

Rural veterinarian's perception and practices in terms of biosecurity across three European countries

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Abstract

The implementation of biosecurity measures in the animal health and production context is quite broad and aims at limiting the risk of introduction and spread of diseases. Veterinarians play a major role in biosecurity as key informants on the subject for cattle holders, key players in terms of disease prevention/control and eradication programs, as well as key risk factor in terms of disease dissemination. Many biosecurity studies have highlighted professional visitors such as veterinary practitioners as representing a high risk factor in terms of disease introduction in animal facilities but, to date, very few studies have focused on the implementation level of biosecurity measures by veterinarians. An on-line survey was implemented in three European countries (Belgium, France and Spain) in order to assess the behaviour of rural veterinarians towards biosecurity, as well as their implementation level of the biosecurity measures. A descriptive analysis of data and a scoring system were applied in order to assess the implementation level of measures. The influence of different factors on the implementation level of biosecurity measures was investigated through a negative binomial regression model. The study identified different strengths, weaknesses, possible constraints and solutions in terms of veterinary perspectives. Veterinarians are considered as key informants by the farmers and could therefore play a more active role in terms of guidance and improvement of biosecurity at farm level. Based on the survey outcomes, two factors seemed to influence significantly the implementation level of measures: the country where he/she practices and the veterinarian's perception level of biosecurity. The biosecurity stages with the lowest application level, therefore representing the biggest threats, were bio-exclusion (increasing the risk of disease introduction) and bio-containment (increasing the risk of inter-herd transmission).

Keywords: biosecurity; veterinarians; survey; perception; cattle; Belgium; France; Spain.

Introduction

Biosecurity (BS) is defined by the Food and Agricultural Organization as “A strategic and integrated approach to analysing and managing relevant risks to human, animal and plant life and health and associated risks to the environment” (FAO, 2007). Over the last decades, the importance of BS in animal production systems has increased due to the large economic impact of animal diseases and increasing awareness on the One Health concept and zoonotic risks. It has been previously reported that 75% of the emerging diseases were originating from domestic or wild animals and 60% of existing human infectious diseases were zoonotic (Taylor, Latham, & Woolhouse, 2001). The World Health Organization (WHO) has recently listed the top 10 emerging pathogens based on outbreaks risks and lack of non-existence medical countermeasures (Pizzi & Chard, 2015). Based on this analysis, an initial list of eight diseases needs urgent attention, as they are all zoonotic: Crimean Congo haemorrhagic fever, Ebola virus disease, Marburg haemorrhagic fever, Lassa fever, Middle East respiratory syndrome (MERS), severe acute respiratory syndrome (SARS), Nipah virus disease and Rift Valley Fever.

The infectious nature of pathogens combined with poor biosecurity practices may contribute to disease transmission within and between farms (e.g. Fretin et al., 2013; Chenais et al., 2017; Kylie et al., 2017). The implementation of biosecurity measures (BSM) in the animal health and production context is quite broad (Mai, 2014) and includes proper implementation of measures to reduce the risk of introduction and spread of the pathogens.

In any animal facility, BSM rely on five stages (Saegerman, Dal Pozzo, & Humblet, 2012): (i) B1, Bio-exclusion: limiting the risk of introduction, (ii) B2, Bio-compartmentation: limiting the spread within the same facility, (iii) B3, Bio-containment: limiting the spread to other animal facilities (inter-herd transmission), (iv) B4, Bio-prevention: preventing human contamination and (v) B5, Bio-preservation: preventing environmental bio-contamination.

In this context, and for these 5 stages, the role and responsibility of veterinarians are key elements to ensure an early detection and control of disease outbreaks. Veterinarians play a major role as key informants on the BS for cattle holders; indeed, they consider their veterinary practitioner as the main source of information and adopt BSM based on veterinary advices (Gunn, Heffernan, Hall, McLeod, & Hovi, 2008; Heffernan, Nielsen, Thomson, & Gunn, 2008; Sayers et al., 2013). On the other hand, veterinarians also represent an important risk factor in terms of disease spread, as many studies have listed visitors, and more specifically professional visitors such as veterinarians, as a key risk factor in terms of bio-exclusion (N. G. Anderson, 2009; Brennan & Christley, 2013; Canadian Food Inspection Agency, 2013; Maunsell &

Donovan, 2008; Mee, Geraghty, O'Neill, & More, 2012a; NADIS, 2015; M. Nöremark, Frössling, & Lewerin, 2010; Sayers et al., 2013; van Schaik et al., 2002; van Winsen et al., 2016). Meanwhile, an on-going survey implemented in Belgian cattle farms (unpublished data) confirmed that most cattle holders were not feeling comfortable in asking their veterinarians to wear clean and/or specific work clothes or boots when visiting their premises; they prefer relying on their professionalism in that regard. Nevertheless, only few studies have assessed the proper implementation of BSM by veterinarians in rural practice. Their perception of the role they play and the responsibilities they have with regard to that aspect remains unclear. Based on a PubMed search with “biosecurity”, “veterinarians” and “cattle OR cow OR bovine” used as keywords, the level of awareness, understanding and/or implementation of BSM by veterinarians has only been studied in the following countries: Sweden (Maria Nöremark & Sternberg-Lewerin, 2014), Great Britain (Gunn et al., 2008; Pritchard, Wapenaar, & Brennan, 2015; Shortall et al., 2016), Ireland (Sayers, Good, & Sayers, 2014) and Spain (Simon-Grifé et al., 2013).

This survey aimed at assessing the perception and interest of rural veterinarians towards BS, as well as the implementation level of BSM through an on-line survey implemented in Belgium, France and Spain. It consisted in identifying strengths and weaknesses in terms of BSM in various cattle production systems from the veterinary perspective. The study also assessed the possible influence of different contextual factors on the implementation level of BSM by veterinarians.

Materials and methods

Questionnaire design

The questionnaire was elaborated based on a literature review of questionnaires used in other studies related to biosecurity practices among veterinarians (D. E. Anderson, 2012; Gunn et al., 2008; Hoe & Ruegg, 2006; Kristensen & Jakobsen, 2011; Maunsell & Donovan, 2008; Maria Nöremark & Sternberg-Lewerin, 2014; Pritchard et al., 2015; Sayers et al., 2014; Shortall et al., 2016; Simon-Grifé et al., 2013), and a working session gathering 10 rural veterinarians from the three countries, held to identify the problems they faced in their daily practice in relation with BSM. The questionnaire (**Appendix 1**) was initially divided into 11 categories: clothes, boots, material, organisation of visits, hand hygiene, vehicle, management of medical waste, biosecurity of the veterinarian, advices to farmers, veterinary training and veterinary profile. It was pre-tested with 6 veterinarians from the 3 countries before final validation and launching.

It included multiple choice and open questions, and was designed as an on-line survey hosted in Google Drive™ in order to reach a maximum of veterinarians and ease data collection. It was opened for 3 months and different channels were used to invite veterinarians to participate:

- in Belgium, invitations were sent to 2,850 private veterinarians by the Professional Union of Veterinarians (U.P.V), through their monthly booklet. This exhaustive list included 500 veterinarians with a rural or mixed practice.

- in France, invitations were sent by the National Society of Veterinary Technical Groups (SNGTV), based on their mailing list of 2,000 members; 1,300 of them were included, whatever animal species and type of practice.

- in Spain, the questionnaire was hosted on the Spanish Association of Bovine Veterinarians website (<http://www.anembe.com/>). The association's membership is 1,000.

Analysis of descriptive data

The answers provided were standardised and re-categorised.

Regarding the questions on work environment, veterinarians were asked to mention the application level of some key BSM by cattle holders, such as: (i) operational footbaths, (ii) separated/isolated calving boxes, (iii) adequate quarantine for incoming animals and (iv) consideration of the veterinarian as the most appropriate adviser on BSM. These answers described the farm environment in which veterinary practitioners were working and the possible influence they could have on farmer practices. The last two questions concerned the main points the cattle holder, and the veterinarian her/himself, could improve, as well as the BS stage they considered as the most important. The possible areas of improvements for cattle holders and veterinarians were asked in an open question with a list of 3 measures to improve in decreasing order of importance. A score of 3 to 1 was assigned to each listed measure: 3 for the first measure listed, 2 for the second one and 1 for the third one. The total score per measure was calculated (e.g: a measure listed twice in first position, 5 times in second position and only once in third position would obtain a total score of 17 (sum of $(2*3) + (5*2) + 1$). Finally, a ranking of all measures was carried out, based on such total score.

A scoring system was applied to data in order to estimate different types of scores in relation with implementation of BSM by veterinarians (**Appendix 2**). In case of no answer, the lowest score was imputed, assuming the absence of answer was masking poor BS practices. Sub-questions with a $\leq 30\%$ -answer rate were not considered. First of all, seven categories of BSM

were created: (1) work clothes, (2) boots, (3) hands, (4) material, (5) risk consideration, (6) management of medical waste and (7) advices on purchase.

For each category, a specific score was generated per BS stage (B1-5) based on the answers provided. A general biosecurity score (5B score) was then calculated for each category, based on the formula below:

$$[5B\ score]_x = 100 * \frac{\sum_{i=1}^5 B(i)_x}{[Maximum\ score]_x}$$

With x= 1 to 7 for the category of measures concerned; i = 1 to 5 for the biosecurity stages B1 to B5. Maximum score = sum of maximum scores possible for B1 to B5.

After calculating the 5B scores of each category, a global 5B score was obtained by summing the 5B scores of each category. Global scores for each biosecurity stages (B1 to B5) were also calculated based on the formula below:

$$Global\ score\ B_x = \sum_{i=1}^7 B_x^* \text{ of category } (i)$$

With x= biosecurity stage concerned; i = 1 to 7 for each measure category

* expressed as a score of 0 to 100, with 100 as the maximum score obtainable.

