TITLE: A survey of biosecurity-related practices, opinions and communications across dairy farm veterinarians and advisors

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Biosecurity-related practices, communication, and opinions of veterinarians and dairy advisers in Ireland.

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Abstract

Biosecurity is a fundamental component of preventative medicine and an important concept to promote within farming communities. Implementation of biosecurity at farm-level tends to be poor, and lack of information has been cited by many studies as a potential cause. Private veterinary practitioners (PVPs) and dairy advisors (DAs) play a pivotal role in the provision of animal health and farm management services to dairy farmers. The objective of this study was to document and compare biosecurity-related practices and opinions across Irish PVPs, DAs, and a selection of international veterinary experts (VEs).

Questionnaire surveys were completed and acceptable response rates of 47% (PVP), 97% (DA), and 65% (VE) were achieved. Significant differences were identified in the promotion and implementation of biosecurity between PVPs and DAs, with a higher proportion of PVPs regularly advising clients on biosecurity ($P<0.0001$) and receiving requests for biosecurity advice from clients ($P=0.004$). Communication between DAs and PVPs was sub-optimal with over 60% of each group not in regular communication. With regard to the main farmer motivator for biosecurity implementation, the majority of PVPs (62%) prioritised external factors (economic benefit, mandatory obligation) as the main farmer motivator for biosecurity implementation. The majority of DAs prioritised health/animal related factors (69%) in closer agreement with farmers (83.1%), although still significantly less likely (OR=1.8) than farmers to choose such motivators ($P=0.005$). Importance ranking of biosecurity measures by PVPs and VEs was also documented as a basis for veterinary education and farm biosecurity risk assessments.

DA and PVP communication is sub-optimal in Ireland and development of interactive teams and training could provide a vehicle for improved promotion of biosecurity on farm.

Key words: Biosecurity, Veterinarian, Advisor, Dairy farmer, Communication, Ranking.

Introduction

It is becoming increasingly evident that there is a need to re-orient livestock farmers to preventative rather than curative medicine (LeBlanc et al., 2006; EC, 2007; More, 2007; Conraths et al., 2011). Biosecurity, a merging of the concepts of bioexclusion and biocontainment (Mee et al., 2012), is a fundamental component of preventative medicine and an important concept to promote within farming communities. International studies have highlighted that implementation of biosecurity at farm-level is poor and lack of information a potential cause (Delabbio, 2006; Hoe and Ruegg, 2006; Gunn et al. 2008; Heffernan et al., 2008; Moore et al., 2008; Schemann et al., 2011; Brennan and Christley, 2012; Sayers et al., 2012). However, a willingness amongst farmers to implement biosecurity can exist should guidance on an effective approach be provided (Sayers et al., 2012).

Private veterinary practitioners (PVPs) play a pivotal role in the provision of animal health services to dairy farmers. Dairy advisors (DAs) offer invaluable advice to support farmers in the role out of best-practice general farm management. Practical implementation of biosecurity at farm level requires knowledge of the pathogens that constitute a threat to the farming enterprise and also knowledge of the livestock production system in place (Graham et al., 2008; Larson, 2008). Thus, the combined expertise and experience of PVPs and DAs provides an ideal vehicle through which to impart biosecurity advice to dairy farmers. This is recognised by farmers with veterinary practitioners ranked as the favoured farmer referent for biosecurity information (Jordan and Fourdraine, 1993; Gunn et al., 2008; Jensen et al., 2009; Hernández-Jover, 2012; Sayers et al, 2012; Schemann et al., 2012; Brennan and Christley, 2013) and farm advisors also ranked highly (Vergot et al., 2005; Jensen et al., 2009; Sayers et al., 2012).

Issues have been highlighted with implementation of biosecurity even in more compliant countries (Heffernan et al., 2008; Kristensen & Jakobsen, 2011). Potential reasons

for this include poor communication amongst stakeholders (Vaillancourt and Carver, 1998; Gunn et al., 2008; Benjamin et al., 2010; Kleen et al., 2011) and the provision of conflicting information from multiple sources. A lack of standardised information has been highlighted in the US as leading to confusion and apathy amongst clients with regard to implementation of biosecurity (Moore et al., 2008). In order to actively support their clients, therefore, service providers require an interest in and knowledge of disease prevention measures, but also require the ability to communicate with each other and their clients in an effective manner.

Assessment of PVP and DA knowledge and opinions regarding biosecurity will allow a better understanding of the communication needs between client and professional (Cattaneo et al., 2009). In this regard, it is useful to examine PVP and DA practices, interactions, and opinions with regard to biosecurity. It will allow the effectiveness of these service providers in increasing the perceived value of biosecurity amongst livestock farmers to be assessed. The objective of this study, therefore, was to both document and compare biosecurity practices and opinions across Irish veterinarians and dairy advisors. A panel of veterinary experts (VEs) was also included in the study as a means of benchmarking practicing veterinarians against veterinarians integrally involved in herd health, but at a more academic level.

Materials and methods

Questionnaire

Three biosecurity questionnaires were designed and circulated to Irish PVPs, DAs and internationally based VEs. Survey questionnaires are included in Appendix A, supplementary material. In order to ensure a standard basis for replies across the study

114 population, a definition of biosecurity ("the protection of a herd from the introduction and
115 spread of infectious diseases") was included in each questionnaire. The PVP and VE
116 questionnaires were piloted by Teagasc (Irish Food and Agriculture Development Authority)
117 veterinary researchers, and the DA questionnaire by retired Teagasc advisors. Based on
118 piloting results, minor modifications were made prior to administration.
119
120 *Survey Procedure*
121 Participation in surveys was voluntary and was not incentivised. PVPs were selected
122 following nomination by clients partaking in a parallel study (Sayers et al., 2012). In all, 236
123 PVPs were nominated. The study population of DAs consisted of 82 Teagasc dairy advisors[1].
124 The geographical distribution of surveyed PVPs and DAs is outlined in Figure 1. A total of
125 34 VEs were selected for inclusion based on a record of international publication and/or
126 recognised experience in the application of biosecurity and herd health programmes.
127
128 The PVP survey was administered by post, the DA survey during in-service training,
129 and the V E questionnaire administered on-line[2]. A single reminder was forwarded to non-
130 responders across all surveys four weeks following initial administration of the questionnaire.
131 Questionnaire responses were recorded on a web-based survey tool[2], with electronic entries
132 being manually checked against hardcopy versions, where applicable.
133
134 *Data Analysis*
135 Coded responses to each question were downloaded from SurveyMonkey. Excel (MS
136 Office version, 2007) was used to collate the data and generate graphical representations.
137 Chi-squared, student t-test, logistic regression, and Pearson correlation analyses were

