transmission	0 = I don't know/no, not confident/no, confident; 1 = yes, confident/yes, not confident	Dichotomous
	Sow to Boar	Knowledge of PRRSV venereal transmission	0 = I don't know/no, not confident/no, confident; 1 = yes, confident/yes, not confident	Dichotomous
Use of vaccines	Vaccine target	Belief related to vaccine performance	0 = Yes, one vaccine covers for one disease 1 = No, one vaccine covers for more than one disease	Dichotomous
	Vaccine effectiveness	Perception of vaccine effectiveness	0 = rarely/never; 1 = sometimes/always	Dichotomous
Attitude towards the veterinary service	VAHW	Frequency of which VAHW is called in the event of disease	3 = always; 2 = sometimes/rarely; 1 = never	Ordinal (three-point Likert scale)
	Local Vet	Frequency of which VAHW is called in the event of disease	3 = always; 2 = sometimes/rarely; 1 = never	Ordinal (three-point Likert scale)

clinical signs for PRRS. Semi-commercial and backyard farmers' responses were merged; farm typology (semi-commercial or backyard) was considered a potential confounder and incorporated as a fixed effect in each of the models.

Due to the hierarchical structure of the data obtained (farmers: level 1\\nested within villages: level 2\\nested within communes: level 3) multilevel regression was applied. Generalised linear mixed models (GLMMs) were implemented in STATA 11.2 (StataCorp LP, TE). The adaptive approximation method was used for all models, to improve accuracy and calculation time (Rabe-Hesketh et al., 2004; Rabe-Hesketh and Skrondal, 2012).

Communes and villages were initially added to the models as random effects, in order to account for the variation within and between the two levels. The following procedure was then applied to fit the models: maximum likelihood (ML) estimates of parameters were obtained for models with and without random effect containing only a constant; likelihood ratio tests were then used to assess improvements in the model fit. It was decided to retain commune level in all models even if variance estimates were not significantly different from zero, in order to allow for identical data structure through the whole analysis. However, village level variance proved always to be very small, and because there were no major differences in the magnitude of coefficients between a model with and without the village random effect, it was decided to eliminate this level.

Univariate analysis was performed using binary logistic or ordinal regressions depending on the outcome of interest. Variables with a significance level $\alpha \leq 0.20$ where checked for co-linearity by calculating variance inflation factors (VIF) and variables with VIF < 10 retained for further analysis (Dohoo et al., 2010; UCLA, 2012). Once in the final multivariate model, non-significant ($P > 0.05$) variables were removed sequentially. Biologically or other meaningful interactions (e.g. gender and year of schooling) were manually tested and retained when $P \leq 0.05$.

Following the described model building strategy eleven different models were developed:

Table 3
Description of independent variables included in the eleven statistical models designed to analyse the association between recorded KAPs and a number of hypothetical predictors (zero is the baseline value). Farm typology is incorporated in the model as fixed effect.

Variables	Categories
Gender of the respondent	1 = male; 0 = female
Years of formal schooling	0 = none; 1 = Primary school; 2 = Secondary school or higher
Duties in relation to pig rearing	
Farmer taking care of livestock	1 = yes; 0 = no
Farmer taking care of crop	1 = yes; 0 = no
Farmer: other	1 = yes; 0 = no
Farming system	
Breeder	1 = yes; 0 = no
Farrow to finish + Breeder	1 = yes; 0 = no
Farrow to finish	1 = yes; 0 = no
Farrow to finish + Fattener	1 = yes; 0 = no
Fattener	1 = yes; 0 = no
Herd size	Total number of pigs (continuous variable log-transformed)
Experienced PRRS in 2010	1 = yes; 0 = no
PRRS as cause of listed clinical signs	1 = yes; 0 = no
Farm typology	1 = backyard; 0 = semi-commercial

- Model 1: Likert-scale responses of the six questions investigating knowledge of farmers concerning transmission mechanisms of PRRSV through direct contact, aerosol, fomites, dung contamination, and venereal transmission (boar to sow and sow to boar) were ranked (Table 2). Scores for each of the six questions were added up in order to give a total outcome (transmission index), which was then divided into quartiles and analysed using a multilevel ordinal regression model.
- Models 2–7: responses of the previous six transmission questions investigating the knowledge of farmers towards transmission mechanisms were also categorised into “yes” and “no/I don’t know” (Table 2). Six categorical outcomes were then analysed singularly using a multilevel logistic regression model.
- Models 8 and 9: beliefs over vaccine features and effectiveness of vaccination were considered as outcomes of interest (Table 2). For the first model, yes/no answers to the question “Does one vaccine cover for one disease only?” were analysed in a multilevel logistic model by considering as a binary outcome the two beliefs: “yes, one vaccine covers for one disease” and “no, one vaccine covers for more than one disease”. For the second model, the frequency by which a farmer perceived vaccination to be successful in protecting his/her pigs was used as proxy for the general perception of vaccine effectiveness (Table 2): the outcome was treated as binary – effective or not effective – and analysed using multilevel logistic regression.
- Models 10 and 11: the frequency with which participants were requesting VAHWs and local veterinarians to visit their farms in the event of disease (always, sometimes, never) was used as proxy for participants’ perception of VAHW and local veterinarian effectiveness (Table 2). Results were considered as ordinal variables and analysed using multilevel ordinal regression. The outcome variable of the VAHW model was also added as independent variable to the local veterinarian model; this was done in order to investigate the interaction between the frequency participants’ were contacting the VAHW with the perception of the local veterinarian effectiveness. For the same reason, the outcome variable of the local veterinarian model was added as an independent variable to the VAHW model.