A descriptive analysis of data was performed in order to estimate the application level of BSM by veterinarians, per category of measures and BS stage (bio-exclusion, bio-compartmentation, bio-containment, bio-prevention and bio-preservation), as well as to assess the farm environment and identify possible ways or areas of improvements.

Regression analysis

Some variables were selected as possible explanatory variables: country, years of experience, type of practice, number of herds managed, main type of herds and perception of biosecurity (**Appendix 3**) while the others contributed to the calculation of different BS scores (**Appendix 2**).

A negative binomial regression model was built in Stata SE 14.1® (StataCorp LP, College Station, TX, USA), using the global 5B score as dependent variable and different explanatory variables (**Appendix 3**). The negative binomial regression method was applied due to extra-binomial variability. A p-value of 0.05 was considered as significant.

The first model included all explanatory variables (**Appendix 3**) and the non-significant variables ($p>0.05$) were removed in a step-by-step approach (starting from the least significant variable, i.e. the variable with the highest p-values). Interactions between “country” and “BSM perception” was considered in the initial model. At each step, a likelihood ratio test comparing two nested models allowed comparing the simplified to the more complex model. When the likelihood ratio test yielded a $p>0.05$, the explanatory variable was discarded. The final model was selected when the likelihood ratio test stated a significant difference between the more complex and the simplified model ($p<0.05$). In this case, the more complex model was retained.

The same procedure was followed using the specific BS scores (from B1 to B5) as dependent variables and the same initial explanatory variables. It aimed at assessing eventual differences in terms of considerations given by the veterinarians to each BS stages.

Results

A total of 205 surveys were properly completed by the rural veterinarians. Based on the number of veterinarians reached in the different countries, the global answer rate is of 7.3% with rates of 19.4%, 4.8% and 4.6% in Belgium (N=97), France (N=62) and Spain (N=46), respectively. The global, French and Spanish answer rates are under-estimated as the veterinary practitioners invited to participate were not only rural or mixed practitioners.

Descriptive analysis of the veterinary survey

Profiles of respondents are presented in Table 1 while Appendix 4 (A-G) summarises the dependent variables used in the negative binomial regression model.

Table 1. Overview of the number of respondents per country (N = 205)

		Belgium	France	Spain	Total
Type of practice	100% Rural	39	13	39	91
	>50% rural	48	39	6	93
	<50% rural	10	10	1	21
Years of experience	0-13	38	18	9	65
	14-24	18	15	16	49
	24-31	20	12	16	48
	>31	21	17	5	43
Perception of Biosecurity measures	Very high	30	14	3	47
	High	13	14	7	34
	Average	25	12	9	46
	Low	20	14	17	51
	Very low	9	8	10	27
	1-40	2	12	61	47

Number of farms in the practice	41-80	8	11	53	34
	81-150	18	13	45	14
	>150	34	10	46	2
Type of herds	Dairy	12	18	33	63
	Mixed	25	0	0	25
	Suckling	33	31	10	74
	Varied	27	13	3	43
Total respondents		97	62	46	205

Regarding the perception of veterinarians concerning BSM (**Figure 1**), most of them considered it as a priority for the profession, while 2% did not answer, as shown in Figure 1A. The majority of the veterinarians (80%) do not consider to be usually at risk, from the safety point of view, while 1.5% perceived they were systematically at risk (Figure 1B). For what professional training in terms of biosecurity was concerned, 23% mentioned not having followed any training after graduating, either due to lack of interest (2.5%) or to the lack of time (20.5%); 13.7% of participants mentioned biosecurity trainings as being part of their veterinary curriculum while post-graduation studies or readings on the topic were specified by 36.1% of them (Figure 1C).

In terms of farm environment (**Figure 2**) facilities required in terms of BS are rather poorly present. Less than 10% of farms have functional footbath(s) as mentioned by 89% of participants. Specific boxes for calving is mentioned for less than 25% of farms by 87% of veterinarians. More than 90% of cattle holders do not apply an appropriate quarantine period for incoming animals, as specified by 63 % of veterinarians. The majority of veterinarians (67%) mention being considered by farmers as their privileged interlocutor in terms of biosecurity advices.

From the veterinarians' perspective, the most important measures to improve in cattle holdings are: (i) make functional footbaths and cleaning facilities (e.g. boot and hand washing stations) available for visitors, (ii) apply control measures and quarantine upon purchasing animals and (iii) have an appropriate attitude towards BSM in terms of awareness, understanding and behaviour change (**Table 2**). Small differences were noticed between countries. In Spain, the lack of cleaning facilities and footbaths was not seen as a priority while the control of visitors seemed a more important issue. In France, the absence of an isolation area was mentioned as the third most important measure to improve.

After calculating specific scores for each of the five BSM stages (B1 to B5) and the general 5B score for each category of measures, it was possible to assess the implementation level of BSM per category and stage, as well as the possible improvements (**Figure 4 A and B**). In terms of proportion of BSM implementation per category, “management of medical waste” was the category with the highest implementation level (79%), followed by the category “materials” (63%), “hands” (47%), “work clothes” (45%), “risk consideration” (35%), “Advices on purchase” (34%) and “boots” (24%).

Table 2. Veterinarians’ ranking of biosecurity measures to be improved by cattle holders (N=205)

Measure to be improved by cattle holders	Belgium	France	Spain	Total
Lack of functional foot baths /cleaning facilities for visitors	213	232	36	481
Purchases: no quarantine	191	82	63	336
Purchases: no control	131	58	88	277
Behaviour of cattle holders towards BSM: lack of awareness, understanding and behaviour change	86	45	51	182
Prevent contact between domestic animals and wildlife	42	41	43	126
Control of visitors	34	27	63	124
Isolation of sick animals / having an isolation area	29	75	15	119
General hygiene of the cattle holder	59	43	11	113
Unfitted infrastructures for implementation of BSM	31	19	47	97
Appropriate and regular cleaning and disinfection of stables	27	30	19	76
Limited time or possible investments	33	10	22	65
General hygiene of materials and equipment	18	14	10	42
Calving boxes/area	18	20	1	39
Provide specific clothes/boots for visitors	26	4	6	36
Bio-exclusion measures	0	31	4	35
Appropriate disease control and management system at farm level	20	1	7	28
Improve national system in terms of control, regulation and communication	13	4	4	21
Bio-confinement measures	13	2	0	15
Control of vector and rodents	9	0	6	15
Appropriate animal grouping system	6	1	5	12
Other	9	1	5	15

Legend: BSM = biosecurity measures; in bold and italic: the four most important measures, ranked per country.

Hygiene measures related to hand, work clothes and boots reached a score generally low. For boots measures (**Appendix 4B**), 63% of the veterinarians never wear cover-boots, while 89% of them do not wash their boots under the water jet upon entering premises; they usually wash

and brush boots only when exiting farms (94%). Veterinarians using cover-boots (but not systematically; N=65) report doing it mainly in the following situations: outbreaks, high risk or suspicion of infection, expertise visits or trainings and in off-land rearing facilities. On the contrary, they do not use cover-boots if they need to enter the boxes or walk in the litter: indeed, cover-boots are not considered as practical in such cases. For what work clothes are concerned (**Appendix 4A**), 58% of veterinarians only change clothes when they look dirty or less often than daily. Disposable calving gowns are used by 60% of participants in case of surgery. Regarding hand hygiene (**Appendix 4D**), 66% of the veterinarians wash their hands after each farm but only 25% of them use antibacterial soap (65% of them use soap and 9% clear water). Only 30% of the veterinarians always wear disposable examination gloves during their visits, while 29% use them often, 32 %, sometimes and 8%, never.

For purchase advices provided to cattle holders (**Appendix 4G**), most veterinarians advocate for risk mitigation by suggesting to limit or avoid purchases (69%), test animals (79%) and/or apply quarantine (1%). Nevertheless, advices seem limited, in terms of diseases to test for: those that are not targeted by a disease control or eradication programs are usually not suggested (e.g. the proportion of veterinarians who never mention bluetongue, Schmallenberg disease, Mortellaro disease and mastitis reached 63%, 66%, 55% and 42%, respectively).

Regarding risk considerations for organizing work (**Appendix 4F**), 65% of the veterinarians do not organise their farm visits based on risks. Furthermore, within a same cattle farm, 25% of them do not visit the animals in an order based on contamination risk. Most veterinarians are aware of the risk linked to necropsies and, either they refuse to perform them on site (20%), or they take specific measures to limit the number of necropsies or the risk of contamination (65%). The vehicle is parked inside the farm for 47% of participants and 8% of them bring their dog in the car during the visits.

Hygiene of medical materials (**Appendix 4E**) and management of medical waste (**Appendix 4C**) are generally well implemented. The large majority of veterinarians do not use domestic trash to dispose of their empty flasks (82%), out of date medicine flasks (88%), needles and scalpel blades (88%). A yellow container for medical waste is present in the vehicle of 71% of veterinarians. Regarding medical equipment (needles, etc.), the majority of participants (>50%) change after each animal, and a large majority change at least after each farm, except for syringes; indeed, 33% of veterinarians change them daily (or less often) and only 32% of them change after each animal. Reusable material is mainly sterilized after each animal (67%), and

the sterilization process seems fully effective for only 28% of veterinarians, while not fully effective for 64% and ineffective for 5%.

Based on the veterinary perception of their work practices, the biosecurity stage they consider to implement the best is bio-exclusion (B1) for 56% of participants and bio-containment (B3) for 21% of them (**Figure 3A**). When considering specific scores per biosecurity stage (**Figure 3B**), it appears that 54% of the veterinarians obtained the highest score for bio-prevention (B4), 22% for bio-preservation (B5) and 15% for bio-compartmentation (B2). Their lowest score was obtained for the concept/pillars they thought to manage correctly (**Figure 3A and B**). After ranking the most important measures to be improved in their practice (**Table 3**), the five most important were: (i) improve disinfection of clothes and boots between farms, (ii) provide more technical guidance/advice to farmers in terms of biosecurity, (iii) require minimal cleaning facilities and equipment at farm level (for Belgian and French veterinarians), (iv) cleaning and disinfection of medical materials and (v) use of disposable clothes and/or gloves. In Spain, an appropriate vehicle hygiene by increasing the cleaning frequency appeared in the top five measures to be improved.