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1 See http//www.teagasc.ie
2 See http://www.surveymonkey.com

138 completed using STATA (Version 12). Prevalence ratios and associated chi-squared
139 (Pearson and Fischer exact) analyses, were calculated using a web-based statistical tool[3].
140 Rating scales were automatically generated in SurveyMonkey for those survey questions
141 requiring ranking of responses.
142
143 Dependent variables (survey questions) were catagorised as either 'biosecurity
144 knowledge-transfer' (Table 1) or 'biosecurity opinion' (Table 2). Supplementary comments
145 collected in semi-closed and open survey questions were categorised under broad headings
146 and tabulated (Table 3). Responses to questions that appeared on both PVP and DA
147 questionnaires were compared using prevalence ratios (PRs) following dichotomisation of
148 responses. Associated *P* values for chi-squared or Fisher exact tests were estimated across
149 responses with values of $P<0.05$ considered significant. Opinions of PVPs, DAs, and VEs
150 with regard to the main motivating reason that a dairy farmer might implement biosecurity
151 were compared with actual farmer data sourced from Sayers et al., 2012. Responses were
152 categorised into 'extrinsic' (economic benefit and mandatory obligation) or 'intrinsic'
153 (prevention of disease introduction and improve health and welfare) for the purposes of PR
154 calculation.
155
156 Non-binary dependent variables were dichotomised for the purposes of logistic
157 regression. For PVPs, the effect of two independent variables (Region [1, 2, or 3] and decade
158 of qualification [1960s, 1970s, 1980s, 1990s, 2000s]) was assessed. In the case of DAs, the
159 independent variable decade of qualification was dichotomised in order to ensure sufficient
160 responses for analysis (1 960s, 1970s, and 1980s versus 1990s, and 2000s). Again the effect
161 of region and decade of qualification on dependent variables was assessed. Logistic

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3 See http://www.quantitativeskills.com/sisa/statistics/twoby2.htm

regression analysis was not carried out on VE survey questions due to the small sample population. As a first step analysis, associations between independent and dependent variables were identified by Chi-squared procedures. Where an association with a P 0.15 was identified, a second step regression analysis including a backwards elimination with a forward step was completed to describe the association. Results of regression analysis were regarded as significant at the 5% level. Pearson correlation tests were used to assess for multicollinearity.

Results

Descriptive Analysis

Response rates of 47%, 97% and 65% were achieved for PVP, DA, and VE surveys, respectively. Distribution of PVP and DA respondents is outlined in Table 4. No significant difference in geographical location between PVP (P=0.96) and DA (**P**=0.98) responders and non-responders was recorded. The nationality and affiliation of V E respondents are outlined in Figures 2 and 3. The decade of qualification of each surveyed group is outlined in Figure 4. Over 95% of PVPs and DAs surveyed completed their undergraduate training in Ireland. Approximately 75% of PVPs worked in mixed practice while the remainder worked in specialist large animal practice. A PVP priority-ranking of diseases for which health schemes should be developed in Ireland is included in Table 5.

Biosecurity 'knowledge transfer' variables examined across both PVPs and DAs are outlined in Table 1. Significant differences were identified in the promotion and implementation of biosecurity between PVPs and DAs, with a higher proportion of PVPs regularly advising clients on biosecurity (P<0.0001) and receiving requests for biosecurity advice from clients (P=0.004). Implementation of basic biosecurity hygiene measures (e.g.

cleaning hands, boots) was poorer amongst DAs than PVPs. Communication between PVPs and DAs was poor overall with approximately one third of PVPs and two thirds of DAs stating they do not communicate with the alternate group ($P<0.0001$). Biosecurity 'opinion' variables are outlined in Table 2. The most significant difference of opinion between surveyed PVPs and DAs relates to reasons that farmers would implement biosecurity ($P<0.0001$). In this regard, the majority of PVPs (approximately 62%) prioritised 'extrinsic' motivators, while the majority of DAs prioritised 'intrinsic' factors (69%). More detailed examination of this survey question across all surveyed populations (Table 6) highlighted that the expert veterinary group also prioritised 'extrinsic' motivators to a large degree (54.5%), although to a lesser extent than PVPs. Irish service provider opinions differed significantly from their clients with DAs almost twice as likely ($P=0.005$) and PVPs almost four times more likely (**P**<0.0001) than farmers to choose 'extrinsic' rather than 'intrinsic' factors (Table 6b) as motivators for biosecurity implementation. A ranking by PVPs and VEs of the top three reasons why veterinarians might not promote biosecurity on dairy farms is included in Table 7. Both PV Ps and V Es ranked "clients have no interest" and "clients not willing to invest" as the top two reasons for lack of promotion. Financial and time resources were also highlighted as potentially impacting on biosecurity promotion.

VE-ranking of the importance of a number of on-farm biosecurity measures is outlined in Figure 5. Rating scores ranged from 1.18 (most important) to 3.5 (least important) in terms of minimising disease introduction and spread. PVP-ranking of these measures is also included in Figure 5 which highlights a number of ranking differences between PVPs and VEs (e.g. PVPs prioritised 'good hygiene' over 'maintaining a closed herd'). However rating scores did not differ significantly between both populations ($P=0.276$).

Selected quotes from open questions from all three surveys are outlined in Table 8. A number of common themes are highlighted including, the need for increased education amongst both farmers and service providers, the importance of understanding disease spread and epidemiology, and a belief amongst PVPs that farmers will not pay for advice.