Approximate likelihood-ratio test of proportionality of odds was used to check that the proportional odds assumption of ordered logistic regression was not violated. Level 2 and 3 residuals were checked for normality and homoscedasticity. Level 1 residuals are generally disregarded because GLMMs models do not have normally distributed error terms at this level and therefore corresponding residuals and diagnostics are difficult to assess (Dohoo et al., 2010). Note that for GLMMs some special statistics that are often used for generalised linear model (GLMs) diagnostics, such as the Hosmer–Lemeshow test for goodness of fit, are not available (Dohoo et al., 2010).

The total variance was commutated assuming level 1 variance on logit scale as in Eq. (1) (Dohoo et al., 2001, 2010):

$$var(Z_i) = \sigma_c^2 + \sigma_v^2 + \frac{\pi^2}{3} \quad (1)$$

where

Z_i: Latent continuous measure of binary or ordinal outcome i
σ_c^2: Commune level variance
σ_v^2: Village level variance
$\pi^2/3$: Ordinary logistic regression residual variance

Based on this estimate, the intra-class correlation coefficient (ICC) of commune level was calculated for each model using Eq. (2) (Dohoo et al., 2010):

$$\rho = \frac{\sigma_c^2}{var(Z_i)} \quad (2)$$

In the case of commune level the ICC (%) is also equal to its proportion to the total variance.

2.4. Ethical approval

Permission to undertake the work reported was granted by the Cambodian National Veterinary Research Institute, which is part of the Animal Health and Production office of the Ministry of Agriculture Food Fishery and Forestry. The questionnaire was previously submitted and approved by the Royal Veterinary College (UK) Ethics and Welfare Committee.

3. Results

A total of 112 farms, comprising 34 semi-commercial farms and 78 backyard farms, were included in the survey. The farms studied were located in 42 villages within 24 communes of seven districts. Forty-seven percent of participants from semi-commercial farms were male and 76% of backyard farmers were female. The fattening of pigs

Table 4
Demographic and farm characteristics of 112 surveyed Cambodian semi-commercial and backyard swine farmers. Results are reported per farm typology: semi-commercial (SC) and backyard (BY) farms.

Variables	% SC (*n* = 34)	% BY (*n* = 78)
Gender of participants (person in charge of pig rearing)		
Female	53	76
Male	47	24
Age of participants		
15–20	0	3
21–30	15	17
31–40	35	33
41–50	38	24
>50	12	23
Number of years attending school		
None	3	11
1–5 (Primary school)	15	39
6–10 (Secondary school)	73	42
>10 (Higher education)	9	8
Duties of participants		
Farmer – looking after the crops	65	79
Farmer – looking after animals	91	82
Housewife	18	21
Shop keeper/street vendor	21	42
Teacher/student	6	4
Government employee	6	1
Non-Government employee	3	0
Middleman/trader	3	0
Participants' farming practices in the last 12 months		
Breeder	9	9
Farrow to finish/breeder	35	23
Farrow to finish	26	6
Farrow to finish/fattener	3	1
Fattener	44	67
Experienced PRRS outbreak in July–August 2010		
Yes	82	35
No	18	65

was the most common activity among participants. Demographic and farm characteristics are shown in Table 4.

3.1. Knowledge of PRRS and its transmission patterns

When presented with the list of clinical signs typical of PRRS (Fig. 1), most farmers acknowledged an "infectious disease" as the origin of those signs. According to participants, other potential origins included weather changes, diet, enteric parasites and insect bites.

When asked about the spread of the disease between pigs (Table 5), direct contact was indicated by more than 80% of participants in both groups, while 53% of semi-commercial farmers and 19% of backyard farmers indicated "people who come into contact with pigs" as one of the potential routes of transmission. Fifteen percent of semi-commercial farmers and 19% of backyard farmers also considered environmental contamination by dung and water used to wash the pens, and 18% of semi-commercial and 10% of backyard farmers mentioned the sharing of materials – such as food bowls – between pigs. Physical contact with serving boars was never mentioned and only 3% of semi-commercial farmers considered the possibility of infected sows transmitting the disease to their foetuses.

When a number of specific transmission routes typical of PRRSV (direct contact, aerosol, fomites, dung contamination and venereal transmission) were listed to participants the majority of semi-commercial (68–94%) and backyards farmers (58–82%) were confident in agreeing that these were potential routes of infection, with the exception of fomite transmission for backyard farmers (Fig. 2). Overall, backyard farmers were less aware of typical PRRSV transmission routes than semi-commercial participants.

When participants were asked how they thought the disease could spread between farms located in the same village (Table 5) they indicated "other farmers and/or people moving between those farms" (74% of SC and 45% of BY) as one of the main routes of spreading, together with wind (38% of SC and 31% of BY). Transmission of the disease between farms situated in different villages (Table 5), was viewed as caused by "other animals present in the village which have access to the pig farms" (47% of SC and 19% of BY), wind (29% of SC and 24% of BY), infected pork meat (21% of SC and 28% of BY) and specifically by "traders and veterinarians and/or their vehicles" (21% of SC and 8% of

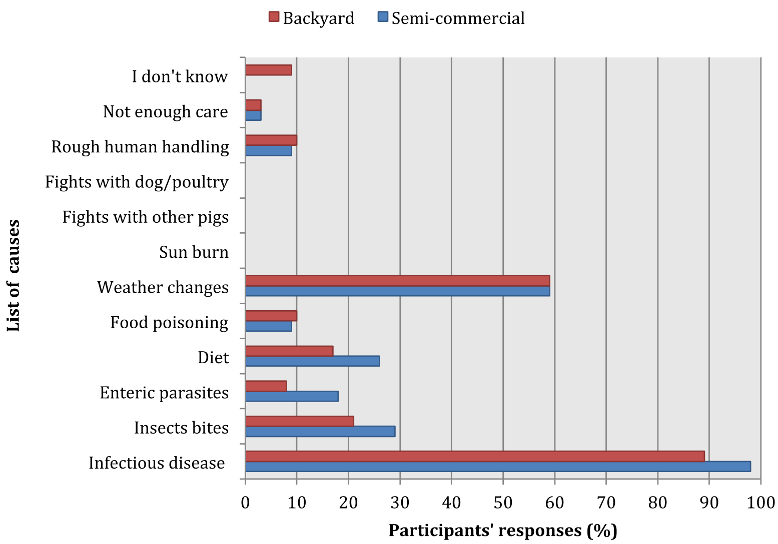

Fig. 1. Participant responses to possible causes of listed PRRS-like clinical signs in their pigs.

