



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

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

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40 Abstract

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

48 Questionnaire surveys were completed and acceptable response rates of 47% (PVP),
49 97% (DA), and 65% (VE) were achieved. Significant differences were identified in the
50 promotion and implementation of biosecurity between PVPs and DAs, with a higher
51 proportion of PVPs regularly advising clients on biosecurity ($P<0.0001$) and receiving
52 requests for biosecurity advice from clients ($P=0.004$). Communication between DAs and
53 PVPs was sub-optimal with over 60% of each group not in regular communication. With
54 regard to the main farmer motivator for biosecurity implementation, the majority of PVPs
55 (62%) prioritised external factors (economic benefit, mandatory obligation) as the main
56 farmer motivator for biosecurity implementation. The majority of DAs prioritised
57 health/animal related factors (69%) in closer agreement with farmers (83.1%), although still
58 significantly less likely (OR=1.8) than farmers to choose such motivators ($P=0.005$).
59 Importance ranking of biosecurity measures by PVPs and VEs was also documented as a
60 basis for veterinary education and farm biosecurity risk assessments.

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

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

64 Introduction

65 It is becoming increasingly evident that there is a need to re-orient livestock farmers
66 to preventative rather than curative medicine (LeBlanc et al., 2006; EC, 2007; More, 2007;
67 Conraths et al., 2011). Biosecurity, a merging of the concepts of bioexclusion and
68 biocontainment (Mee et al., 2012), is a fundamental component of preventative medicine and
69 an important concept to promote within farming communities. International studies have
70 highlighted that implementation of biosecurity at farm-level is poor and lack of information a
71 potential cause (Delabbio, 2006; Hoe and Ruegg, 2006; Gunn et al. 2008; Heffernan et al.,
72 2008; Moore et al., 2008; Schemann et al., 2011; Brennan and Christley, 2012; Sayers et al.,
73 2012). However, a willingness amongst farmers to implement biosecurity can exist should
74 guidance on an effective approach be provided (Sayers et al., 2012).

75 Private veterinary practitioners (PVPs) play a pivotal role in the provision of animal
76 health services to dairy farmers. Dairy advisors (DAs) offer invaluable advice to support
77 farmers in the role out of best-practice general farm management. Practical implementation
78 of biosecurity at farm level requires knowledge of the pathogens that constitute a threat to the
79 farming enterprise and also knowledge of the livestock production system in place (Graham
80 et al., 2008; Larson, 2008). Thus, the combined expertise and experience of PVPs and DAs
81 provides an ideal vehicle through which to impart biosecurity advice to dairy farmers. This
82 is recognised by farmers with veterinary practitioners ranked as the favoured farmer referent
83 for biosecurity information (Jordan and Fourdraine, 1993; Gunn et al., 2008; Jensen et al.,
84 2009; Hernández-Jover, 2012; Sayers et al, 2012; Schemann et al., 2012; Brennan and
85 Christley, 2013) and farm advisors also ranked highly (Vergot et al., 2005; Jensen et al.,
86 2009; Sayers et al., 2012).

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

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

97

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

108

109 **Materials and methods**

110 *Questionnaire*

111 Three biosecurity questionnaires were designed and circulated to Irish PVPs, DAs and
112 internationally based VEs. Survey questionnaires are included in Appendix A,
113 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 advisors¹.
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-line². 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 tool², 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

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 tool³.

140 Rating scales were automatically generated in SurveyMonkey for those survey questions
141 requiring ranking of responses.

142

143 Dependent variables (survey questions) were categorised 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 (1960s, 1970s, and 1980s versus 1990s, and 2000s). Again the effect
161 of region and decade of qualification on dependent variables was assessed. Logistic