Logistic Regression Analysis

Chi-squared and regression analysis highlighted a significant association between DA decade of qualification and whether they would advise a client on biosecurity (P=0.004) with those qualifying more recently 4.7 less likely to advise clients on biosecurity. Unvariable chi-squared analysis of PVPs highlighted an association between region (P=0.133), decade of qualification (P=0.08) and completion of herd health/biosecurity training. Subsequently multivariable analysis showed that PVPs that qualified in the 1970s, 1980s and 1990s were found to be 3.28, 4.33, and 4.23 more likely to have completed training than those that qualified in 1960s. Those qualifying in 2000's were not significantly different from those that qualified in the 1960s. In general, practitioners based in Region-1 were over twice as likely to have completed herd health or biosecurity training as those in Regions-2 and -3. Of the regions examined, Region-2 PVPs were least likely to state that herd health is an area which could earn their practices more income (Table 9).

Discussion

The importance of a team-based approach in promoting herd health concepts to clients is continuing to be recognised (Weinand and Conlin, 2003; Hohmann and Ruegg, 2012; Devitt et al., 2013; Gilmour et al., 2013). Communication between service providers is a critical contributor to improved extension services and could lead to improvements in

biosecurity implementation (Kleen et al., 2011; Conraths et al., 2011; Hernández-Jover, et al., 2012). This is not a new concept, Meyerholz, (1974) having provided an insight into the desired working relationship between advisor and veterinarian as early as 1974. In this study, a low level of direct communication between PVPs and DAs with regard to client herd health issues has been highlighted. Client confidentiality was cited as a potential communication obstacle by a single VE and may explain the proportion of PVPs and DAs who reported only communicating with each other at a client's request. However, with over 60% of each group stating that they do not communicate with each other regularly, significant improvements are required to effectively promote biosecurity best-practice in a standardised manner. It is possible that establishing a relationship between service providers can be difficult as professionals may view themselves as competitors, rather than associates working towards a common goal. Such difficulties are exacerbated by a lack of communication (Meyerholz, 1974). Many countries, including Ireland, have established national bodies i.e. Animal Health Ireland, to provide coordinated approaches and information resources regarding herd health (More, 2007). Unless these resources are used in a harmonised manner by PV Ps and DAs at client-level, they are unlikely to achieve maximal impact (Moore et al., 2008). Indeed, Hernández-Jover et al. (2012), reported Animal Health Australia (agency with a high interest in biosecurity) as having no influence on farmers with regard to implementation of biosecurity at farm-level while veterinarians were reported as having a 'high' influence. Similar results have been reported by Gilmour et al. (2013). Design of training programmes and structures to engage and promote communication across all professionals involved in advising livestock farmers, therefore, would prove highly beneficial in achieving improved implementation of biosecurity (Gunn et al., 2008). It is also likely that service provider teams would lead to a greater confidence amongst clients and

greater trust in the information being shared with them, an important basis for influencing client behaviour (Hernández-Jover et al., 2012; Schemann et al., 2012).

Having established that communication between the two main referents for biosecurity information is poor in Ireland, it is important to examine to what extent these professionals communicate with their clients regarding biosecurity (Kleen et al., 2011). This study highlights that the proportion of PVPs and DAs regularly imparting biosecurity advice to clients is again less than optimal. Having said that, PVPs were over twice as likely as DAs ($P<0.0001$) to regularly advise clients on biosecurity, and have clients request biosecurity information from them ($P=0.004$). This is not an entirely unexpected response given the PVP's established role in animal health. However, while PVPs are a more appropriate vehicle to impart biosecurity information to farmers, given their knowledge of disease spread and epidemiology (Mee, 2007), this study does highlight does an underutilisation of the DA resource in reinforcing disease prevention strategies. In addition, veterinarians (both practitioners and experts) ranked 'clients having no interest' as one of the top two reasons that vets would not promote biosecurity to clients. Although an opinion not unique to this study (Gunn et al., 2008), it is not entirely consistent with a previous study of Irish dairy farmers where a majority of farmers did express an interest and were seeking knowledge on the topic (Sayers et al., 2012). Mee (2007) highlighted a similar issue with reluctance amongst service providers to offer a fertility service as there was no demand for the service. Demand must often be created though education and motivation of clients and targeted marketing (Moore et al., 2000; Mee, 2007), a concept well established in the area of public health (Cheng et al., 2011). A schematic of a marketing cycle to underpin successful 'sale' of biosecurity concepts is outlined in Figure 6. It involves an initial sharing of information between client and provider with subsequent communication of the value of a service to the

client (Kotler et al., 2009). Surveyed VEs highlighted a possible issue of PVPs not having the time to promote biosecurity or indeed engage in the marketing process, a barrier also identified in human clinical practice (Gravel et al., 2006). In 2007, 44% of Irish PVPs operated one- or two-person vet practices (Mee, 2007) which does place resource restrictions on carrying out advisory work. Additionally, a proportion of PVPs in this study did highlight an issue with not being paid for advice (Table 8) similar to US veterinarians surveyed in 2000 (Moore et al., 2000). Farm income on dairy farms in the US was not found to influence the use of the veterinary practitioner for information (Jensen et al., 2009). Once a practical and value-added service is marketed correctly to the client, therefore, the opportunity should exist to be paid for the service. DAs have a role to play in client education and reorientation in this regard, and highlight the importance and potential synergies that exist between PVPs and DAs that are currently underexploited.

Use of the marketing cycle by service providers must be underpinned by an understanding of client attitudes, perceptions, and motivators (Delabbio, 2006; Delgado et al., 2012). Professionals can become task- and self-orientated rather than client orientated (Brown and Swartz, 1989) and service providers need to become more aware of how to motivate their clients i.e. become more involved in risk communication as well as risk identification (Hernández-Jover et al., 2012). This understanding does not as yet exist amongst the service providers examined in this study as highlighted by significant differences in PVP, DA, VE and dairy farmer opinions on motivators for implementation of biosecurity (Table 6). While it is likely that dairy farmers would in some way be influenced by all reasons outlined in Table 6a, the differences recorded across study populations highlights an important communication gap between clients and providers. Similar communication gaps have been identified previously between veterinarians and clients relating to issues ranging