Table 3. Veterinarians' ranking of measures to be improved in their own practice (N=205)

Measures to be improved by the veterinarians	Belgium	France	Spain	Total
Cleaning and disinfection between farms (clothes and/or boots)	<i>76</i>	<i>77</i>	<i>43</i>	<i>196</i>
Provide technical advice to cattle holders	<i>49</i>	<i>21</i>	<i>31</i>	<i>101</i>
Require minimal cleaning facilities and equipment at the farm level such as dedicated boots, clothes, and surgical materials	<i>62</i>	<i>28</i>	10	<i>100</i>
Appropriate cleaning and disinfection of surgical materials	<i>38</i>	<i>29</i>	<i>20</i>	<i>87</i>
Use of disposable clothes and/or gloves	<i>30</i>	<i>27</i>	<i>12</i>	<i>69</i>
Hygiene of professional vehicle	13	14	<i>19</i>	46
Technical advice provided to the farmer regarding purchases of animals	17	7	14	38
Better time and stress management and risk based planning	19	10	12	41
Hand hygiene	9	8	2	19
Other	4	8	6	18
General hygiene	8	8	0	16
Disposable clothes and/or gloves for surgeries	8	5	0	13
Technical advice in terms of animal grouping system	6	6	1	13
Use of disposable cover-boots	4	4	3	11
Management of medical waste	8	0	3	11
Hygiene measures between animals	0	1	8	9
Technical advice on control of visitors	6	0	3	9
Not depend on the farmer for hands and boots disinfection	3	3	0	6

Legend: In bold and italic, the five most important ranks by country.

Negative binomial regression model

The first model using the general 5B score as dependent variable showed significant differences between countries and BSM perception level by veterinarians. The score was significantly higher for France ($p = 0.011$, coeff. = 0.0565 and 95% CI = 0.0197-0.1531) and Spain ($p < 0.001$, coeff. = -0.1432 and 95% CI = 0.0675-0.2191) compared to Belgium; no significant difference was observed between France and Spain. The score was also significantly higher for veterinarians with the highest BSM perception level ($p=0.005$, coeff. = -0.1455 and 95% CI = 0.0446-0.2465). No significant difference was highlighted when considering other explanatory variables and/or interaction between country and BSM perception level.

When the models using specific BS stage scores as dependent variable were applied, significant explaining variables were similar, with two exceptions: no significant differences between Belgium and Spain for B4 score, and no significant difference due to BSM perception for B2 score (**Table 4**).

Table 4. List of significant explanatory variables in the final models, using the different scores of biosecurity measures as dependent variables (N total= 205, Belgium: N=97, France: N=62, Spain: N=46)

Dependent variable	Significant explanatory variables		p-value	Coefficient	95% confidence interval	
	Variable	Variable category				
5B	Country	France	0.011	0.087	0.020	0.153
		Spain	<0.001	0.143	0.067	0.219
	BSM perception	BSM perception 5	0.005	0.146	0.045	0.247
B1- Bioexclusion	Country	France	0.002	0.148	0.055	0.241
		Spain	<0.001	0.209	0.124	0.293
	BSM perception	BSM perception 5	0.006	0.150	0.043	0.258
B2- Biocompartmentation	Country	France	<0.001	0.225	0.124	0.326
		Spain	0.001	0.195	0.084	0.306
B3- Bioconfinement	Country	France	0.008	0.087	0.023	0.151
		Spain	<0.001	0.164	0.092	0.236
	BSM perception	BSM perception 5	0.006	0.135	0.039	0.230
B4- Bio prevention	Country	France	0.011	0.120	0.028	0.213
	BSM perception	BSM perception 5	<0.001	0.178	0.038	0.318

B5- Bio preservation	Country	France	0.046	0.070	0.001	0.138
		Spain	0.068	0.072	-0.005	0.150
	BSM perception	BSM perception 5	0.005	0.148	0.045	0.251

Legend: BSM perception 5 = very high level of perception of biosecurity.

Discussion

The present online survey provides a useful analysis of the current level of implementation of BSM by rural veterinarians, which is in line with the general outcomes of previous biosecurity studies implemented in Europe (D. E. Anderson, 2012; Brennan & Christley, 2013; Gunn et al., 2008; Heffernan et al., 2008; Laanen et al., 2014; Mee, Geraghty, O'Neill, & More, 2012b; M. Nöremark et al., 2010; Maria Nöremark & Sternberg-Lewerin, 2014; Sarrazin, Cay, Laureyns, & Dewulf, 2014; Sayers et al., 2014, 2013; Toma, Stott, Heffernan, Ringrose, & Gunn, 2013; Villarroel, Dargatz, Lane, McCluskey, & Salman, 2007). It also highlighted the areas of improvements. Moreover, the present scoring system allowed a more specific analysis per biosecurity pillar/concept and category of measures. The main factors influencing significantly the application level of BSM were identified in order to facilitate decision-making.

The scoring system gave the same weight to each category of measures in the calculation of the global 5B score. This could generate a bias if some category of measures represent a higher biosecurity risk. This was taken into account, as the method assigned a higher weight to measures affecting all concept/pillars of biosecurity, compared to measures influencing only one of them.

This survey analysed mainly BSM practices of veterinarians in terms of role and responsibilities on: (1) technical guidance of cattle holders to improve BS at farm level and (2) their possible role as mechanical vector of diseases.

Biosecurity infrastructures (e.g. calving areas, isolation stall) are rarely available in farms. The main weaknesses that should be corrected, as a matter of priority, are linked to bio-exclusion and bio-containment (footbath and cleaning facilities for visitors, quarantine for newcomers, control of visitors and contacts with other domestic species and wildlife). The survey also confirmed that cattle holders do consider the veterinarian as a key informant on the biosecurity topic. Therefore, veterinarians could and should play an active role in terms of guidance and BSM improvements at farm level.

Regarding the veterinary practices, the current implementation level is quite low, which leaves, except for management of medical waste and material, a large place for improvement. These findings are in line with the most important improvements the veterinarians consider as a priority to implement in their practice. Hygiene of boots and clothes between farms is probably conditioned by the lack of cleaning facilities in farms, which was reported as the main weakness in French and Belgian farms. Another improvement suggested by some veterinarians was the possibility to have their own cleaning and disinfection system in their vehicle. From the comments reported in the survey, organising the visits on the basis of contamination risks is not always possible as most visits are set up on last-minute phone calls. Nevertheless, it is taken into account whenever possible, and within a same farm, if several operations are planned. Improvement of time and stress management is also seen as a priority; it is perceived as an important obstacle to an appropriate implementation of BSM by veterinarians.

It appears clearly that veterinarians do not self-evaluate themselves adequately, in terms of BSM implementation. They generally overestimate their degree of BSM implementation, especially for bio-exclusion (B1) and bio-containment (B3). Indeed, they consider they implement these stages the best while the lowest scores were reached for both of them and the analysis of priority measures to be improved shows mainly measures related to these stages. They also consider they should play a more active role in terms of advising cattle holders to increase biosecurity at farm level.

Even though trends are generally similar for the 3 countries surveyed, biosecurity scores were significantly higher in France and Spain compared to Belgium, both for global and specific biosecurity stage scores. This seems contradictory, as the percentage of veterinarians with a very high perception level is higher in Belgium (30.9%) compared to France (22%) and Spain (6%). Reasons might be found in the level of awareness, the usual practices of veterinarians in those countries and/or different working environments, which could better enable the adequate implementation of BSM by veterinarians. As an example, the lack of cleaning facilities in farms was a priority to address for Belgian and French veterinarians, while this constraint did not appear to be major in Spain (low ranking by the veterinarians).

Conclusion

The large majority of veterinarians consider biosecurity as a priority for their profession although they do not consider their own safety to be at risk in their daily practice. This could represent a threat in terms of public health as seroprevalence for zoonotic diseases is usually

significantly higher among rural veterinarians (Dal Pozzo et al., 2017; Molineri, Signorini, Perez, & Tarabla, 2013; Bernard et al., 2012; Luce et al., 2012). The survey highlighted weaknesses and margin for improvements, especially regarding bio-exclusion (related to the risk of disease introduction) and bio-containment (related to the risk of inter-herd disease transmission). Therefore, in case they do not adopt good practices, veterinarians might fail in one of their main responsibilities, i.e. limit the spread of a disease in case of outbreak. They can also be a high risk for farmers by playing the role of unintentional mechanical vector of diseases in premises. Although veterinarians expressed different constraints, possible solutions exist and have already been implemented by some veterinarians, such as an autonomous and mobile decontamination system or farm-dedicated clothes, boots and/or surgical material boxes that are left on premises.

The perception level of BSM by the veterinarians influences significantly the adequate implementation of good practices. Therefore, and in order to improve veterinary good practices, it is essential to allow biosecurity a greater role in veterinary training programs and curriculum, and to ensure an appropriate and ongoing awareness raising on the issue as part of continuing education proposed to veterinarians.

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We would also like to thank all Belgian, French and Spanish veterinarians, who voluntarily agreed to take part to this survey and took the time to share their experience and constraints with us. We do hope that the outcomes of this survey will be helpful in their practice.