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

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

169

170 **Results**

171 *Descriptive Analysis*

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

181

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

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

204

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

212

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

217

218 *Logistic Regression Analysis*

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

231

232 **Discussion**

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

237 biosecurity implementation (Kleen et al., 2011; Conraths et al., 2011; Hernández-Jover, et al.,
238 2012). This is not a new concept, Meyerholz, (1974) having provided an insight into the
239 desired working relationship between advisor and veterinarian as early as 1974. In this
240 study, a low level of direct communication between PVPs and DAs with regard to client herd
241 health issues has been highlighted. Client confidentiality was cited as a potential
242 communication obstacle by a single VE and may explain the proportion of PVPs and DAs
243 who reported only communicating with each other at a client's request. However, with over
244 60% of each group stating that they do not communicate with each other regularly,
245 significant improvements are required to effectively promote biosecurity best-practice in a
246 standardised manner. It is possible that establishing a relationship between service providers
247 can be difficult as professionals may view themselves as competitors, rather than associates
248 working towards a common goal. Such difficulties are exacerbated by a lack of
249 communication (Meyerholz, 1974). Many countries, including Ireland, have established
250 national bodies i.e. Animal Health Ireland, to provide coordinated approaches and
251 information resources regarding herd health (More, 2007). Unless these resources are used in
252 a harmonised manner by PV Ps and DAs at client-level, they are unlikely to achieve maximal
253 impact (Moore et al., 2008). Indeed, Hernández-Jover et al. (2012), reported Animal Health
254 Australia (agency with a high interest in biosecurity) as having no influence on farmers with
255 regard to implementation of biosecurity at farm-level while veterinarians were reported as
256 having a 'high' influence. Similar results have been reported by Gilmour et al. (2013).
257 Design of training programmes and structures to engage and promote communication across
258 all professionals involved in advising livestock farmers, therefore, would prove highly
259 beneficial in achieving improved implementation of biosecurity (Gunn et al., 2008). It is also
260 likely that service provider teams would lead to a greater confidence amongst clients and

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

263

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

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

298

299 Use of the marketing cycle by service providers must be underpinned by an
300 understanding of client attitudes, perceptions, and motivators (Delabbio, 2006; Delgado et al.,
301 2012). Professionals can become task- and self-orientated rather than client orientated
302 (Brown and Swartz, 1989) and service providers need to become more aware of how to
303 motivate their clients i.e. become more involved in risk communication as well as risk
304 identification (Hernández-Jover et al., 2012). This understanding does not as yet exist
305 amongst the service providers examined in this study as highlighted by significant differences
306 in PVP, DA, VE and dairy farmer opinions on motivators for implementation of biosecurity
307 (Table 6). While it is likely that dairy farmers would in some way be influenced by all
308 reasons outlined in Table 6a, the differences recorded across study populations highlights an
309 important communication gap between clients and providers. Similar communication gaps
310 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

336 was good agreement between VEs and PVPs (Figure 5), with a single notable exception.
337 PVPs chose good hygiene as the most important biosecurity measure on farm, with VEs
338 choosing a closed herd. In terms of on-farm biosecurity, maintaining a closed herd is
339 regarded as the most important measure in preventing disease introduction (Wells et al.,
340 2002; Caldow, 2004), highlighting an important education gap amongst PVPs. In addition,
341 almost 20% of PVPs stated that biosecurity had a minor or no impact on disease levels on
342 Irish farms again highlighting a need for effective and appropriate training. Use of the
343 biosecurity weightings outlined in this study will provide a simple but useful basis for
344 veterinary education and a risk assessment tool to engage clients in biosecurity (Moore and
345 Payne, 2007; Villarroel et al., 2007; Moore et al., 2010). It is also clear from this study that
346 improved training in practical biosecurity measures employed during farm visits is required
347 to ensure necessary standards of hygiene outlined by Wenzel and Nusbaum, 2007. A focus
348 on recently qualified professionals would be beneficial with more recently qualified DAs in
349 this study five times less likely to advise clients on biosecurity. A similar finding was
350 reported in veterinarians in the US (Fosgate, 2008) with younger vets concentrating more on
351 individual animal tasks than broadening their knowledge into population medicine. Training
352 of young professionals in communication strategies will be an important component in
353 ensuring efficient message delivery to farmers and resultant improvements in disease control
354 (Hooper, 2008).