311 from biosecurity (Benjamin et al., 2010) to antibiotic resistance (Cattaneo et al., 2009).
312 Additionally, it has been reported in the field of human medicine that community nurses
313 share the closest views to their clients than other health professionals due to home visits
314 which allow a more informed view of clients (Stirling et al., 2012). Similarly, the results of
315 this study suggest that DAs may better recognise dairy farmer motivators than PVPs or VEs,
316 most likely due to closer client contact and/or greater time resources during farm visits.
317 PVPs and VEs cannot be blamed for a focus on the economic benefit in order to motivate
318 farmers as it is often documented that farmers require an economic/cost-benefit analysis in
319 order to be persuaded to take action (Payne et al., 1999; Stott and Gunn, 2008; Roberts et al.,
320 2012). Although important, economics should not, however, be viewed as the sole driver in
321 motivating farmers to implement biosecurity or health programmes (Delgado et al., 2012;
322 Sayers et al., 2012). At present, therefore, the DA in Ireland would appear ideally placed to
323 gain knowledge of, and influence client expectations, an important step in allowing design of
324 herd health services that will match or exceed client expectations (Brown and Swartz, 1989).
325 Development of working relationships between PVPs and DAs should, therefore, be
326 promoted by national agencies. Such relationships would allow PVPs to market and
327 reinforce their unique expertise more effectively to the benefit of dairy farmers and national
328 livestock populations.
329
330 Wells (2000) highlights the need for effective biosecurity programmes to be
331 adaptable, decision-focused, and underlined by an understanding of basic biosecurity
332 principles and disease epidemiology. To this end, this study aimed to provide an
333 importance-ranking of a number of bioexclusion and biocontainment measures, a resource
334 gap identified by Moore et al. (2008). Notwithstanding the fact that the importance of
335 measures may vary between individual farms (Maunsell and Donovan, 2008), in general there

was good agreement between VEs and PVPs (Figure 5), with a single notable exception. PVPs chose good hygiene as the most important biosecurity measure on farm, with VEs choosing a closed herd. In terms of on-farm biosecurity, maintaining a closed herd is regarded as the most important measure in preventing disease introduction (Wells et al., 2002; Caldow, 2004), highlighting an important education gap amongst PVPs. In addition, almost 20% of PVPs stated that biosecurity had a minor or no impact on disease levels on Irish farms again highlighting a need for effective and appropriate training. Use of the biosecurity weightings outlined in this study will provide a simple but useful basis for veterinary education and a risk assessment tool to engage clients in biosecurity (Moore and Payne, 2007; Villarroel et al., 2007; Moore et al., 2010). It is also clear from this study that improved training in practical biosecurity measures employed during farm visits is required to ensure necessary standards of hygiene outlined by Wenzel and Nusbaum, 2007. A focus on recently qualified professionals would be beneficial with more recently qualified DAs in this study five times less likely to advise clients on biosecurity. A similar finding was reported in veterinarians in the US (Fosgate, 2008) with younger vets concentrating more on individual animal tasks than broadening their knowledge into population medicine. Training of young professionals in communication strategies will be an important component in ensuring efficient message delivery to farmers and resultant improvements in disease control (Hooper, 2008).

Conclusion

This study has highlighted communication gaps both between groups of service providers, and between clients and providers. These issues could potentially be overcome through effective integration of PVPs and DAs using shared-training and joint-marketing initiatives. Improved integration across dairy service providers would also optimise the impact of

Animal Health Ireland outputs at farm-level and increase the perceived value of biosecurity amongst dairy farmers.

Conflict of interest statement

None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at doi:

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590 **Table 1**

591

592 Biosecurity 'knowledge transfer' survey questions (variables) and comparison of responses across PVPs and DAs.

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Question	Practice Variable	Response Options	PVPs		DAs		Responses	PVP vs. DA		
			Outcome (%)	n	Outcome (%)	n	Compared	PR	95%CI	Chi^2
Q1DA	Advise Clients on biosecurity	Regularly	52.3		16.2		Regularly vs.			
Q1PVP		Rarely	19.8	111	44.6	74	Rarely	2.7	1.6, 4.5	P<0.0001
		No	3.6		8.1		Regularly vs.			
		Only if information requested	24.3		31.1		No	1.4	1.0, 1.9	P=0.007*
Q2DA	Clients request information	Regularly	30.6		10.5		Regularly vs.			
Q4PVP		Rarely	57.7	111	67.1	76	Rarely	2.6	1.3, 5.2	P=0.004
		Never	11.7		22.4		Regularly vs.			
							Never	2.3	1.2, 4.1	P=0.001
Q4DA	Biosecurity measures used	Clean and disinfect hands	85.5		37.8		Clean hands	2.3	1.7, 3.1	P<0.0001
Q5PVP	between farm visits	Clean boots	97.3		94.6		Clean boots	1.0	0.9, 1.1	P=0.441*
		Clean overalls / waterproofs	80.0	110	21.6	74	Clean clothing	3.7	2.4, 5.8	P<0.0001
		Disinfect vet equipment	64.5		-					
		Keep car away from animals	30.9		36.5		Car away	0.8	0.6, 1.3	P=0.431
Q6PVP	Does vet practice have	Yes	24.1		-					
	biosecurity policy	No	69.4	108	-	-	Excluded		-	
		I don't know	6.5		-					
Q7DA	Communication between PVP	Yes	12.6		4.0		Yes &			
Q9PVP	& EA and vice versa	No	34.2	111	60.0	75	Sometimes vs.	2.8	1.6, 4.9	P<0.0001
		Sometimes	29.7		10.7		No			
		Only if requested by client	23.4		25.3					
Q10PVP	Completed biosecurity	Yes	50.0	110	-	-	Excluded		-	
	training	No	50.0		-					

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595 n= total responses per survey question; PR= Prevalence ratio; *Fisher exact test used to calculate P value.

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597 '-' Indicates questions inapplicable to dairy advisors.

598 **Table 2**

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600 Biosecurity 'opinion' survey questions (variables) and chi-squared analysis of responses across PVPs and DAs.