Table 5
Participants' knowledge of PRRS transmission routes between pigs, farms and villages based on responses from 112 participants of Takeo province's semi-commercial and backyard swine farms, Cambodia (2012). Results are reported per farm typology: semi-commercial (SC) and backyard (BY) farms.

Participants' responses	Pig to pig		Farm to farm		Village to village	
	% SC (n = 34)	% BY (n = 78)	% SC (n = 34)	% BY (n = 78)	% SC (n = 34)	% BY (n = 78)
Direct contact between pigs	94	82	0	5	0	0
Aerosol that transports the agent	9	14	38	31	29	24
Weather changes	0	0	0	3	0	3
Mosquitoes	0	0	0	4	0	1
Environmental contamination (water/dung)	15	19	6	10	0	9
Boar – sow cover (venereal transmission)	0	1	6	0	0	1
Sow to foetus (vertical transmission)	3	0	0	0	0	0
Farmers/people moving between farms	53	19	74	45	3	4
Trader/middleman that travel between farms in the same day	0	0	18	6	21	8
Trader/middleman vehicles used to travel between farms during the same day	0	0	6	4	21	8
VAHW/local vet that visit different farms in the same day	0	0	18	4	21	8
VAHW/local vet vehicles used to travel between farms during the same day	0	0	0	0	3	0
Free ranging pigs that have access to pigs in the farm	0	0	0	12	6	4
Other animals that have access to pigs in the farms	15	1	18	6	47	19
Through infected pork meat	6	4	15	28	21	28
Sharing farming materials (food bowls)	18	10	0	0	0	0
Sharing used syringes and needles	3	5	0	0	0	0
Transmission is not possible	0	0	0	3	3	5
I don't know	0	5	12	10	15	21

BY). Again, no participants mentioned serving boars, which travel between farms, as a potential route of disease spread.

The results of the multilevel ordinal regression for the participants' knowledge of general transmission of PRRSV are presented in Table 6. The commune level ICC, which describes the proportion of the total variance due to the location of recruited farms in different communes, is 0.03 (3%), signifying almost total independence between observations within the commune cluster. As shown in Table 6, male farmers and farmers with a higher level of education were more likely to have a better knowledge of transmission routes between pigs.

Significant results of the multilevel logistic regressions model for factors associated with the knowledge of specific transmission routes are shown in Table 6. Male farmers and farmers with a secondary level education (high school) had higher odds of being aware of the role of aerosol and fomites in the transmission of the disease. Male farmers seemed to be more aware of the risk of boars infecting sows, while farmers who were mostly working with crops were less aware of this particular route of infection. Knowledge of transmission through direct contact and contaminated dung was not associated with any of the independent variables considered.

3.2. Participants' attitude and practices towards biosecurity measures targeted at PRRS prevention and control

Responses to open-ended questions describing attitudes towards bio-security practices of semi-commercial and backyard farmers (Table 7) were compared for each of the different disease scenarios and no major differences in perceptions were identified: vaccination and disinfection were the control measures most frequently mentioned as being effective for the control of the disease. For the last

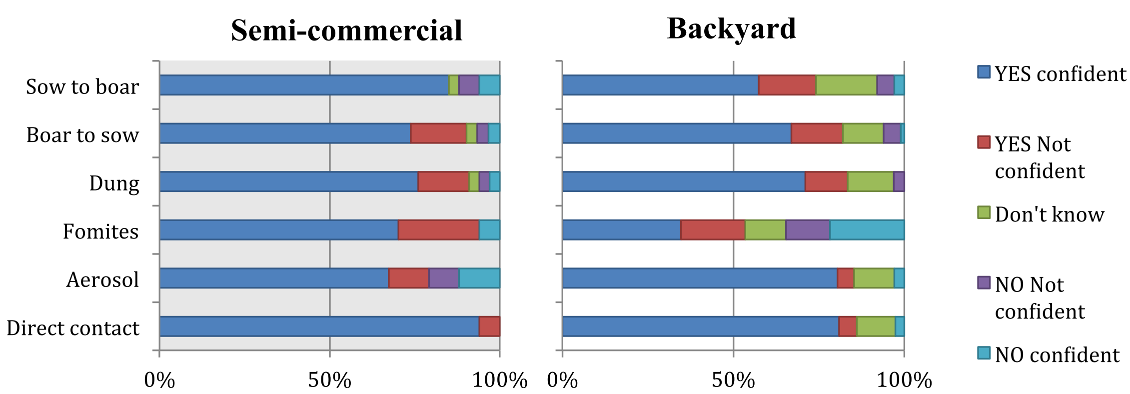

Fig. 2. Participants' knowledge of PRRS transmission routes. Participants were given scenarios describing each transmission route and Likert-scales were used to record their knowledge and the confidence level of related responses.

Table 6
Multilevel ordered and logistic models of seven dependent variables associated with farmers' knowledge of PRRSV transmission patterns based on responses from 112 participants of Takeo province's semi-commercial and backyard swine farms, Cambodia (2012).