355

356 **Conclusion**

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

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

363

364 **Conflict of interest statement**

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

367

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373

374 **Appendix A. Supplementary material**

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

376

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590 **Table 1**

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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 Compared	PVP vs. DA					
			Outcome (%)	n	Outcome (%)	n		PR	95%CI	Chi ²			
Q1DA Q1PVP	Advise Clients on biosecurity	Regularly	52.3	111	16.2	74	Regularly vs.	2.7	1.6, 4.5	P<0.0001			
		Rarely	19.8		44.6		Rarely						
		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 Q4PVP	Clients request information	Regularly	30.6	111	10.5	76	Regularly vs.	2.6	1.3, 5.2	P=0.004			
		Rarely	57.7		67.1		Rarely						
		Never	11.7		22.4		Regularly vs.				2.3	1.2, 4.1	P=0.001
Q4DA Q5PVP	Biosecurity measures used between farm visits	Clean and disinfect hands	85.5	110	37.8	74	Clean hands	2.3	1.7, 3.1	P<0.0001			
		Clean boots	97.3		94.6		Clean boots				1.0	0.9, 1.1	P=0.441*
		Clean overalls / waterproofs	80.0		21.6		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 biosecurity policy	Yes	24.1	108	-	-	Excluded	-	-	-			
		No	69.4		-								
		I don't know	6.5		-								
Q7DA Q9PVP	Communication between PVP & EA and vice versa	Yes	12.6	111	4.0	75	Yes &	2.8	1.6, 4.9	P<0.0001			
		No	34.2		60.0		Sometimes vs.						
		Sometimes	29.7		10.7		No						
		Only if requested by client	23.4		25.3								
Q10PVP	Completed biosecurity training	Yes	50.0	110	-	-	Excluded	-	-	-			
		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 Compared	PVP vs. DA	
			Outcome (%)	n	Outcome (%)	n		PR 95%CI	Chi ²
Q2PVP	Impact of biosecurity on disease	Major	75.5	110	-	-	Excluded		
		Minor	16.4		-				
		None	0.9		-				
		I don't know	7.3		-				
Q3DA	Is biosecurity important in minimising disease?	Yes	-	-	94.7	76	Excluded		
		No	-		1.3				
		I don't know	-		3.9				
Q5DA	Would you use biosecurity guidelines?	Yes	-	-	98.6	74	Excluded		
		No	-		1.4				
Q6DA	Main reason farmer would implement biosecurity	For economic benefit	38.2	108	21.1	71	Economics & Mandatory vs. Disease, Health & Welfare	2.0 1.4, 2.9 P<0.0001	
Q8PVP		If mandatory only	23.6		9.9				
		If disease introduction prevented	27.3		62.0				
		If health and welfare improved	10.9		7.0				
Q8DA	Should PVPs/EAs promote biosecurity?	Yes	96.4	110	90.8	76	Yes vs. No	1.1 0.9, 1.2 P=0.137*	
Q11PVP		No	3.6		9.2				
Q9DA	Would farmers join health Scheme?	Yes	66.7	108	69.0	71	Yes vs. No	1.0 0.8, 1.2 P=0.742	
Q13PVP		No	33.3		31.0				
Q14PVP	Could herd health practice greater income?	Yes	66.0	106	-	-	Excluded		
		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 Categorized comments and chi-squared analysis of PVP, DA, and VE semi-closed and open questions

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	-		Excluded
	Time implications	23.1		13.3		-		
	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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616 **Table 4**

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618 Regional distribution of surveyed and respondent DAs and PVPs.

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Survey Region ^a	Percentage DAs per region		Percentage PVPs per region		Counties represented
	Surveyed(n)	Respondents(n)	Surveyed(n)	Respondents(n)	
Region 1	25% (20)	24% (18)	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

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621 ^aRegions were chosen to correspond with Irish dairy farm distribution (Sayers et al., 2012) and to represent a natural geographical spread.

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636 **Table 5**

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

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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



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

642 diseases requiring health schemes. Lower values indicate greater priority.

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658 **Table 6**

659 Analysis of farmer motivators for biosecurity implementation

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661 (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

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664 (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 Chi ²	PVPs PR 95%CI Chi ²
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

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666 *Data extracted from Sayers et al., 2012.