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Question	Opinion Variable	Response Options	PVPs		DAs		Responses	PVP vs. DA		
			Outcome (%)	n	Outcome (%)	n	Compared	PR	95%CI	Chi^2
Q2PVP	Impact of biosecurity on disease	Major	75.5		-					
		Minor	16.4	110	-	-	Excluded		-	
		None	0.9		-					
		I don't know	7.3		-					
Q3DA	Is biosecurity important	Yes	-		94.7					
	in minimising disease?	No	-	-	1.3	76	Excluded		-	
		I don't know	-		3.9					
Q5DA	Would you use biosecurity	Yes	-	-	98.6	74	Excluded		-	
	guidelines?	No	-		1.4					
Q6DA	Main reason farmer would	For economic benefit	38.2		21.1		Economics &			
Q8PVP	implement biosecurity	If mandatory only	23.6	108	9.9	71	Mandatory vs.	2.0	1.4, 2.9	P<0.0001
		If disease introduction prevented	27.3		62.0		Disease, Health &			
		If health and welfare improved	10.9		7.0		Welfare			
Q8DA	Should PVPs/EAs promote	Yes	96.4	110	90.8	76	Yes vs. No	1.1	0.9, 1.2	P=0.137*
Q11PVP	biosecurity?	No	3.6		9.2					
Q9DA	Would farmers join health	Yes	66.7	108	69.0	71	Yes vs. No	1.0	0.8, 1.2	P=0.742
Q13PVP	Scheme?	No	33.3		31.0					
Q14PVP	Could herd health earn	Yes	66.0	106	-	-	Excluded		-	
	practice greater income?	No	34.0		-					

602 n= total responses per survey question; PR: Prevalence ratio; *Fisher exact test used to calculate P value.

603

604 '-' Indicates questions inapplicable to dairy advisors.

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607 **Table 3**

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609 Categorised comments and chi-squared analysis of PVP, DA, and VE semi-closed and open questions

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~~Comment~~	Category	PVPs		DAs		VEs		Chi^2
		Outcome (%)	n	Outcome (%)	n	Outcome (%)	n	PVP vs. DA PVP vs. VE DA vs. VE
~~Why PVPs/DAs should~~ promote biosecurity	Improve health/prevent disease	48.4	65	31.0	49	54.5	11	P<0.0001
	Disease prevention and economics	24.2		11.8		18.2		P=0.246
	Economic benefit alone	6.1		26.2		9.1		P<0.0001
	National interest/protect clients	21.2		31.0		18.2		
Why farmers would join health scheme	Improve health	31.3	48	18.8	32	-		P=0.004
	For economic benefit	64.5		78.1		-		n/a
	Pride	4.2		3.1		-		n/a
Why farmers would not a join a health scheme	Cost implications	53.8	26	53.3	15	-		
	Time implications	23.1		13.3		-		Excluded
	Farmer unwilling to share data	7.7		0.0		-		
	Too much regulation	3.8		33.3		-		
	Farmers have no interest	11.5		0.0		-		
Why herd health would earn practice greater Income	Generate additional product sales	50.0	28	-		0.0	11	Excluded
	Is a new business opportunity	50.0		-		100.0		
Why herd health would not earn practice greater income	Farmers will not pay for advice	66.7	33	-		0.0	0	Excluded
	Farmers have no interest/will not comply	24.2		-		0.0		
	Too time consuming for vet	3.0		-		0.0		
	Healthier herds; less calls	6.1		-		0.0		

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612 *n*= total responses per survey question

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Table 4

Regional distribution of surveyed and respondent DAs and PVPs.

Survey Region[a]	Percentage DAs per region Surveyed(n)	Respondents(n)	Percentage PVPs per region Surveyed(n)	Respondents(n)	Counties represented
Region 1	25%(20)	24%(1 8)	31 %(73)	32%(36)	Donegal, Sligo, Leitrim, Cavan, Monaghan, Louth, Galway, Mayo, Roscommon, Laois, Offaly, Longford, Westmeath, Dublin, Meath, Kildare, Wicklow
Region 2	41%(35)	42%(32)	38%(89)	36%(40)	Wexford, Carlow, Kilkenny, Tipperary, Waterford, Clare, Limerick
Region 3	34%(27)	34%(26)	31 %(74)	32% (35)	Cork, Kerry

[a]Regions were chosen to correspond with Irish dairy farm distribution (Sayers et al., 2012) and to represent a natural geographical spread.

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Table 5

Ranking of diseases for which surveyed PVPs stated health schemes should be developed in Ireland (*n*=109).

Source of information	Ranking	Rating*	Preference
BVD	1	1.30	Maximal priority
Johne's Disease	2	2.22	
Digital Dermatitis/Mortellaro	2	2.22	
Leptospirosis	3	2.26	
Salmonellosis	4	2.30	
IBR	5	2.35	
Other e.g. mastitis, calf disease	6	2.50	
Neospora	7	3.00	Minimal priority

*Rating scores automatically generated by SurveyMonkey based on percentage of survey respondents ranking first, second, and third choices of diseases requiring health schemes. Lower values indicate greater priority.

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Table 6

Analysis of farmer motivators for biosecurity implementation

(a) Breakdown of the main reasons that farmers would implement biosecurity as stated by Irish dairy farmers, DAs, PVPs and VEs;

Reason	Dairy Farmers* %	DAs %	PVPs %	VEs %
For economic benefit[1]	12.2	21.1	38.2	54.5
If it was mandatory only[1]	4.7	9.9	23.6	0
If it improved cattle health and welfare on their farm[2]	52.7	62	27.3	18.2
If it prevented disease introduction onto their farm[2]	30.4	7	10.9	27.3

(b) Chi-squared analysis of farmer, DA, PVP and VE responses; extrinsic vs. intrinsic factors

	Dairy Farmers PR 95%CI Chi[2]	DAs PR 95%CI Chi2	PVPs PR 95%CI Chi2
Dairy farmers	-		
DAs *vs.*	1.8 1.2, 2.7 P=0.005	-	
PVPs *vs.*	3.7 2.8, 4.7 P<0.0001	2.0 1.4, 2.9 P<0.0001	-
VEs *vs.*	3.2 2.1, 4.9 P<0.0001	1.8 1.1, 2.9 P=0.044	0.9 0.6, 1.3 P=0.512

*Data extracted from Sayers et al., 2012.

1 Combined for the purposes of Chi-squared analysis

2 Combined for the purposes of chi-squared analysis

Table 7

Ranking of reasons why PVPs might not promote biosecurity.

Reason	VE ranking	Priority	PVP ranking	Priority
Clients have no interest	1.64	**1**	1.73	**2**
Clients not willing to invest	1.67	**2**	1.71	**1**
Vets do not have the time	1.93	**3**	2.27	5
Clients cannot afford to invest	2.14	4	1.90	**3**
Clients do not have the time	2.17	5	2.42	6
Vets have insufficient knowledge	2.4	6	2.0	4
Vets do not believe it is beneficial to clients	2.5	7	3.0	7

*Rating scores automatically generated by SurveyMonkey based on percentage of survey respondents ranking first, second, and third choices.