Model Variables	1 TRANSMISSION INDEX (*ordered*)		3 AEROSOL (*logistic*)		4 FOMITES (*logistic*)		6 BOAR TO SOW (*logistic*)		7 SOW TO BOAR (*logistic*)	
Random effect	Variance	S.E.[a]	Variance	S.E.	Variance	S.E.	Variance	S.E.	Variance	S.E.
Commune	0.116	0.214	>0.001	>0.001	2.499	1.966	1.093	7.866	2.473	1.940
Fixed effect	OR	*p*-Value	OR	*p*-Value	OR	*p*-Value	OR	*p*-Value	OR	*p*-Value
Typology = Backyard	1.145	0.735	0.517	0.189	1.689	0.581	0.602	0.450	0.424	0.261
Gender = Male	3.59	0.002	3.882	0.009	19.592	0.024	9.07	0.011	–	–
School = Primary	3.798	0.097	4.198	0.114	7.394	0.057	–	–	–	–
School = Secondary school or higher	5.958	0.024	6.078	0.041	21.04	0.012	–	–	–	–
Duty = Farmer: livestock	–	–	–	–	–	–	–	–	0.384	0.025
Cut 1[b]	0.955	0.246	–	–	–	–	–	–	–	–
Cut 2	2.390	0.006	–	–	–	–	–	–	–	–
Cut 3	3.328	0	–	–	–	–	–	–	–	–
Observations	112		–		–		–		–	
Proportion of variance (%)	3		–		43		24		41	

[a] Standard error of estimate of variance component.
[b] Cut: estimated cutpoint on the latent variable used to differentiate low, medium and high response variables when values of the predictor variables are evaluated at zero.

scenario, (PRRS circulating in the farm) participants also indicated "separate sick pigs from healthy" and "stop buying pork meat" as the two most important measures to apply. Quarantine was never mentioned, neither during disease epidemics, nor in the absence of disease. During active circulation of the disease, controlling free-range pigs, both from entering or leaving the farm and stopping the purchase of pigs from other farms/villages, were mentioned only by a small portion of participants (3–15% of SC and 6–12% of BY) (Table 7).

The results of ranking cards suggested that participants gave the same importance to the set of control measures throughout the four scenarios. Semi-commercial and backyard participants' responses were very similar. As

Table 7
Results of open format questions investigating participants' attitudes towards PRRS preventive and control measures in different disease scenarios (1 = no disease; 2 = disease in the district; 3 = disease in the village; 4 = disease in the farm) based on responses from 112 participants of Takeo province's semi-commercial and backyard swine farms, Cambodia (2012).

Suggested measures	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	% SC (*n* = 34)	% BY (*n* = 78)	% SC (*n* = 34)	% BY (*n* = 78)	% SC (*n* = 34)	% BY (*n* = 78)	% SC (*n* = 34)	% BY (*n* = 78)
Nothing	0	0	0	0	0	0	3	1
Apply vaccination	91	79	62	53	0	0	38	47
Apply disinfection	79	72	76	69	76	69	50	58
Would not let pigs free range	0	12	0	8	6	9	3	9
Would not allow free range into farm	0	5	0	8	3	6	0	8
Apply quarantine	0	1	3	0	0	1	12	3
No access to the farm to roaming animals	3	1	9	5	6	4	6	4
No access to the farm to family involved swine/pork industry	12	0	12	4	9	4	12	1
Stop visiting other farms	15	1	26	9	24	8	18	9
Restrict access to the farms	29	8	29	17	32	10	26	10
Stop access of middleman/trader	0	0	12	5	18	8	0	0
Stop access of middleman/trader vehicles	0	0	0	4	3	4	6	0
Stop access of VAHW/local vet	0	0	3	3	0	0	0	0
Call the VAHW or local vet	12	17	18	24	12	41	26	35
Stop using kitchen scraps to feed pigs	18	15	15	31	21	35	12	22
Stop using unclean water to clean pigs	21	28	35	40	32	38	12	22
Keep pigs cool/clean	29	35	38	29	24	37	12	22
Good/change feed	29	35	9	12	0	8	12	10
Treat pigs with medicine	0	0	0	0	0	0	26	23
Use mosquitoes net	24	9	12	8	18	9	0	4
Stop purchasing pigs	12	1	12	1	0	0	15	6
Stop buying pork meat	6	15	6	15	9	23	68	71
Sell pigs	0	1	0	1	0	4	0	4
Separate sick pigs from healthy pigs	0	0	0	0	0	0	68	71