667 ¹ Combined for the purposes of Chi-squared analysis668 ² Combined for the purposes of chi-squared analysis

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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	<p>“It will take a lot of time and education to make farmers conscious and aware of the need and value of biosecurity”</p> <p>“As vets, we need to be at the fore in protecting the health status of our beef and dairy herds. Many vets overestimate farmers knowledge of epidemiology and we need to keep reminding them of the challenges in controlling disease”</p> <p>“We have tried and failed over the years; farmers resent paying for advice”</p> <p>“Very difficult to get paid – provide free advice mostly unless product sold or physical service provided”</p> <p>“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”</p> <p>“Give farmers the right incentives and education and it will work”</p> <p>“Integrate veterinary involvement with farm advisory on farms - holistic approach”</p>
DAs	<p>“Don’t make biosecurity mandatory. There are enough regulations and deadlines already being imposed on farmers”</p> <p>“Huge ignorance and confusion on dairy farms”</p> <p>“The concept is tremendous; the practicality of getting it done.....”</p>
VEs	<p>“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”</p> <p>“If vets were giving reliable practical herd health advice then they could charge professional fee for this advice”</p> <p>“It requires a different mindset and a discipline to follow than most farmers are aware of right now”</p> <p>“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)”</p>

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696 **Table 9**

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

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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 Qualified 1980's vs. 1960's Qualified 1990's vs. 1960's Qualified 2000's vs. 1960's Region 1 vs. Region 2 Region 1 vs. Region 3	Yes vs. No	3.28 4.33 4.23 0.65 2.50 2.96	0.89, 11.97 1.13, 16.62 1.11, 16.22 0.09, 4.51 0.90, 6.97 1.03, 8.53	P=0.073 P=0.032 P=0.035 P=0.667 P=0.078 P=0.045	Region Decade of qualification (p=0.036)
PVP	Earn practice more money Region 1 vs. Region 2 Region 3 vs. Region 2	Yes vs. No	4.56 2.63	1.53, 13.53 1.00, 6.91	P=0.006 P=0.049	Region (p=0.01 1)