688 **Table 8**

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690 Representative quotes relating to biosecurity supplied in open survey questions by PVPs, DAs and VEs.

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Survey group	Quote
PVPs	"It will take a lot of time and education to make farmers conscious and aware of the need and value of biosecurity"
	"As vets, we need to be at the fore in protecting the health status of out beef and dairy herds. Many vets overestimate farmers knowledge of epidemiology and we need to keep reminding them of the challenges in controlling disease"
	"We have tried and failed over the years; farmers resent paying for advice"
	"Very difficult to get paid – provide free advice mostly unless product sold or physical service provided"
	"I think Animal Health Ireland will need to provide leadership both for farmers and vets. This organisation should set out a roadmap for farmers and vets on the steps to deal with diseases i.e. have all farmers and vets working in the same direction using the same tools"
	"Give farmers the right incentives and education and it will work"
	"Integrate veterinary involvement with farm advisory on farms - holistic approach"
DAs	"Don't make biosecurity mandatory. There are enough regulations and deadlines already being imposed on farmers"
	"Huge ignorance and confusion on dairy farms"
	"The concept is tremendous; the practicality of getting it done....."
VEs	"Education of vets is crucial to improving biosecurity both at an on-farm and national level. This should be a priority in any national herd health programme"
	"If vets were giving reliable practical herd health advice then they could charge professional fee for this advice"
	"It requires a different mindset and a discipline to follow than most farmers are aware of right now"
	"1 .Help farmers to calculate the cost of disease. 2. Teach them how disease spreads. 3. Teach them the real meaning of biosecurity. 4. Help them to develop tailor-made biosecurity plans for their own farms (and don't be afraid to charge them for it)"

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Table 9

Significant associations between independent (region, decade of qualification) and dependent (survey questions) variables*.

Survey Population	Biosecurity practice variables	Dichotomised Response	Odds Ratio	Confidence Interval	*P*-value	Model (P-value)
DA	Advise clients on biosecurity					
	Qualified 1960's/1970's/1980's vs. 1990's/2000's	Regularly & Rarely vs. No & Only if requested	4.65	1.66, 13.07	P=0.004	Region Decade of qualification (p=0.007)
PVP	Completed biosecurity training					
	Qualified 1970's vs. 1960's		3.28	0.89, 11.97	P=0.073	
	Qualified 1980's vs. 1960's	Yes vs.	4.33	1.13, 16.62	P=0.032	Region
	Qualified 1990's vs. 1960's	No	4.23	1.11, 16.22	P=0.035	Decade of qualification
	Qualified 2000's vs. 1960's		0.65	0.09, 4.51	P=0.667	(p=0.036)
	Region 1 vs. Region 2		2.50	0.90, 6.97	P=0.078	
	Region 1 vs. Region 3		2.96	1.03, 8.53	P=0.045	
PVP	Earn practice more money					
	Region 1 vs. Region 2	Yes vs. No	4.56	1.53, 13.53	P=0.006	Region
	Region 3 vs. Region 2		2.63	1.00, 6.91	P=0.049	(p=0.01 1)

*Only those variables for which significant associations were recorded are listed.