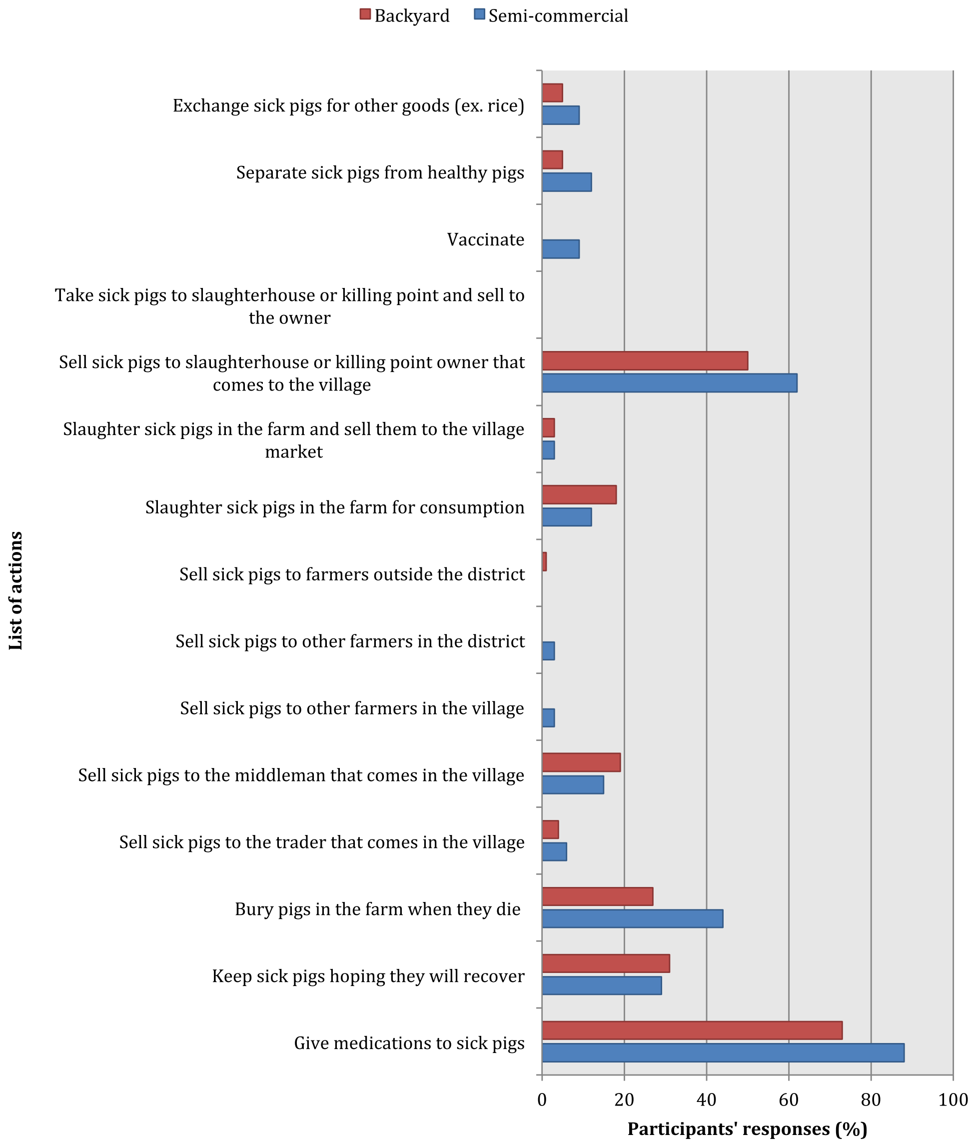

Fig. 3. Participants' actions towards pigs showing clinical signs typical of PRRS.

expected, vaccination and disinfection were perceived to be the most effective practices to follow during any of the disease events.

When asked which practices participants physically implement when they have diseased pigs in the farm, semi-commercial and backyard farmers appeared to have very similar approaches towards control practices (Fig. 3). Most participants chose either to treat sick animals in the hope they would recover, or to sell the pigs directly to the owners of small official slaughterhouses or killing points (informal local slaughterhouse). Most participants (100% of SC and 90% of BY farmers) also kept their "healthy" pigs (no clinical signs), hoping they would not get sick before the completion of a normal production cycle.

3.3. *Knowledge attitudes and practices towards the use of vaccine*

Even if vaccination was selected as one of the most effective control measures (only 15% of SC and 19% of BY farmers reported they would not use it the event of a disease), half of participants were under the impression that vaccines were only occasionally effective. Only a few participants (3% of SC and 4% of BY) raised the issue that it might be difficult to keep vaccines on the farm because of the absence of a cold chain, while almost no farmers (3% of SC and 4% of BY) thought that they were too expensive or difficult to find. Only 3% of semi-commercial farmers and 9% of backyard farmers did not know what a vaccine was.

Table 8
Multilevel logistic models describing association between factors and vaccination beliefs based on responses from 112 participants of Takeo province's semi-commercial and backyard swine farms, Cambodia (2012).

Model	8		9	
Variable	VACCINE TARGET (*logistic*)		VACCINE EFFECTIVENESS (*logistic*)	
Random effect	Variance	S.E.[a]	Variance	S.E.
Commune	0.178	0.452	0.071	0.543
Fixed effect	OR	*p*-Value	OR	*p*-Value
Typology = Backyard	3.966	0.010[*]	0.947	0.923
Vaccine target	–	–	4.155	0.047
Observations	112		112	
Proportion of variance (%)	5		2	

[a] Standard error of estimate of variance component.
[*] Significant.

3.4. Perception about effectiveness of vaccination

Results of two multilevel logistic models analysing the association of selected factors with participants' beliefs on vaccination are shown in Table 8. Compared to semi-commercial farmers, backyard farmers were more likely to believe that one vaccine type protects from one specific disease and participants with this belief seemed to find vaccination more effective.

3.5. Farmers' attitudes towards the veterinary services

Frequencies of interactions between participants and VAHWs or local veterinarians in the event of disease are shown in Fig. 4. VAHWs were called out more frequently than veterinarians. Overall, 70% of all farmers were confident that the visit of a VAHW or local veterinarian would help improve the health of all or some of sick pigs.

Among participants who did not routinely call the VAHW, 19% of semi-commercial and 21% of backyard farmers stated that they called the VAHW out only when pigs were very sick and when medicines bought privately were not effective. Fourteen percent of semi-commercial and 6% of backyard participant thought the VAHW was too expensive, and 18% of semi-commercial participants, compared to 6% of backyard participants, stated they could treat pigs themselves. Thirty-two percent of the semi-commercial farmers who never contacted VAHWs thought that the y were not good at treating their animals.

Among participants who did not contact local veterinarians, around half (42% of SC and 52% of BY) responded that they were not sure how to reach them and 19% semi-commercial and 42% of backyard farmers felt the veterinarian was living too far from the farm; some (17% SC and 6% BY) thought that the veterinarian was generally not interested in visiting farms. They also thought that the veterinarian generally took too long to reach the farm after the first telephone contact (3% SC and 3% BY) or that he/she was too expensive (6% SC and 7% BY). Very few farmers (3% SC and 8% BY) were unaware of the existence of their local veterinarian.

Results of the last two multilevel ordinal models are shown in Table 9. The results show that the likelihood of calling VAHWs during a disease event decreased as the herd size increased. In addition, the results indicate that participants who contacted VAHWs more frequently were less prone to call the local veterinarian.