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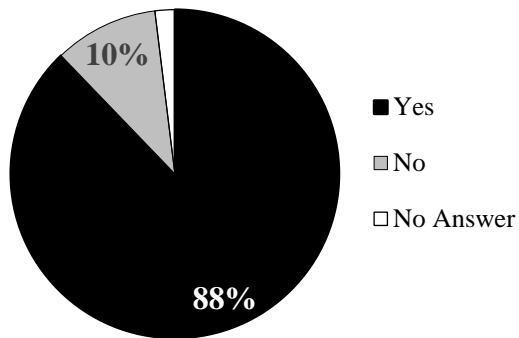
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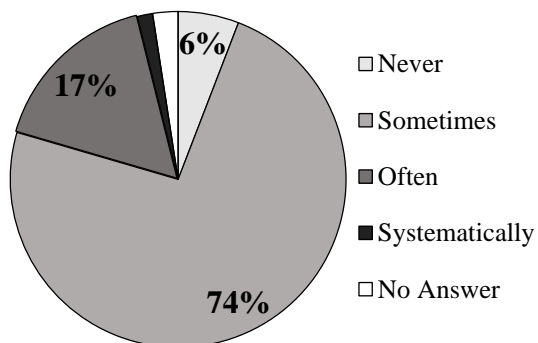
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Figure 1. Veterinary perception and attitude towards biosecurity (N = 205)

[A]. Do you consider biosecurity as a priority for the veterinarians?



[B]. Do you consider to be at risk, from a safety point of view, in your daily practice?



[C]. Have you already followed trainings in biosecurity?

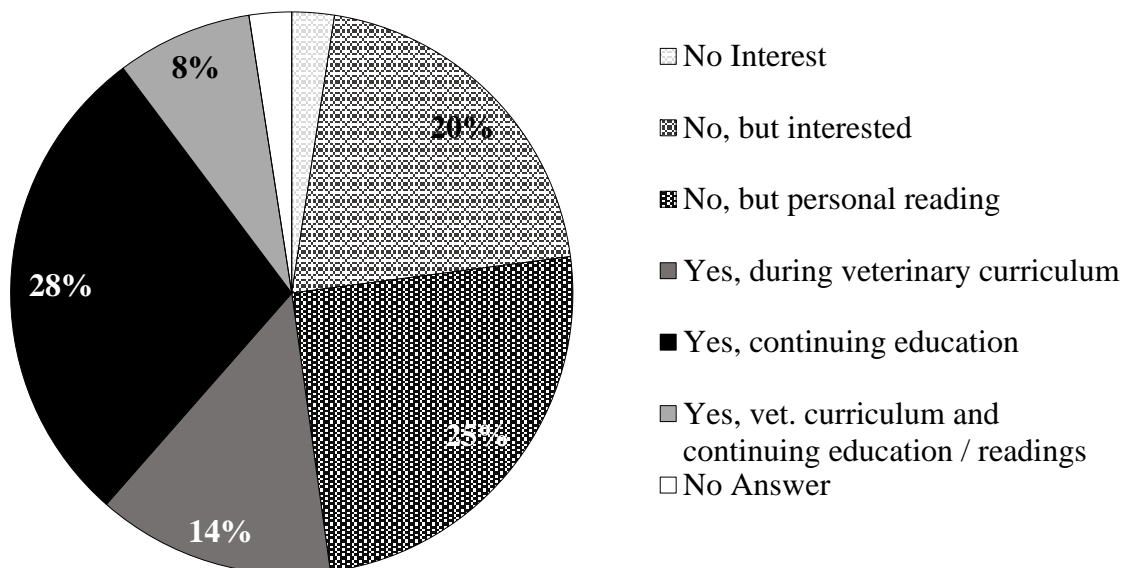


Figure 2. Farm environment of the veterinary practitioners

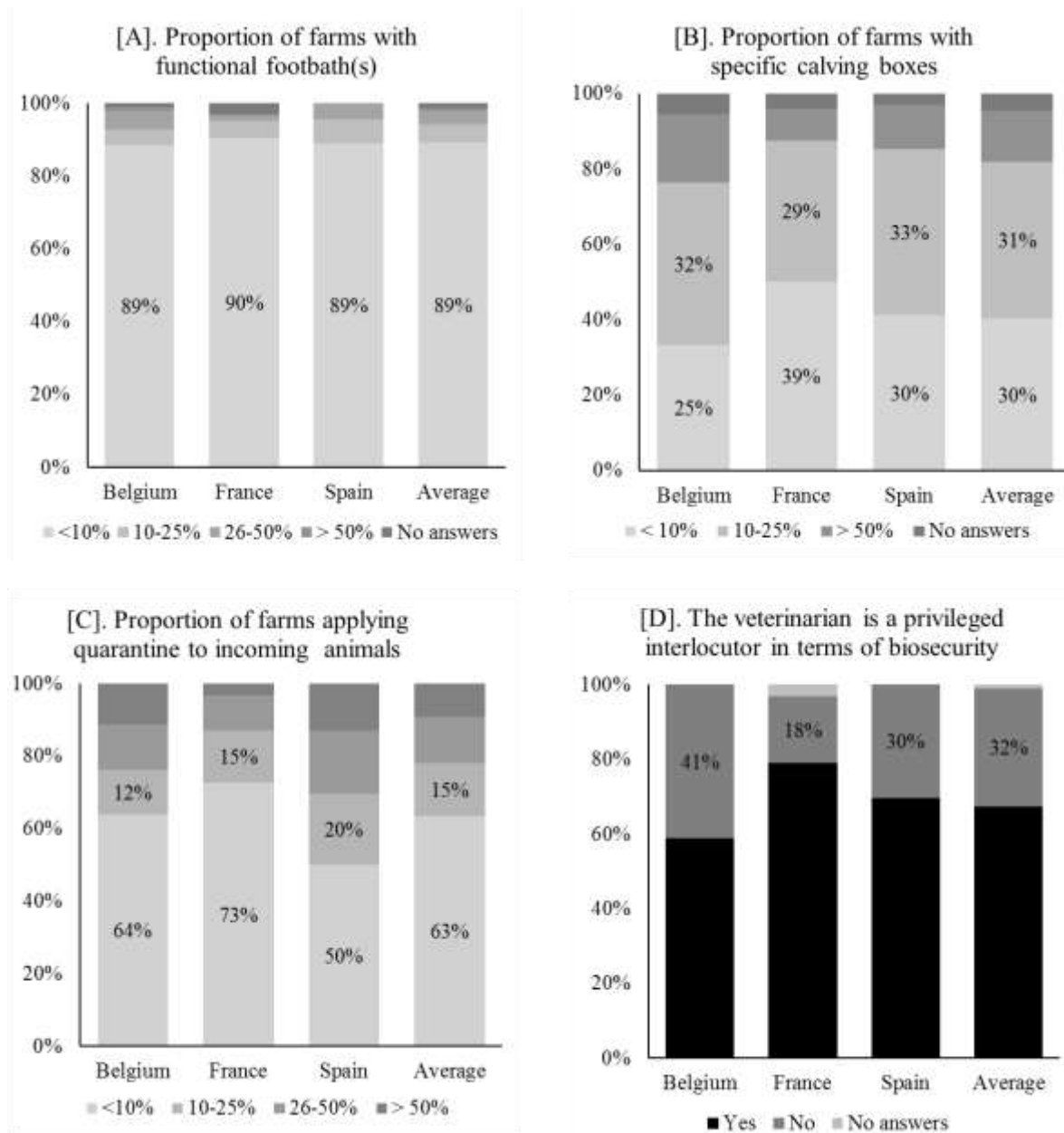
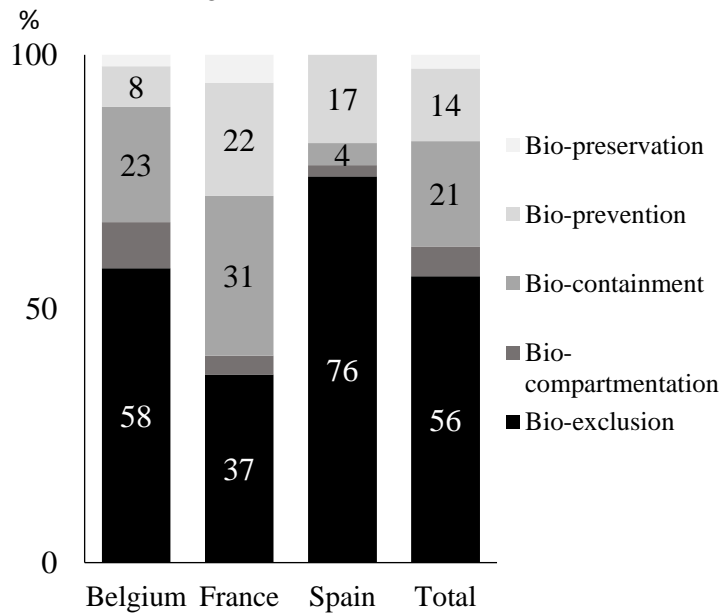


Figure 3. Biosecurity concept/pillar best implemented, based on the veterinarian's perspective (N = 205)

[A]. Which biosecurity concept/pillar do the veterinarians consider to manage as best?