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Figure legends

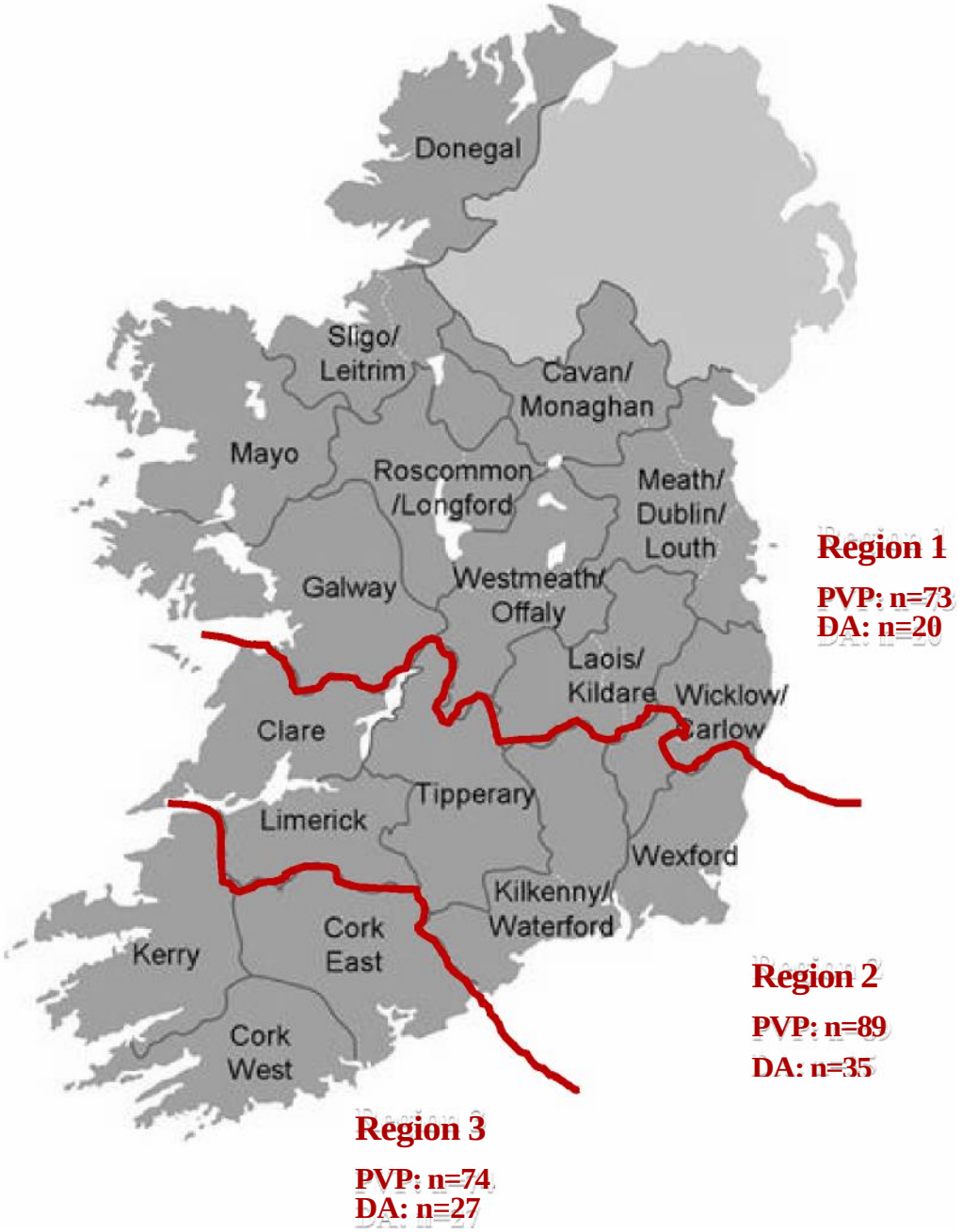


Fig. 1. Geographical distribution of surveyed PVPs and DAs. Regions (1, 2 and 3) used for logistic regression analysis are also outlined.

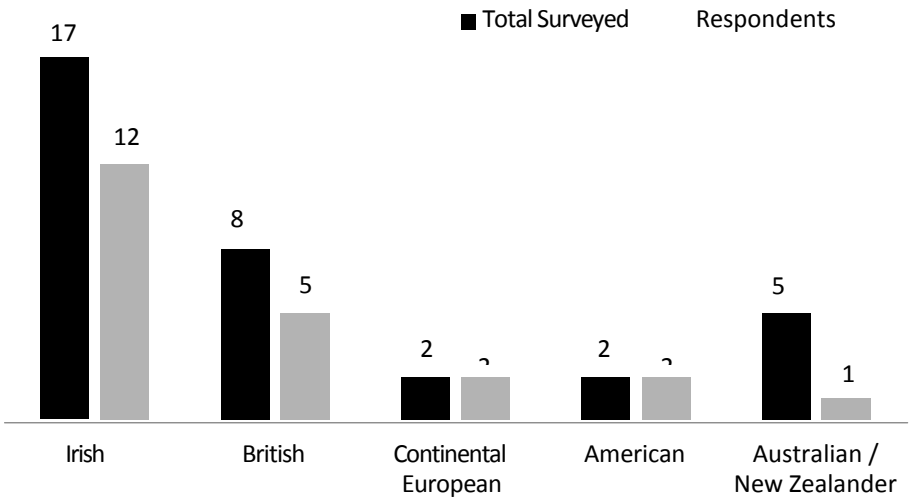


Fig. 2. Nationality of surveyed VEs and subsequent respondents.

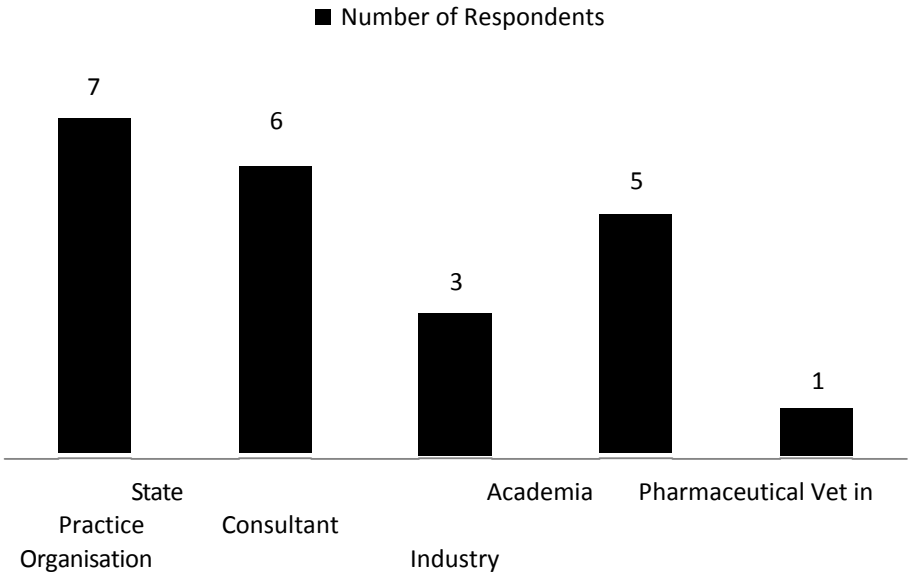


Fig. 3. Affiliations of veterinary experts survey respondents.