4. Discussion

This study integrates previous knowledge of features of PRRS in Cambodia with an analysis of one of the most

Table 9
Multilevel logistic models describing participants' perception of VAHW and Veterinarians effectiveness based on responses from 112 participants of Takeo province's semi-commercial and backyard swine farms, Cambodia (2012).

Variable (*MLM regression*)	10 VAHW (*ordered*)		11 LOCAL VETERINARIAN (*ordered*)	
Random effect	Variance	S.E.[a]	Variance	S.E.
Commune	>0.001	>0.001	0.602	0.674
Fixed effect	OR	*p*-Value	OR	*p*-Value
Typology = Backyard	1.476	0.400	1.087	0.880
Herd size	0.944	0.014	–	–
VAHW	–	–	0.184	0
Local Veterinarian	0.255	0	–	–
Cut 1[b]	−3.713	0	−2.232	0.777
Cut 2	−1.963	0.001	−1.285	0.743
Observations	112		112	
Proportion of variance (%)	–		15	

[a] Standard error of estimate of variance component.
[b] Cut: estimated cutpoint on the latent variable used to differentiate low, medium and high response variables when values of the predictor variables are evaluated at zero.

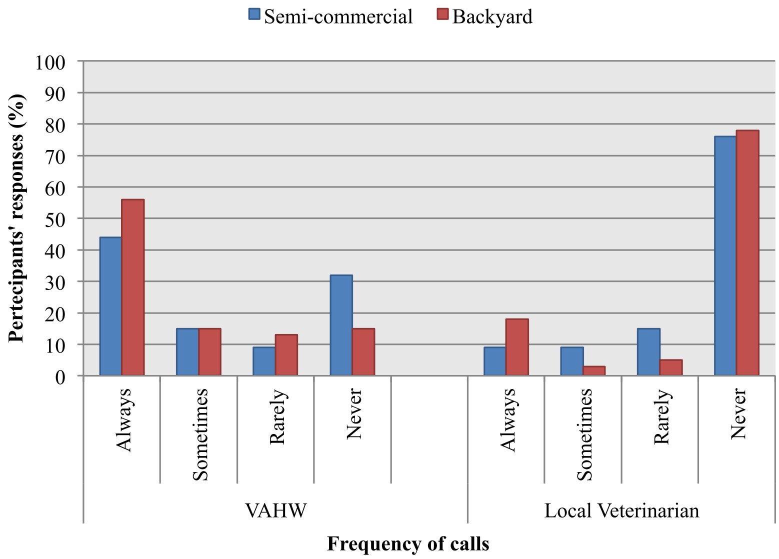

Fig. 4. Frequency with which participants call VAHWs and local veterinarians in case of disease.

important components of its epidemiology – those human beliefs and actions that might shape the way the disease develops in a population. Although the results of this survey can be considered just a snapshot of a single Cambodian province, Takeo, Cambodian farming practices seem to be consistent throughout geographical areas with similar characteristics (Tornimbene and Drew, 2012). Accordingly, these results are potentially applicable to other similar provinces in the lower Mekong region of Cambodia, which is also the area with the highest pig density. They may also be applicable to neighbouring countries with similar practices.

Differences between Cambodian semi-commercial and backyard farms are not marked in terms of knowledge, attitude, and practices towards PRRS. These findings reflect the fact that semi-commercial husbandry techniques are still rudimentary and that semi-commercial farmers have a limited understanding of disease epidemiology and application of control measures (Tornimbene and Drew, 2012). This could prove costly to farmers in the region, considering that the more vulnerable entry points in Cambodia for the 2010 PRRS epidemic were very likely semi-commercial farms, which have larger herds, trade more widely and have a bigger turnover of pigs (Wu et al., 2008; Dietze et al., 2011).

Although farmers did demonstrate awareness about what might cause PRRS-like signs, this was not associated with having experienced the disease in 2010; this knowledge might derive from experience of an endemic situation in respect of other respiratory diseases that have been shown to be present in Cambodia. When interpreting farmers responses in relation to PRRS clinical signs, it is important to note that differential diagnosis includes a number of diseases: of those commonly circulating in Cambodia, classical swine fever (CSF) and porcine circovirus type 2 (PCV2) need to be considered (Psilos, 2008; Dietze et al., 2011); however, the cyanosis of the ears and the perineal areas, and lameness associated to respiratory symptoms are very characteristic of the highly pathogenic form of PRRS circulating in Asia since 2006, so that farmers responses were considered consistent enough with the identification of the disease (Tian et al., 2007; Metwally et al., 2010; Dietze et al., 2011).

The second most reported explanation among farmers as to the cause for the listed clinical signs was "weather changes", and although PRRS outbreaks have shown seasonality patterns in Viet Nam, we think it is unlikely that Cambodian farmers have experienced deadly outbreaks of PRRS frequently enough to be able to build a mental timeline (Le et al., 2012). A possible explanation for all participants associating clinical signs with weather changes could be the common farmers' awareness of the effect of high temperature on animals; heat in fact raises pigs stress levels and inhibits immune responses, so that farmers might see pigs generally getting sicker during the hot season (Le et al., 2012).

Besides investigating farmers' awareness of the existence of infectious diseases, this project looked at exploring the level of farmers' knowledge in terms of disease biology, and identifying differences in KAPs between small and medium-scale keepers. Farmers were left free to respond on questions about 'pig to pig' viral infection routes and direct contact between infected pigs was the transmission route most frequently identified by participants. This, together with environmental contamination, were the two mechanisms equally mentioned by both semi-commercial and backyard farmers. In general, semi-commercial farmers showed a higher awareness of the risk of pathogen transmission via humans or other animals accessing the farm and other fomites, compared to backyard farmers. However, when specifically asked, employing Likert-scale format questions about transmission routes typical of PRRS, both semi-commercial and backyard farmers seemed equally knowledgeable. This discrepancy could be related to various factors including: (1) The questionnaire's open questions might not have been clear or correctly formulated; (2) Farmers did not feel the need to be very specific in their responses so as to speed up the interview; (3) Farmers did not perceive those routes of infection as being important enough to be mentioned (Kristensen and Jakobsen, 2011).