[B]. Best biosecurity concept/pillar score obtained

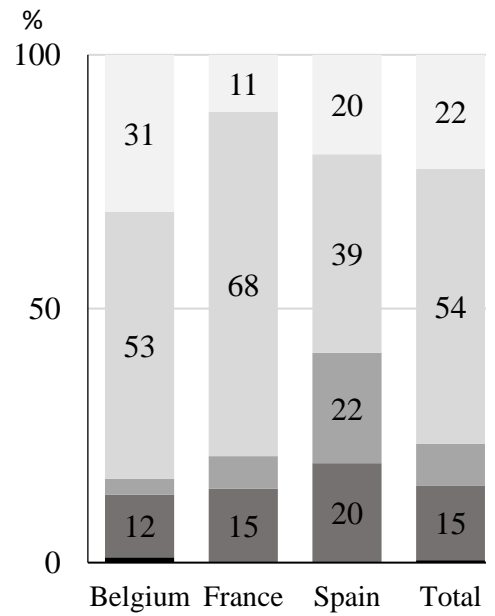
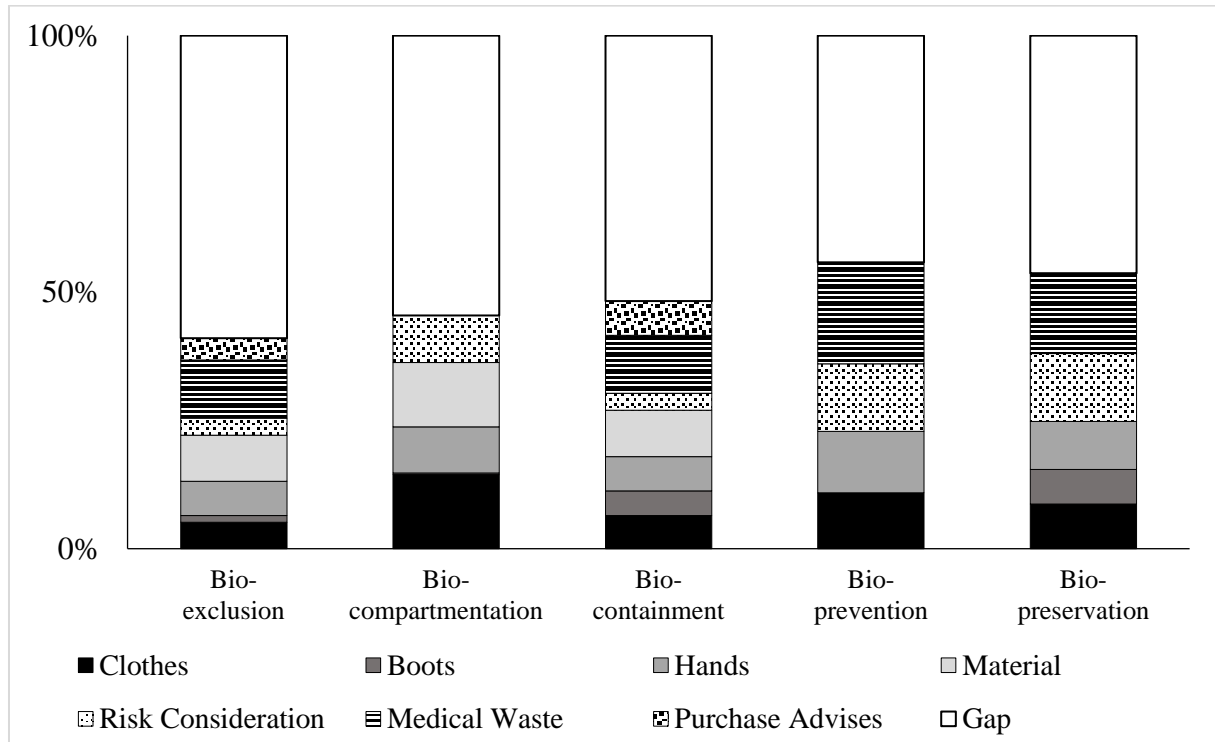
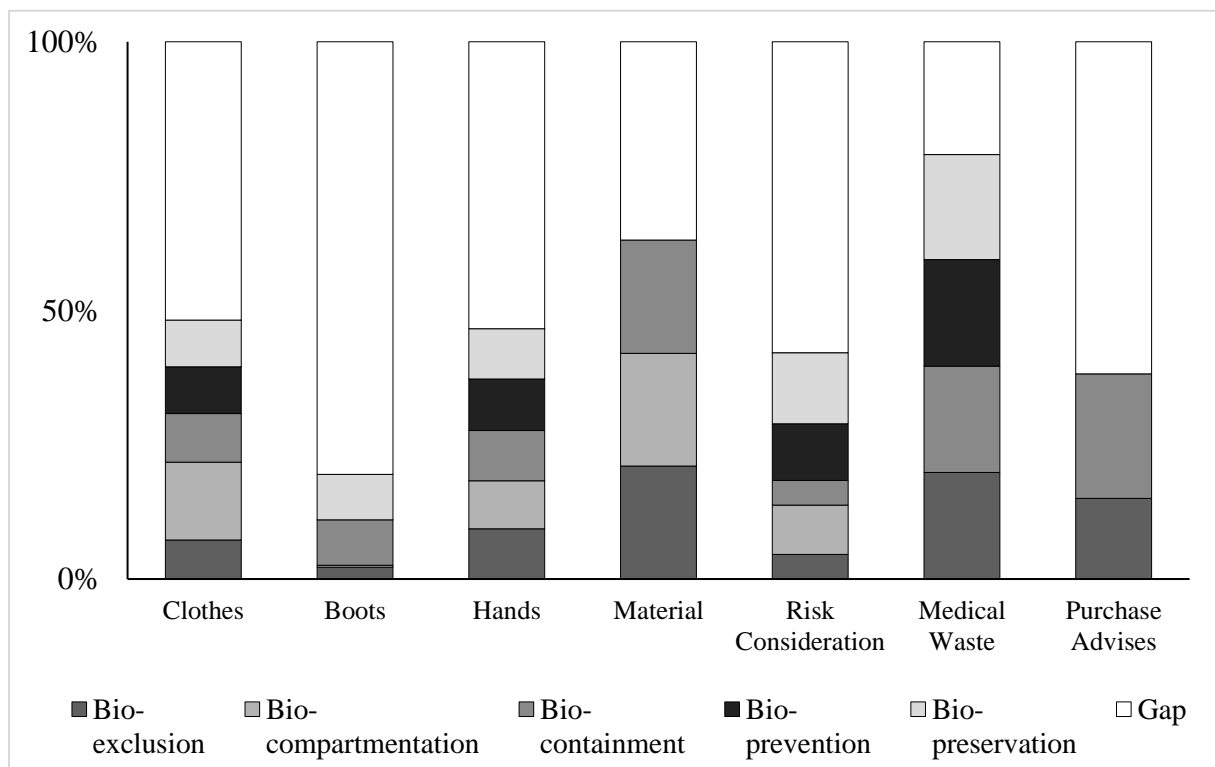


Figure 4. Implementation level of biosecurity measures per category and biosecurity stage (N = 205)

[A]. Contribution of each category of measures to the different biosecurity stages and possible progression



[B]. Implementation level (in %) of each biosecurity stage, per category of measures



Legend: Some measures concern several biosecurity stages.

APPENDIX 1 – EPIDEMIOLOGICAL SURVEY OF BIOSECURITY MEASURES AS IMPLEMENTED BY VETERINARY RURAL PRACTITIONERS

YOUR PROFESSIONAL PROFILE:

Sex:

- Female
- Male

Country:

Zip code – place of residence:

You practice:

- Alone
- In association

If you practice in an association, could you indicate the number of associates (including yourself):

Does the structure in which you practice have one or more specialized veterinary auxiliaries?

- Yes
- No

Year of graduation:

Practice:

- Only rural
- Mixt with $\geq 50\%$ of rural practice
- Mixt with $< 50\%$ of rural practice

Number of cattle herds in your practice:

What is the percentage of mixt herds (dairy/suckling) in your practice?

Answer in per cents.

What is the average size of a mixt herd (dairy/ suckling) in your practice?

Answer in cattle heads.

What is the percentage of dairy herds in your practice?

Answer in per cents.

What is the average size of a dairy herd in your practice?

Answer in cattle heads.

What is the percentage of suckling herds in your practice?

Answer in per cents.

What is the average size of a suckling herd in your practice?

Answer in cattle heads.

1. BIOSECURITY AND WORKING CLOTHES

How often do you change your work clothes (overall, apron, overcoat, etc.), except boots and surgery clothes?

- One own work clothing per day
- One own work clothing changed as soon as it is visually dirty
- One own work clothing per day + one disposable clothing for specific cases ('dirty' work)
- One own work clothing + one disposable clothing per cattle farm, systematically
- One disposable clothing per cattle farm, systematically
- One clothing provided by the farmer, per cattle farm
- Others

When performing surgeries, do you wear:

- Disposable calving gowns, systematically
- Washable calving gowns and disposable gowns in case of known septic risk (e.g. emphysematous calf)
- Washable calving gowns, several gowns in my vehicle in case of known septic risk (e.g. emphysematous calf)
- A washable calving gown

At what temperature do you wash your work clothes and linen?

Answer in °C.

What is the average cleaning time of your work clothes and linen?

Answer in minutes.

Do you add some disinfectant when washing your work clothes and linen?

- Yes
- No

Which drying method do you apply after washing your work clothes and linen?

- Linen thread
- Electric dryer

Do you have a washing machine reserved only for washing work clothes and linen?

- Yes
- No

2. BIOSECURITY AND BOOTS

Which particular care do you bring to the boots you use for your professional activity? Check the boxes corresponding to your choices

	After each cattle farm	Before each cattle farm	After and before each cattle farm	Between two buildings of a same cattle farm	None of the proposals, when they are visually dirty	Never
Brushing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water jet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cleaning with soap	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Disinfection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Foot bath, foot mat	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

What is the proportion of cattle farms in which a footbath is in place?

- <10%
- 10-25%
- 26-50%
- 51-75%
- 76-100%

What is the proportion of cattle farms in which a clean and working footbath is in place (with disinfectant recently added)?

- <10%

- 10-25%
- 26-50%
- 51-75%
- 76-100%

Do you wear disposable cover-boots?

- Never
- Sometimes
- Often
- Always

If you have answered 'sometimes' or 'often' to the previous question, please specify in which context you wear disposable cover-boots.

3. BIOSECURITY AND MATERIAL

How often do you replace the following disposable materials?

Check the boxes corresponding to your choices

	After each animal	After each lot	After each cattle farm	Every day	More rarely
Needles for injections	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Needles for sampling	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Syringes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Scalpel and razor blades	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Examination gloves	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Full-arm veterinary gloves	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Which care do you bring to your reusable material (e.g.: material for C-sections)?