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

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713 **Figure legends**

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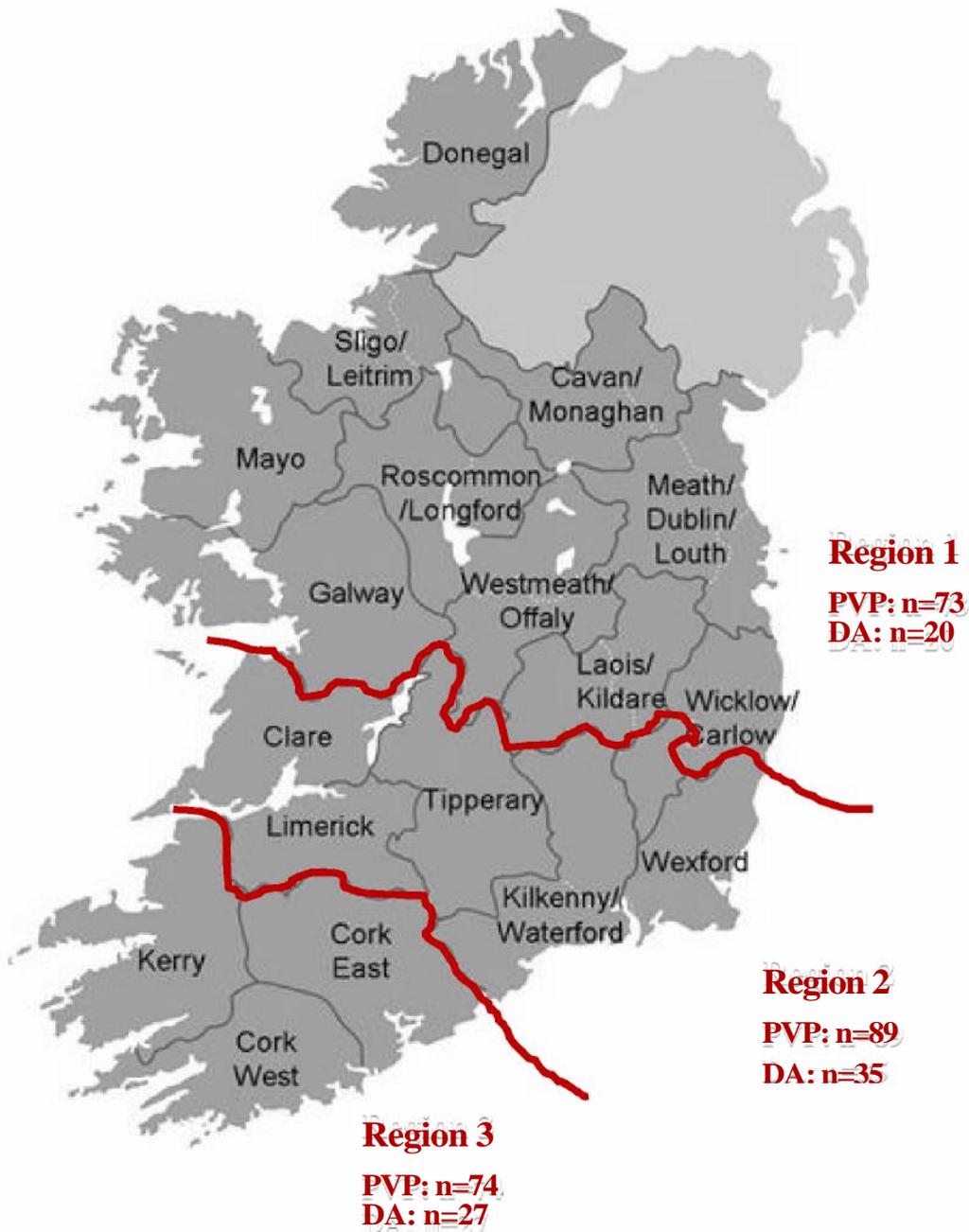
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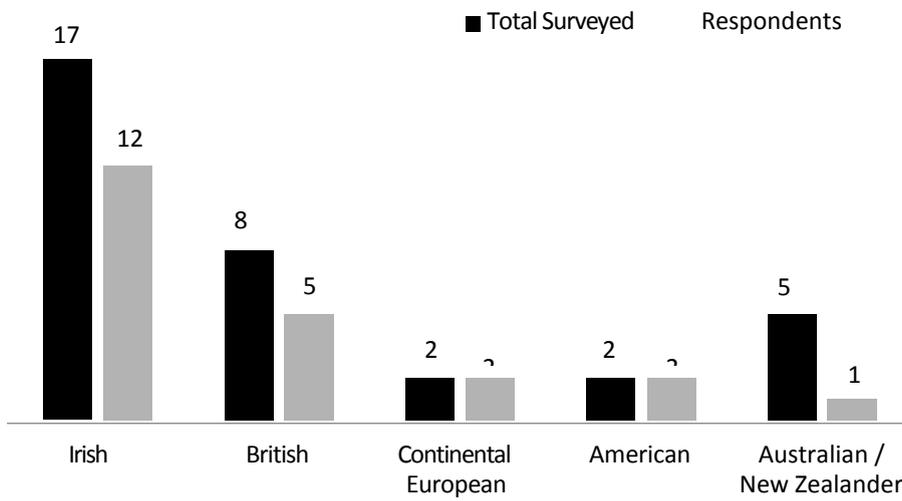
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736 Fig. 1. Geographical distribution of surveyed PVPs and DAs. Regions (1, 2 and 3) used for
737 logistic regression analysis are also outlined.

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

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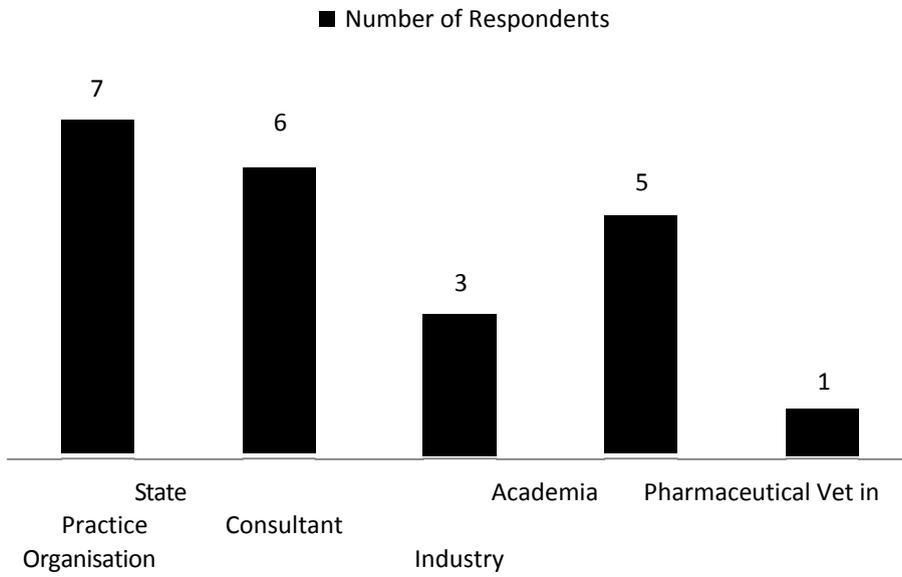
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764 Fig. 3. Affiliations of veterinary experts survey respondents.