It is not surprising that formal secondary school education had a positive impact on farmers' knowledge with regard to transmission routes; such farmers are more likely to be literate, with greater level of access to information and are also likely to be aware of the general concepts of disease causation and transmission (Carnoy, 1992; Udeh et al., 2010; Tiongco et al., 2012). It has been shown that a key factor influencing farmers' behaviours is the access to available sources of information on biosecurity measures and animal health issues (Tiongco et al., 2012; Toma et al., 2013). For example, in our study responses to questions on fomite transmission and venereal transmission varied among communes. This variance could be attributed to differences in quality or availability of the information to which farmers might have had access to in the past (Carnoy, 1992). The need for effective communication strategies and the existence of misunderstanding between the national animal health organisation and farmers has previously been associated with poor farmer knowledge of animal diseases (Caro III et al., 2010). In Cambodia, government information campaigns are not generally available to farmers, but they are mainly targeted to VAHWs and local veterinarians (personal observation) who may or may not then distribute the relevant knowledge to farmers.

Male farmers appeared to be more knowledgeable than female farmers, although the analysis that looked for any correlation between gender and year of schooling failed to identify any significant association between the two variables. Previous studies on farmers' agricultural knowledge, carried out in Nepal and Africa, have indicated that perceived gender differences might have their origin in the division of labour (Kekeunou et al., 2006). In our study interviewed male farmers were mostly in charge of bigger farms and probably spent most of their focus on pig rearing. This could explain why they tended to have a better knowledge of disease transmission patterns. In contrast, female farmers were more often in charge of backyard farms. Given that these smaller farmers might have less access to information due to the limited nature of their business and that women are often busy with household chores and children, the finding that female farmers are less knowledgeable might therefore be a reflection of them having less time to read or access training (Nöremark et al., 2009; Udeh et al., 2010). Moreover, in 2010 semi-commercial farms appeared to have experienced a higher number of PRRS outbreaks than backyard farms (unpublished data). It is therefore possible that male farmers, who predominate in this sector, might have been more aware of the causes of the disease at the time of this survey. In contrast, women, who predominate in the backyard sector, could be perceived as less knowledgeable simply because they have experienced PRRS less and have therefore not yet had the opportunity to obtain sufficient information on PRRS epidemiology.

Interestingly, knowledge of the concept of infectious disease or having previously experienced PRRS did not have an impact on farmers' knowledge of PRRSV transmission routes and this would therefore probably not enhance farmers' preparedness towards possible future PRRS outbreaks; this could mean that even if farmers are aware of an event, they might only have a limited understanding of it. For example, Tiongco et al. (2012), in his KAP study for HPAI risk and management options among Kenyan poultry producers, found no correlation between lack of knowledge about disease signs and frequency of disease. This raises the question of how farmers perceive the infection itself: surprisingly in our study, farmers do acknowledge other people and animals as mechanical vectors for PRRS (traders, middleman and roaming animals for between-village transmission), but almost ignore the role of boars, which travel extensively from farm to farm and constantly come into direct contact with sows in different villages, posing a great threat of disease spread during epidemics, both through physical contact and via semen. Some recent studies on risk perception have focussed on the recognition of the mismatch between perceptions of risk and measurable probabilities of risk (Palmer et al., 2009). The probability of an event's occurrence may be overshadowed by personal experience, memory and other factors which influence the way people perceive risks (Palmer et al., 2009). It is probably more difficult to conceive the idea of venereal transmission than fomite transmission, simply because in the first case it might take a long time between the visit of the boar to the onset of any clinical sign in the farm; also the boars do not visit farms very frequently. In contrast it is very common for other farmers or friends to come into contact with pigs and other animals which could make it quite intuitive for farmers to think about the risk of the virus circulating though people moving in and out the village.

Thus, even if farmers show baseline knowledge in terms of what is affecting the health of their livestock and seem aware of potential PRRS transmission routes, real understanding of viral pathobiology is missing; as a result, basic control measures (quarantine, testing breeding stock, limiting access to farms to roaming animals, avoiding free-ranging) are rarely mentioned as important practices to follow. Farmers are more concerned with looking after the tangible and daily wellbeing of their pigs (water, feed, keeping them fresh), than building farms that could guarantee a basic level of bio-security (personal observation).

Participant attitudes towards control measures was found to be quite similar for all of the disease scenarios described, which suggests a limited concept of prevention as such. As discussed by Janz and Becker (1984), people's (preventive) measures tend to be determined by (i) the perceived threat (perceived vulnerability and perceived severity) and (ii) the perceived effectiveness of proposed measures (perceived benefits and barriers) (Kristensen and Jakobsen, 2011). At the time of the study, the majority of Cambodian farmers appeared to lack the level of knowledge of disease spread necessary to enable them to foresee events. As a result farmers seemed constrained to analysing situations as they emerged and then taking action (personal observation).

In general, very few farmers seemed to be concerned about bio-containment in the case of an outbreak of the disease on their farm. There was some awareness of the risk posed by sick pigs – it was interesting to note that a high percentage of farmers would consider dividing sick pigs from healthy ones once PRRS was present on the farm. However, the sick pigs would then be left to free-range, with the threat of harming other farmers' livelihoods by letting potentially infectious pigs roam the village probably not being perceived as of concern.