- Cleaning
- Cleaning and soaking in disinfectant

- Cleaning and autoclaving (hot sterilization)
- Others

If you have answered 'Cleaning and soaking in disinfectant' to the previous question, please specify which disinfectant(s) you use.

On average, how long does the sterilization process last (cleaning excluded)?
Answer in minutes.

If you have experienced a difficulty in answering the previous question, please specify the minimal duration of the sterilization process (cleaning excluded).
Answer in minutes.

How often do you clean/sterilize your reusable material (among others: material for C-sections)?

- After each animal
- After each lot
- After each cattle farm
- Every day
- More rarely, with time

4. BIOSECURITY AND ORGANIZATION OF YOUR VISITS

What is the proportion of farms in your practice, which uses a stall 'exclusively' dedicated to calving?

Give a percentage.

Do you perform necropsies on farms?

- No
- Yes, whatever the place
- Yes, but in a place minimizing the risk, as possible (concreted ground, washable without any contact with food-producing or companion animals)
- Others:

In a same cattle farm, do you organize your visit according to the susceptibility of animals (from the most susceptible (maternity, calves...) to the most contagious)?

- Never

- Sometimes
- Often
- Always

Do you organise your tour of visits in function of the general sanitary status of cattle farms (from the least at risk status to the most at risk status)?

- Never
- Sometimes
- Often
- Always

5. BIOSECURITY AND HAND HYGIENE

Do you wear disposable examination gloves during your visits?

- Never
- Sometimes
- Often
- Always

1 **Do you wear gloves when performing surgeries?**

- 2 Yes
3 No

4 **If you have answered 'Yes' to the previous question, please indicate which**
5 **type(s) of gloves you use.**

- 6 Examination gloves (latex-type)
7 Long-arm disposable veterinary gloves
8 Long-arm disposable veterinary gloves and examination gloves
9 Sterile gloves

10

11 **How often do you wash your hands?**

- 12 After each animal
13 After each lot
14 After each cattle farm
15 Others:

16

17 **How do you wash your hands?**

- 18 With clear water
19 With a soap provided by the farmer
20 With an antibacterial soap (available in your vehicle, for example)

21

22 **After washing your hands, how do you dry them?**

- 23 Hand towel provided in the cattle farm
24 Paper (kitchen roll) provided in the cattle farm
25 Hand towel available in your vehicle
26 Paper (kitchen roll) available in your vehicle

27 **If you have answered 'Hand towel available in your vehicle' to the previous**
28 **question, please indicate the frequency of changing.**

29 Answer in number of changes per month.

30

31

31 **6. BIOSECURITY AND YOUR VEHICLE**

32 **Do you let your dog go inside your professional vehicle?**

- 33 Yes
34 No

35

36 **If yes, does the dog get out of your vehicle during your visits?**

- 37 Yes
38 No

39

40 **Do you ever park your vehicle inside the farm buildings (stalling, etc.)?**

- 41 Yes
42 No

43

44 **How often do you clean your professional vehicle?**

- 45 ○ Once a week
- 46 ○ Once every two weeks
- 47 ○ Once a month
- 48 ○ Once every four months
- 49 ○ On request, when it is dirty

50

51 **7. BIOSECURITY AND WASTE MANAGEMENT**

52 **Do you have a yellow container for medical waste in your car?**

- 53 ○ Yes
- 54 ○ No

55

56 **How do you dispose of empty medicine and vaccine flasks?**

- 57 ○ Yellow container for medical waste
- 58 ○ Domestic trash can
- 59 ○ Collected by a specialized company
- 60 ○ Glass waste container
- 61 ○ Other

62

63 **How do you dispose of out-of-date medicine and vaccine flasks?**

- 64 ○ Yellow container for medical waste
- 65 ○ Domestic trash can
- 66 ○ Collected by a specialized company
- 67 ○ Glass waste container
- 68 ○ Other

69

70 **Do you throw your needles and scalpel blades in a small yellow container for
71 needles (specific for prickly, sharp and cutting objects)?**

- 72 ○ Yes
- 73 ○ No

74

75 **8. BIOSECURITY OF THE VETERINARY PRACTITIONER**

76

77 **Do you think you take risks, from a safety point of view, in your daily practice?**

- 78 ○ No, never
- 79 ○ Yes, sometimes
- 80 ○ Yes, often
- 81 ○ Yes, systematically

82

83 **9. BIOSECURITY AND ADVICES TO FARMERS**

84 **Do you think your clients see you as a privileged interlocutor in terms of
85 biosecurity?**

- 86 ○ Yes
- 87 ○ No

88 **In the mixt cattle herds of your practice, is the use of a quarantine stall dedicated**
89 **to newly introduced animals frequent?**

90 Give a percentage

91

92 **In the dairy cattle herds of your practice, is the use of a quarantine stall**
93 **dedicated to newly introduced animals frequent?**

94 Give a percentage

95

96 **In the suckling cattle herds of your practice, is the use of a quarantine stall**
97 **dedicated to newly introduced animals frequent?**

98 Give a percentage

99

100 **Which advices do you provide to the clients who want to purchase animals?**

- 101 Never purchase animals
- 102 Purchase the least possible
- 103 Purchase the least possible but systematically test at purchase
- 104 Purchase by reducing the number of originating cattle operations
- 105 Purchase by reducing the number of originating cattle operations but systematically
- 106 test at purchase
- 107 Other
- 108

109 **When an animal is newly introduced in a cattle farm, do you advise screening**
110 **for:**

111 Check the boxes corresponding to your choices

112

	Never	Sometimes	Often	Always	Do not know
Brucellosis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Leukosis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tuberculosis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Neosporosis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Q Fever	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bovine viral diarrhea	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Infectious bovine rhinotracheitis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Ovine catarrhal fever (bluetongue)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Disease caused by the Schmallenberg virus	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Paratuberculosis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mortellaro's digital dermatitis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mastitis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

113

114 **10. BIOSECURITY AND VETERINARY EDUCATION**

115

116 **Following the epidemics that occurred during the last years, do you consider**
 117 **biosecurity as a priority for the veterinary profession?**

- 118 Yes
 119 No

120

121 **Have you already followed trainings in biosecurity (you can check more than one**
 122 **answer)?**

- 123 Yes, during my veterinary curriculum
 124 Yes, within the frameworks of continuing education
 125 No, but personal interest for the subject through the reading of veterinary journals,
 126 the consultation of web sites, etc.
 127 No, by lack of time, but the subject is of interest.
 128 No, never, I am not interested.
 129 Other {

130

131 **11. IMPORTANCE OF BIOSECURITY**

132 **Would you be ready to modify a habit in relation with biosecurity?**

	Yes	No
On advice of a colleague	<input type="radio"/>	<input type="radio"/>
I will never reconsider my way of working for questions of biosecurity	<input type="radio"/>	<input type="radio"/>
If the change does not imply a modification complicating my daily practice	<input type="radio"/>	<input type="radio"/>
Provided that such change is evidence-based	<input type="radio"/>	<input type="radio"/>

133

134 **Which aspect of biosecurity do you consider you best manage through your way**
135 **of practicing veterinary medicine?**

- 136 ○ Bio-exclusion (to avoid the introduction of a pathogen in an cattle farm)
- 137 ○ Bio-compartmentation (to avoid the circulation of a pathogen in the herd)
- 138 ○ Bio-containment (to avoid the spreading of a pathogen outside the cattle farm)
- 139 ○ Bio-prevention (to avoid the transmission of a pathogen to humans)
- 140 ○ Bio-preservation (to avoid the environmental persistence of a pathogen)

141
142 **Which percentage of your turnover is dedicated to biosecurity (purchase of**
143 **disinfectants, consumables, disposable clothes, etc.)?**

- 144 ○ No idea
- 145 ○ Answer this question would take too much time
- 146 ○ < 25%
- 147 ○ 26 to 50%
- 148 ○ 51 to 75%
- 149 ○ 76 to 100%

150
151 **According to you, which are the 3 main weak points in terms of biosecurity**
152 **among the cattle farms constituting your practice?**

153 From the most important to the least important

154

155

156
157 **According to you, which are the 3 main points you think could be improved in**
158 **terms of biosecurity in your daily practice?**

159

160

161

Appendix 2 - Scoring system

Category and sub-category of measure	Scoring
1. Clothing	
CI01_ How often do you change your work clothes?	0 = One proper work clothing per day OR Others with: less /nothing /only if farmer requests 1 = One proper work clothing changed as soon as it is visually dirty OR changed when required 2 = One proper work clothing per day + one disposable clothing for specific cases OR disposable when required 3 = One proper work clothing + one disposable clothing per cattle farm systematically OR washable clothes changed at each farm or washed between each farm 4 = One disposable clothing per cattle farm, systematically 5 = One clothing provided by the farmer and per cattle farm
CI02_ When performing surgeries, do you wear:	1= A washable calving blouse 2= Washable calving blouses, several blouses in my vehicle in case of known septic risk 3= Washable calving blouses and disposable blouses in case of known septic risk 4= Disposable calving blouses, systematically
CI03_C_ Proper washing cycle ?	0= $T*t < 250$ and no use of disinfectant 1= $T*t < 250$ or unknown and use of disinfectant 2= $T*t > 250$ (with or without disinfectant) <i>Calculation: "T" = Nr of degrees above 55 and "t" = duration of washing cycle in minutes</i>
CI04_ Drying method ?	0 = Linen thread / 2= Electric dryer
CI05_Specific washing machine?	0 = No / 2= Yes
Specific scores for clothing	
B1_Clothes	=CI01+CI03+CI04
B2_Clothes	=CI02
B3_Clothes	=CI01+CI02+CI03+CI04
B4_Clothes	=CI03+CI04+CI05
B5_Clothes	=CI03+CI04+CI05
5B_Clothes	=B1_Clothes+B2_Clothes+B3_Clothes+B4_Clothes+B5_Clothes
2. Boots	