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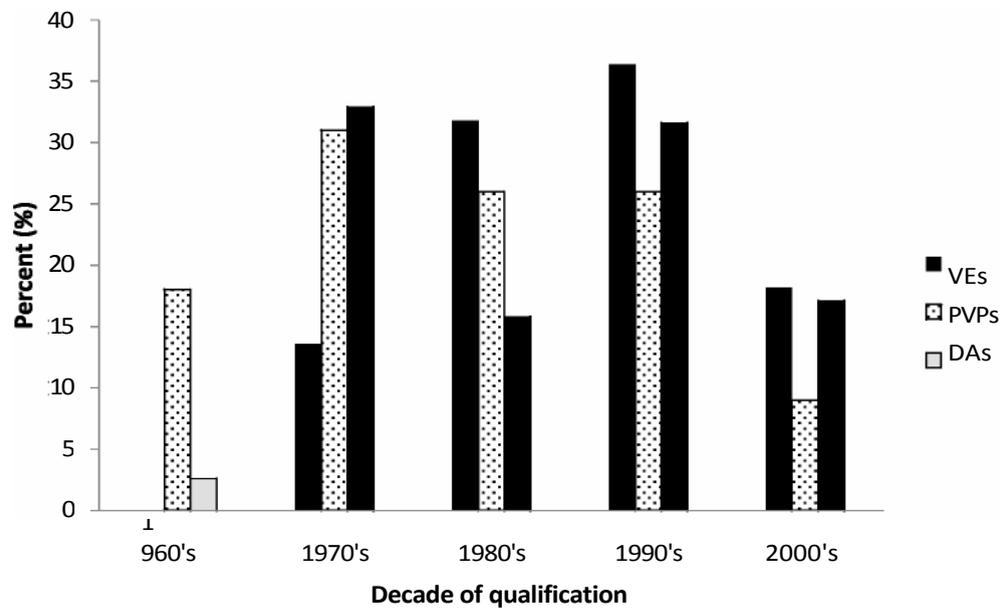
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785 Fig. 4. Decade of qualification (degree in veterinary medicine/degree in agricultural science) of
786 surveyed PVPs ($n=10$), DAs ($n=76$) and VEs ($n=22$).