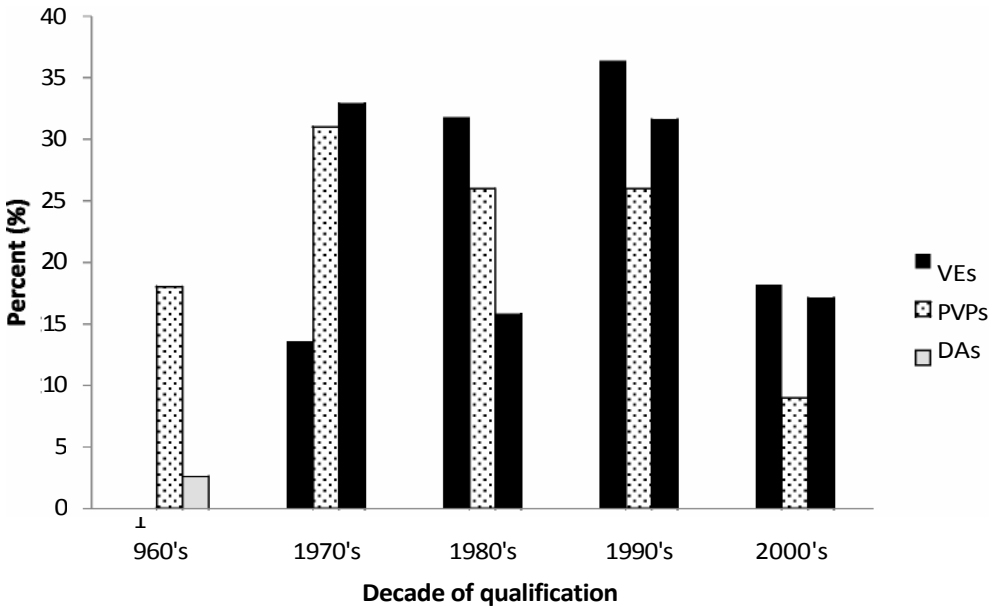
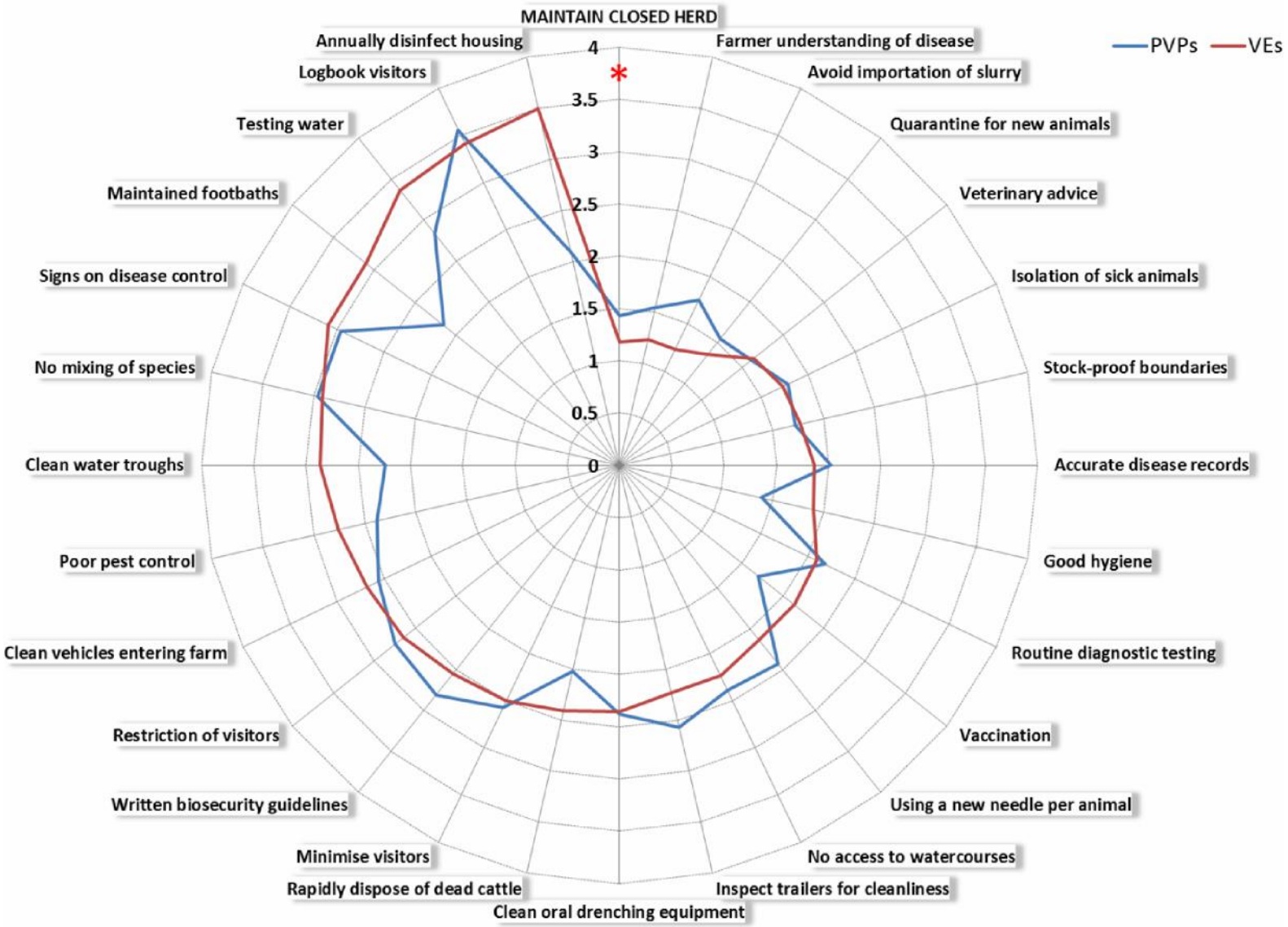


Fig. 4. Decade of qualification (degree in veterinary medicine/degree in agricultural science) of surveyed PVPs (*n*=1 10), DAs (*n*=76) and VEs (*n*=22).



V E-ranked bioexclusion and biocontainment measures are listed in order of importance from the 1 2o 'clock positiion*). Measures are arranged in
798 decreasing importance moving in a clokwise direction (-). Corresponding views of PVPs are outined in blue (-).

Fig. 5. Importance-ranking of biosecurity (bioexclusion and biocontainment) across VEs and PVPs.

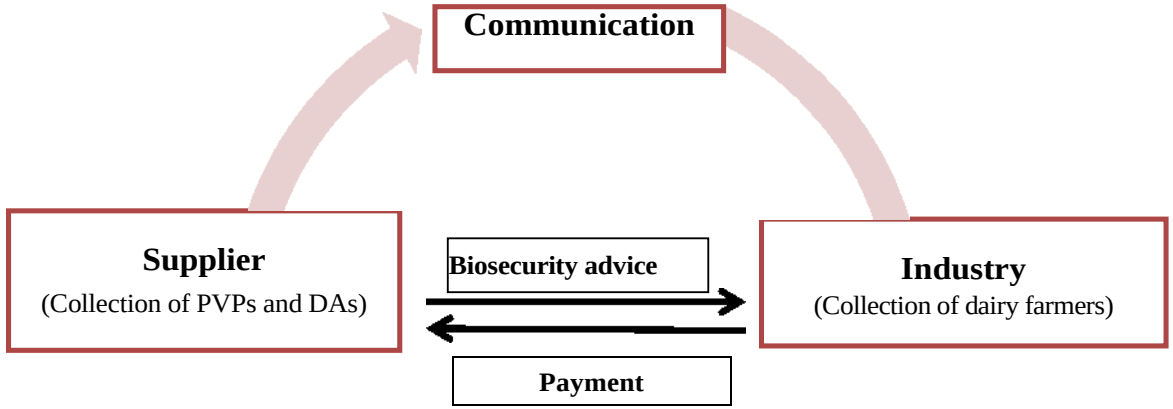


Fig. 6. Marketing cycle to underpin ‘sale’ of biosecurity concepts (Adapted from Kotler et al., 2009)