In terms of action during a disease outbreak on a farm, it appears clear that farmers tended to keep their pigs as long as possible, using medication and hoping for a recovery. An acknowledged limitation of this study was to not differentiate farmers' actions in relation to pig age groups and it therefore was not possible to discern farmers' practices targeting young stock, although in general, farmers tried to reduce economic losses by selling pigs directly to the slaughterhouse owners instead of to middlemen. An interesting point when looking at farmers' actions is the apparent 'cognitive dissonance' between attitudes and behaviours: they perceived vaccination and disinfection as important control strategies, but then they did not generally apply them (Heffernan et al., 2008). Similarly, farmers considered it important to call the VAHWs or the local veterinarian, but they did not always contact them when they had sick pigs in their farms.

More than 90% of participants use vaccination to protect pigs from diseases; however participants did not always perceive vaccines to be effective, which could be related to a number of factors, including scarcity of the vaccine itself, deterioration of the vaccine, error in administration and/or farmers limited understanding of vaccine action (Le Minor, 2011). Also, farmers' knowledge concerning vaccination protocols and vaccine storage requirements seemed very limited, for example, very few farmers recognised the lack of cold storage as a major limitation in a country where temperatures can reach up to 42 °C in the dry season. In contrast to semi-commercial farmers, backyard farmers believed that one vaccine type protected against one specific disease. This discrepancy could possibly be attributed to semi-commercial farmers having had access to multi-pathogen vaccines, which could have created the belief among these farmers that one vaccine type covers for more than one disease. Although a limitation of our study was to not clearly identify the vaccine type within our questionnaire, previous interviews with farmers had generated the impression with the authors that multi-pathogen vaccines were not used by Takeo farmers (personal observation). There was not much variation between responses related to vaccines in different communes, so it can be assumed that VAHWs or the local veterinarian only have a small role in affecting farmers' behaviours in terms of vaccination. It would therefore be interesting to investigate the role of private drug suppliers, who travel through many districts of Cambodia but who were not included in this study.

Farmers seemed generally confident about the effectiveness of both VAHWs and local veterinarians, so there might be other reasons as to why farmers tend to not to contact them during an outbreak. For example, the fact that some farmers have easy access to drugs and vaccines, and can afford them, might explain why semi-commercial farmers tend to rely less on VAHWs or local veterinarians and prefer to treat pigs themselves; in fact, they would have to cover double costs (drugs and any fee the VAHWs or the vet charges) without being sure pigs would get better. It has been reported in a separate study that better off households tend to spend a smaller share of their income on services than those that are very poor (Riviere-Cinnamond, 2005). Social distance, manifesting as a barrier to access to services due to gender, wealth, ethnicity and educational variation between farmers and VAHWs or veterinarians may also play an inhibiting role (Riviere-Cinnamond, 2005).

From discussions with farmers, it was clear that they do not see the two professional figures as complementary, tending instead to call one or the other (generally the VAHWs, who are much easier to reach). It has been previously discussed whether the role of the VAHWs might actually be detrimental to the creation of a more functional farmer-veterinarian relationship, because while VAHWs may be considered to play a more important role than veterinarians in taking care of animals on a daily basis, they may only attend very short training courses and might have limited understanding of disease epidemiology (Ashley, 2002). In addition, they are not recognised as government employees nor remunerated for their services, which often results in three inter-related behaviours: firstly, they might ask farmers to buy unnecessary drugs or feed in order to secure an income; secondly, they may not always to be able to respond to call-outs and cannot afford to leave their daily activities in order to come and visit animals in other farms (there is no electricity in most Cambodian villages, so that animals need to be visited during the day) and thirdly, they might present themselves as appointed veterinarians in order to ask for a fee for each visit. Also, they are often trained by different agencies, and this results in differences in curriculum and training periods which certainly influences their capability and might affect the general credibility of the role itself (Riviere-Cinnamond, 2005).

The model analysing the association between factors and the frequency with which farmers were requesting VAHWs to visit their farms in the event of disease did not highlight a big variation in terms of farmer responses in different communes, although there was some variability in responses with regard to the local veterinarian; this probably reflects the natural variability existing between professional entities. In general, farmers do acknowledge the positive function of local veterinarians, but are still unwilling to involve them. This behaviour is due to a lack of habit or physical impediments (distance, unknown contact) rather than a general mistrust towards government employees, as has been shown in other studies on VAHW and local veterinarian performances in Africa (Hüttner et al., 2000). We have also found proximity to the clientele to be a crucial determinant of the quality and frequency of livestock services for the performance of veterinary technicians (Hüttner et al., 2000; Riviere-Cinnamond, 2005). The nurturing of a more positive attitude among farmers towards the veterinary local authority might therefore be used to strengthen their relationship and their collaboration, to the benefit both of the veterinary authority and the farmers themselves.

5. Conclusions

Semi-commercial and backyard swine farmers in the Takeo province of Cambodia have a sub-optimal knowledge of PRRSV transmission patterns and consequently, a limited attitude towards effective preventive and control measures against PRRS. Farmers of both categories could benefit from a better understanding on the specific characteristics of PRRS viral transmission, and how to apply targeted measures to PRRS control in different disease scenarios (bio-security and animal movement control). Given that in our study education played an important role in farmers' awareness towards the disease and that both genders were represented in taking part in pig rearing, more training should be provided and it should be targeted to both genders.

Although Takeo farmers were using vaccines to protect their pigs, vaccines are not always effective, which could be related to farmers' lack of education in terms of vaccine efficacy, storage, and vaccination protocols as well as to the quality of the vaccine itself and its efficient transport. The relevant authority should regulate access to drugs and vaccines, so that farmers would be more prone to involve VHAW and veterinarian so to benefit of their knowledge.

There is a general lack of engagement and communication between Takeo farmers and the local veterinary authority. Disease control could therefore be further aided by regular meetings between farmers' representatives and veterinarians, which should be encouraged in order to enhance dialogue and collaboration and share information, particularly during times when the threat of disease incursion from neighbouring countries is increased.

Conflict of interest

The authors declare that they have no competing interests.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.prevetmed.2013.12.009.

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