Bo06_ Do you wear disposable over-boots?	0 = Never / 1 = Sometimes / 3 = Often / 4 = Always
Bo07a_C_ Boots measures related to bio-exclusion, bio-preservation and conservation	Steps made before each farm OR after & before each farm OR between buildings: 0= Not even passed in water jet / 1= water jet / 2= water jet + brushing
Bo07b_C_ Boots measures related to bio-compartmentation	Steps made between buildings: 0= Not even passed in water jet / 1= water jet / 2= water jet + brushing
Specific scores for boots	
B1_Boots	=Bo07a+Bo06
B2_Boots	=Bo07b
B3_Boots	=Bo07a+Bo06
B4_Boots	X
B5_Boots	=Bo07a+Bo06
5B_Boots	=B1_Boots+B2_Boots+B3_Boots+B4_Boots+B5_Boots B39 (expressed in % of max. score)

3. Hands

Ha01a_ Do you wear disposable gloves (latex-type) during your visits?	0 = Never / 1 = Sometimes / 3 = Often / 4 = Always
HA01b_ How often do you replace the small or latex gloves?	0 = more rarely and everyday 1 = After each cattle farm 2 = After each lot
Ha01c_ How often do you replace the long arm gloves?	3 = After each animal
Ha02_ Do you wear gloves when performing surgeries?	0 = No / 1= Yes
Ha04_ How often do you wash your hands?	0 = when dirty / back home(1) / if water available(1) / in case of surgery(2) 1 = After each cattle farm 2 = After each lot / 100 times a day (1) 3 = After each animal

Ha05_ How do you wash your hands?	1 = With clear water 2 = With a soap (provided by the farmer) 3 = With an antibacterial soap (available in your vehicle, for example)
Specific scores for hands	
B1_Hands	=HA01b*HA01a +Ha01c+ (Ha04*Ha05)
B2_Hands	=(Ha04*Ha05) + HA01b*HA01a (if Ha01b>1) +Ha01c (if>1)
B3_Hands	=HA01b*HA01a +Ha01c+ (Ha04*Ha05)
B4_Hands	=HA01b*HA01a +Ha01c+ Ha02+ (Ha04*Ha05)
B5_Hands	=HA01b*HA01a +Ha01c+ (Ha04*Ha05)
5B_Hands	=B1_Hands+B2_Hands+B3_Hands+B4_Hands+B5_Hands (expressed in % of max. score)
4. Materials	
Ma01_How often do you replace the needles for injection?	0 = more rarely and everyday 1 = After each cattle farm 2 = After each lot 3 = After each animal
Ma02_How often do you replace the sampling needles?	
Ma03_ How often do you replace the syringes?	
Ma04_How often do you replace the scalpel and razor blades?	
Ma05_ How often do you clean/sterilize your reusable material?	
Ma06_C_Effectiveness sterilization process reusable materials	0 = Just cleaned 1 = cleaned and soaked but not dry heated or dry heated with insufficient or unknown time (A<600) 2 = cleaned and soaked with sufficient time or dry heat with sufficient time (A>600). <i>Calculation: $A = \left[\frac{10}{z} \right]^{((T-80)/z) \times \Delta t}$ with : T = temperature and Δt = sterilization time Value of T was fixed at: 40°C for vets soaking materials (assuming soaking in hot water), 100°C for vets boiling the material and 180°C for vet using dry heat (autoclave or oven).</i>
Specific scores for materials	

B1_Material	=Somme Ma01-04 + Ma05*Ma06
B2_Material	=Somme Ma01-04 + Ma05*Ma06 (if Ma05>1)
B3_Material	=Somme Ma01-04 + Ma05*Ma06
B4_Material	X
B5_Material	X
5B_Material	=B1_Material+B2_Material+B3_Material+B4_Material+B5_Material (expressed in % of max. score)

5. Risk consideration

RC01_ Visits organization based on contamination risk?	0 = Never 1 = Sometimes 2 = Often 3 = Always
RC02_ Order visits based on farm sanitary status?	0 = Yes, independently if risk 2 = Yes, but in a place minimizing the risk, as possible (concreted ground, washable without any contact with food-producing or companion animals) OR "as few as possible" 4 = No
RC03_ Do you perform necropsies on farms?	0 = Yes / 1 = No
RC04_ Do you let your dog go inside your professional vehicle?	0 = Yes / 1 = No
RC05_ If Yes, does the dog get out during your visits?	0 = Yes / 1 = No
RC06_ Do you ever park your vehicle inside the farm?	0 = Yes / 1 = No
RC07_ How often do you clean your professional vehicle?	0 = On request, when it is dirty / 1 = Quarterly / 2 = Monthly / 3 = Every two weeks / 4 = Weekly

Specific scores for risk consideration

B1_RiskConsideration	=RC02+RC04+RC05+RC06*RC07
B2_RiskConsideration	=RC01+RC03
B3_RiskConsideration	=RC02+RC04+RC05+RC06*RC07
B4_RiskConsideration	=RC03
B5_RiskConsideration	=RC03+RC04+RC05

5B_RiskConsideration =B1_RiskConsideration+B2_RiskConsideration+B3_RiskConsideration+B4_RiskConsideration+B5_RiskConsideration
(expressed in % of max. score)

6. Medical waste management (MWM)

MW01_ Yellow container for medical waste in your car? 0 =No / 1 = Yes

MW02_ What do you make with empty medicine and vaccine flasks?
3 = Collected by a specialized company / Yellow container for medical waste / Incineration / VIVGP2
2 = Glass waste container / recycling park (1)
1 = medical waste container of the cattle farm (1 answer)
0 = Domestic trash can

MW03_ What do you make with out-of-date medicine and vaccine flasks?
3 = Collected by a specialized company / Yellow container for medical waste / incineration / IGPG / Return to supplier / Never out of date
2 = Glass waste container
0 = Domestic trash can

MW04_ Needles and scalpel blades in a specific yellow container? 0 =No / 1 = Yes

Specific scores for MWM

B1_MWM =MW01+MW04

B2_MWM X

B3_MWM =MW01+MW04

B4_MWM =MW01+MW04

B5_MWM =MW01+MW02+MW03+MW04

5B_MWM =B1_MWM+B2_MWM+B3_MWM+B4_MWM+B5_MWM (expressed in % of max. score)

7. Purchase advises

AP01_ Advices given for purchases?
0 = Nothing
1 = Reducing purchases or origins but no testing
2 = Reducing + systematic test
3 = Never purchase

AP02_ Advises screening for:
AP02.1_Brucellosis

AP02.2_Leucosis:
 AP02.3_Tuberculosis:
 AP02.4_Neosporosis:
 AP02.5_Q fever:
 AP02.6_BVD: 0 = Never
 AP02.7_IBR: 1 = Sometimes
 AP02.8_OCF: 2 = Often
 AP02.9_Schmallenberg: 3 = Often
 AP02.10_Paratuberculosis:
 AP02.11_Mortellaro:
 AP02.12_Mastitis:

Specific scores for purchase advises

B1_Purchase advises =AP01*(Sum AP02)
 B2_Purchase advises X
 B3_Purchase advises = Sum AP03
 B4_Purchase advises X
 B5_Purchase advises X
5B_Purchase advises =B1_Purchase advises+B2_Purchase advises+B3_Purchase advises+B4_Purchase advises+B5_Purchase advises
 (expressed in % of max. score)

General Score 5B (0-700) % 5B_Clothes+% 5B_Boots + % 5B_Hands +% 5B_Material+ % 5B_RiskConsideration + 5B_MedicalWaste + % 5B_Purchase advises

B1_Bio-exclusion (0-100) (% B1_Clothes + % B1_Boots + % B1_Hands + % B1_Material + % B1_RiskConsideration + % B1_MedicalWaste + % B1_Purchase advises) / 7

B2_Bio-compartmentation (0-100) (% B2_Clothes + % B2_Boots + % B2_Hands + % B2_Material + % B2_RiskConsideration) /5

B3_Bio-containment (0-100) (% B3_Clothes + % B3_Boots + % B3_Hands + % B3_Material + % B3_RiskConsideration + % B3_MedicalWaste + % B3_Purchase advises)/7

B4_Bio-prevention (0-100) (% B4_Boots + % B4_Hands + % B4_RiskConsideration + % B4_MedicalWaste)/4

B5_Bio-preservation (0-100) (% B5_Clothes + % B5_Boots + % B5_Hands + % B5_RiskConsideration + % B5_MedicalWaste)/5

Appendix 3- Explanatory variables

Explanatory variables	Categories
Country	SP =Spain FR =France BEL =Belgium
Experience (years of practice)	1 =1-13 years 2 =14-24 years 3= 24-31 years 4= >31 years
Practice type	1 = <50% rural 2 = >50% rural 3= 100% rural
Number of cattle herds in the practice	1 = 1-40 + non answers (7) 2= 41-80 3 = 81-150 4 = >150
Main type of herds in the practice	V = Varied. Includes practices with no type of farms representing more than 50% of herds, no answers (16) and veterinarians with sum of % for each type of herds not adding up to 100% D = more than 50% of dairy farms S = more than 50% of suckling herds M= more than 50% of mixed herds
Perception BSM	Total score for perception BSM ranging from 0 to 9 based on the answers to 3 questions: - Q1: Do you consider biosecurity as a priority for the veterinary profession? No = 0 / Yes = 1 -Q2: Do you think you take risks for your own safety in your daily practice? No= 0 / Sometimes =1 / Often = 2 / Always = 3 -Q3: Have you already followed trainings in biosecurity? score of 0 to 5. From 0 for "Never and not interested by the topic " to 5 for " Yes during veterinary studies + continuous education and/or readings" Perception score: '1: score from 0 to 3 and no answers (3) 2: score of 4 3: score of 5 4: score of 6 5: score above 5