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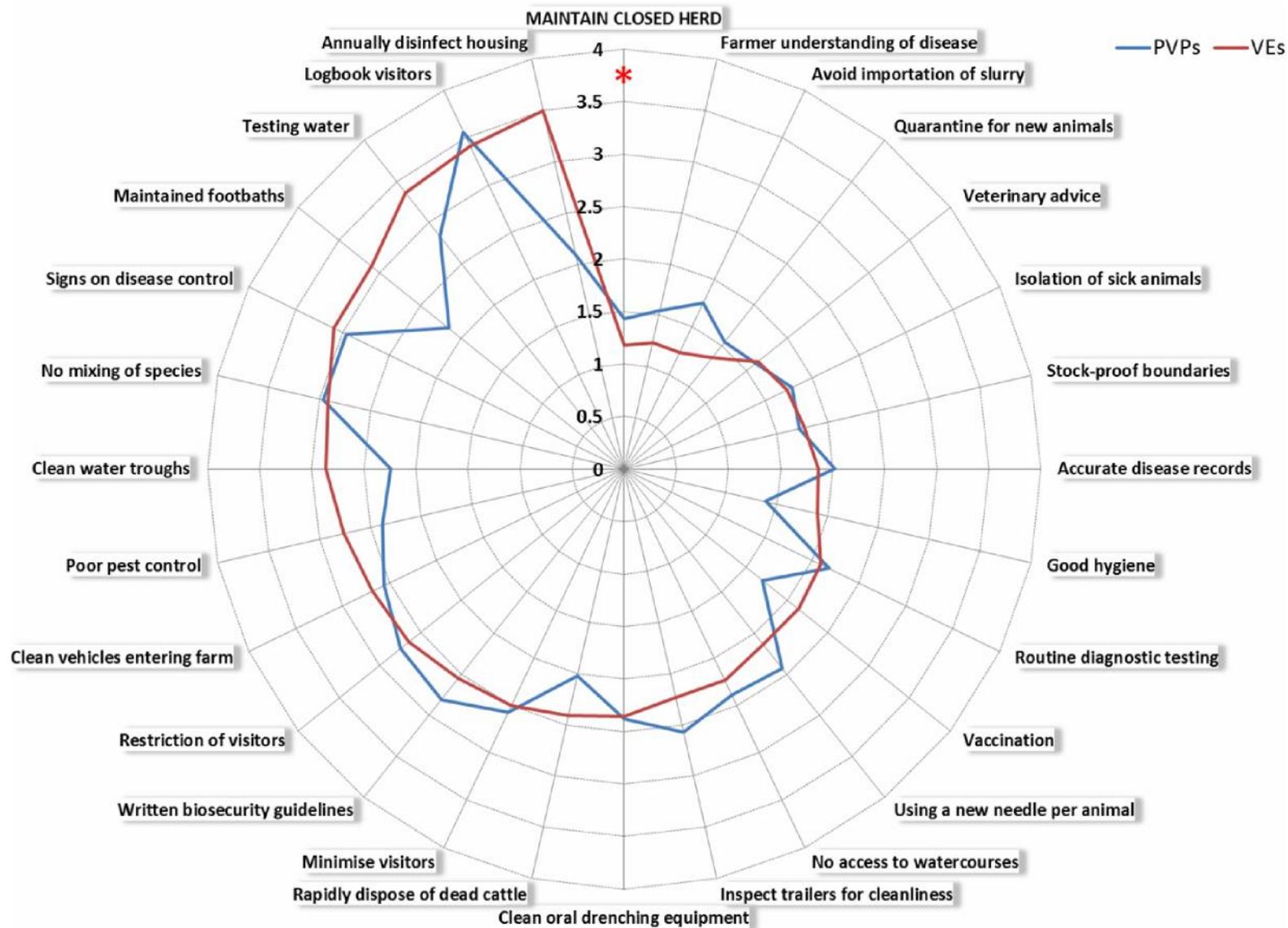
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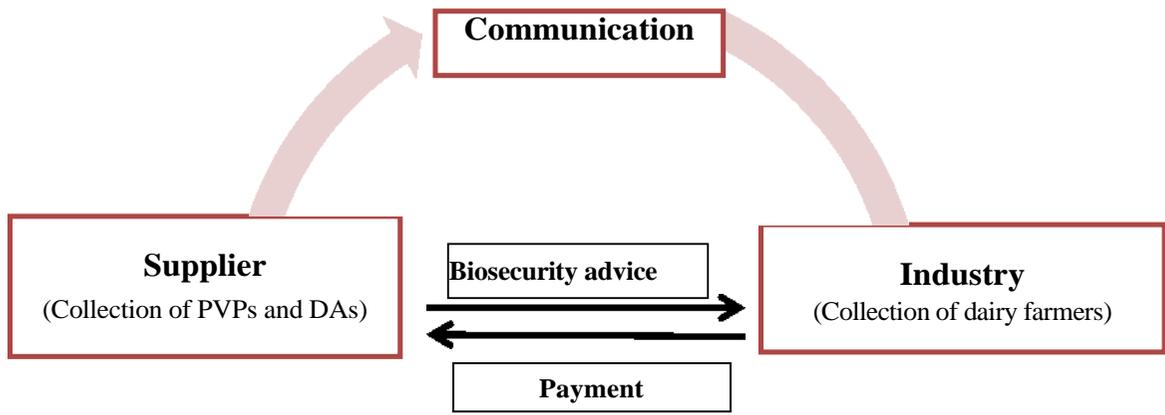
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798 V E-ranked bioexclusion and biocontainment measures are listed in order of importance from the 12 o'clock position*). Measures are arranged in decreasing importance moving in a clockwise direction (-). Corresponding views of PVPs are outlined in blue (-).

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



Information

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