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165 **Appendix 4. Descriptive analysis of the survey data expressed in percentages (N=205)**

	Belgium (N = 97)	France (N = 62)	Spain (N= 46)	Total (N=205)
a. Measures related to clothes				
How often do you change your work clothes?				
One specific work clothing per day OR less	14	3	11	10
One specific work clothing changed when dirty or required	54	52	30	48
One specific work clothing per day + disposable clothes if required /higher risk	23	35	48	32
One specific work clothing + one disposable or washable clothing per cattle farm systematically	6	10	9	8
One disposable clothing per cattle farm, systematically	1	0	2	1
No answer	2	0	0	1
When performing surgeries, do you wear:				
Washable calving gowns	25	2	11	15
Washable calving gowns and disposable gowns in case of known septic risk (e.g. emphysematous calf)	13	11	20	14
Washable gowns, several gowns in my vehicle in case of known septic risk (e.g. emphysematous calf)	12	3	7	8
Disposable calving gowns systematically	46	84	59	60
No answer	3	0	4	2
Proper washing cycle				
Not appropriate	37	29	30	33
Acceptable	9	8	15	10
Appropriate	47	56	52	51
No answer	6	6	2	5
Drying method				
Linen thread	55	56	74	60
Dryer	40	44	22	37
No answer	5	0	4	3
Usage of a specific washing machine				
No	70	45	63	61
Yes	28	55	33	37
No answer	2	0	4	2

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	Belgium (N = 97)	France (N = 62)	Spain (N= 46)	Total (N=205)
b. Measures related to boots				
Do you wear disposable cover-boots?				
Never	76	63	37	63
Sometimes	21	34	39	29
Often	2	2	7	3
Always	0	0	17	4
No answer	1	2	0	1
Hygiene measures implemented before each farm OR after & before each farm OR between buildings				
Not even cleaned with water jet	91	90	83	89
Cleaned with water jet	2	8	11	6
Water jet and brushing	7	2	7	5
Hygiene measures implemented between buildings				
Not even cleaned in water jet	100	97	93	98
Cleaned with water jet	0	3	4	2
Water jet and brushing	0	0	2	0
Hygiene measures implemented after each farm OR after & before each farm OR between buildings				
Not even cleaned in water jet	6	6	7	6
Cleaned with water jet	36	40	43	39
Water jet and brushing	58	53	50	55
c. Management of medical waste				
Yellow container for medical waste in your car?				
No	43	13	17	28
Yes	57	84	83	71
No answer	0	3	0	1
How do you dispose of empty medicine and vaccine flasks?				
Domestic trash	5	32	22	17
Yellow container or medical waste container	42	47	39	43
Glass waste container	30	5	11	18
Specialised company	23	13	28	21
No answer	0	3	0	1
How do you dispose of out-of-date medicine and vaccine flasks?				
Domestic trash	4	10	15	8
Yellow container or medical waste container	53	69	39	55
Glass waste container	6	0	9	5
Specialised company	30	18	30	26
Never out of date	1	0	7	2
No answer	6	3	0	4
Needles and scalpel blades in a specific yellow container?				
No	13	0	22	11
Yes	87	97	78	88
No answer	0	3	0	1

d. Hand hygiene	Belgium (N = 97)	France (N = 62)	Spain (N= 46)	Total (N=205)
Do you wear disposable examination gloves during your visits?				
Never	12	2	7	8
Sometimes	37	40	11	32
Often	29	23	37	29
Always	22	34	43	30
No answer	0	2	2	1
How often do you replace disposable examination gloves?				
Less often than daily	7	2	2	4
Daily	1	0	0	0
After each cattle farm	13	13	20	15
After each lot	15	18	15	16
After each animal	58	68	61	61
No answer	5	0	2	3
How often do you replace full arm veterinary gloves?				
Daily	2	0	2	1
After each cattle farm	11	5	11	9
After each lot	56	39	28	44
After each animal	29	56	54	43
No answer	2	0	4	2
Do you wear gloves when performing surgeries?				
No	29	32	9	25
Yes	68	66	87	72
No answer	3	2	4	3
How often do you wash your hands?				
When dirty	3	3	7	4
After each farm	74	68	48	66
After each lot	8	8	20	11
After each animal	14	19	24	18
No answer	0	2	2	1
How do you wash your hands?				
With clear water	6	11	11	9
With a soap provided by the farmer	77	63	43	65
With an antibacterial soap (available in your vehicle, for example)	16	24	43	25
No answer	0	2	2	1

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e. Materials	Belgium (N = 97)	France (N = 62)	Spain (N= 46)	Total (N=205)
How often do you replace the needles for injection?				
Daily or less often	28	16	2	19
After each farm	13	2	13	10
After each lot	14	3	17	12
After each animal	43	79	65	59
No answer	1	0	2	1
How often do you replace the sampling needles?				
Daily or less often	6	0	0	3
After each farm	14	2	2	8
After each lot	25	16	0	17
After each animal	51	82	93	70
No answer	4	0	4	3
How often do you replace the syringes?				
Daily or less often	39	40	11	33
After each farm	14	8	22	14
After each lot	19	13	17	17
After each animal	25	35	43	32
No answer	3	3	7	4
How often do you replace the scalpel and razor blades?				
Daily or less often	4	0	0	2
After each farm	3	2	0	2
After each lot	4	2	2	3
After each animal	85	95	93	90
No answer	4	2	4	3
How often do you clean/sterilize your reusable material?				
Daily or less often	35	19	7	24
After each animal	55	74	85	67
After each farm	5	5	2	4
No answer	5	2	7	4
Effectiveness of the sterilization process for reusable materials				
Ineffective	5	3	9	5
Not fully effective	68	56	65	64
Effective	23	40	24	28
No answer	4	0	2	2

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	Belgium (N = 97)	France (N = 62)	Spain (N= 46)	Total (N=205)
f. Risk consideration while working				
In a same farm, do you organize the visit based on the risk of contamination?				
Never	25	21	30	25
Sometimes	41	58	30	44
Often	24	19	26	23
Always	8	0	11	6
No answer	2	2	2	2
Do you organize your daily planning/visits based on the farm sanitary status?				
Never	67	74	48	65
Sometimes	19	21	28	21
Often	7	2	13	7
Always	3	2	9	4
No answer	4	2	2	3
Do you perform necropsies on farms?				
Yes, anywhere	12	13	13	13
Yes, but limited numbers and/or by minimising the risk	57	77	67	65
No	29	8	17	20
No answer	2	2	2	2
Do you let your dog go inside your professional vehicle?				
Yes	10	10	2	8
No	88	87	98	90
No answer	2	3	0	2
If Yes, does the dog get out of your vehicle during your visits?				
Yes	0	0	0	0
No	10	6	2	7
No answer	0	3	0	1
Do you ever park your vehicle inside the farm?				
Yes	30	66	57	47
No	69	31	43	52
No answer	1	3	0	1
How often do you clean your professional vehicle?				
If dirty	35	45	41	40
Weekly	14	5	30	15
Twice a month	15	11	24	16
Monthly	33	19	2	22
Once every four months	2	16	2	6
No answer	0	3	0	1

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g. Advices on purchases of animals as provided to farmers	Belgium (N = 97)	France (N = 62)	Spain (N= 46)	Total (N=205)
What type of advices do you provide to the farmer regarding purchases				
to minimise purchases as much as possible	13	3	9	9
to minimise purchases as much as possible and test	64	52	46	56
Minimise the sources of origin and test	13	31	30	22
Never purchase	7	2	0	4
Control the status of the farm of origin	0	2	0	0
Apply a quarantine and test	0	3	0	1
Test	1	3	0	1
No answer	1	5	15	5
Do you advise testing for the following diseases?:				
Brucellosis				
Never	6	31	11	15
Sometimes	15	44	0	20
Often	5	2	7	4
Always	63	16	76	52
No answers	10	8	7	9
Enzootic bovine Leucosis				
Never	23	60	15	32
Sometimes	12	29	7	16
Often	3	0	7	3
Always	47	3	63	38
No answers	14	8	9	11
Tuberculosis				
Never	1	13	11	7
Sometimes	1	61	0	19
Often	2	11	4	5
Always	90	8	76	62
No answers	6	6	9	7
Neosporosis				
Never	4	31	2	12
Sometimes	11	32	7	17
Often	10	19	20	15
Always	68	8	70	50
No answers	6	10	2	6
Q fever				
Never	29	35	41	34
Sometimes	15	39	13	22
Often	8	15	7	10
Always	28	5	9	17
No answers	20	6	30	18
Bovine viral diarrhoea				
Never	1	0	2	1
Sometimes	5	5	13	7
Often	7	26	24	17
Always	82	63	59	71

No answer	4	6	2	4
infectious bovine rhinotracheitis				
Never	1	3	2	2
Sometimes	4	5	13	6
Often	7	5	22	10
Always	84	82	59	78
No answer	4	5	4	4
Bluetongue				
Never	61	81	43	63
Sometimes	7	6	13	8
Often	1	0	4	1
Always	1	0	9	2
No answer	30	13	30	25
Schmallenberg disease				
Never	62	81	57	66
Sometimes	6	6	9	7
Often	1	0	0	0
Always	0	0	2	0
No answer	31	13	33	26
Paratuberculosis				
Never	4	8	7	6
Sometimes	14	29	7	17
Often	8	32	26	20
Always	63	23	57	49
No answer	10	8	4	8
Mortellaro disease				
Never	45	69	54	55
Sometimes	13	11	9	12
Often	7	5	0	5
Always	4	2	2	3
No answer	30	13	35	26
Mastitis				
Never	42	65	13	42
Sometimes	18	16	17	17
Often	2	5	9	4
Always	9	3	43	15
No answer	29	11	17	21

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