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1 **A cross-sectional study of horse owners' awareness and perceived risk of**
2 **exotic diseases in the United Kingdom**

3

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23

24 **Abstract**

25 The international nature of the equine industry provides opportunities for the spread of
26 infectious diseases between countries. While incursions of exotic diseases into the United
27 Kingdom (UK) equine population have been rare, the potential socioeconomic and welfare
28 impacts are a significant concern. However, little is known about leisure horse owners'
29 ability or willingness to prepare for an exotic disease incursion. The objectives of this study
30 were to describe UK leisure horse owners' awareness and perceptions of exotic diseases,
31 and to identify clusters of horse owners characterised by their awareness and perceived risk
32 of exotic diseases. A cross-sectional study of leisure horse owners in the UK was conducted
33 between April and July 2018. Participants (n = 403) completed an online questionnaire with
34 questions pertaining to demographics, experiences with endemic diseases, and awareness
35 and perceptions of exotic diseases. Hierarchical cluster analysis was used to identify groups
36 of participants that were similar in regard to their awareness and perceived risk of exotic
37 diseases. Participants identified a median of 3 (IQR 2 – 4) exotic diseases, with the most
38 recognised exotic diseases being African horse sickness and West Nile virus. The most
39 frequently mentioned clinical signs that participants thought were associated with exotic
40 diseases included high temperature (57.2%), discharge (46.5%), and lack of energy (41.2%).
41 Hierarchical cluster analysis identified three clusters of participants: 1) those who were
42 aware of exotic diseases and perceived a high amount of risk (n = 78); 2) those who were
43 aware of exotic diseases but perceived a low amount of risk (n = 111); and 3) those who
44 were less aware of exotic diseases and perceived a low amount of risk (n = 214). Efforts to
45 communicate the relevance and consequences of exotic diseases to horse owners should
46 consider the potential difference in receptiveness among horse owners in each cluster.

47 Further investigations are required to determine the implications of horse owners'
48 perceived risk on exotic disease preparedness.

49

50 **Keywords:** Equine; Disease preparedness; Infectious disease; Risk perceptions

51

52 **Introduction**

53 The globalisation of the equine industry poses tremendous challenges for the
54 prevention and control of equine infectious diseases. The increased incidence of
55 transnational and transcontinental disease spread can be attributed to frequent movement
56 of horses and their biological products (Timoney, 2000; Sluyter, 2001), the changing
57 distribution of vectors which transmit these diseases (Wittmann and Baylis, 2000; Gould et
58 al., 2006), and failures to implement identification requirements or post-arrival quarantine
59 procedures (Dominguez et al., 2016). In the United Kingdom (UK), diseases which are not
60 normally present in the country are considered 'exotic'. Incursions of equine exotic disease
61 can cause significant socioeconomic and welfare implications (Rosanowski et al., 2019;
62 Hoare, 2011; Smyth et al., 2011) and are therefore a concern for the UK equine industry.

63 A comprehensive exotic disease preparedness strategy involves, but is not limited to,
64 the understanding of knowledge and practices of those expected to prepare for an outbreak
65 (Levings, 2012). While each country in the UK has a contingency plan for exotic diseases, it is
66 unclear whether equine stakeholders, such as horse owners, are aware of the requirements
67 within these guidelines. Some exotic diseases, such as West Nile virus (WNV), African horse
68 sickness (AHS), and equine infectious anaemia (EIA) are notifiable, which means that
69 individuals must report any suspicion of the disease to the government. However, a recent

70 study found that only a few horse owners in the UK could identify clinical signs of
71 arthropod-borne exotic diseases or the likely consequences of an outbreak (Chapman et al.,
72 2018). Findings among other agricultural industries have demonstrated that preparing for
73 exotic diseases is considered a low priority among producers due to a perceived low
74 likelihood of occurrence (Guinat et al., 2016; Hernández-Jover et al., 2016). The inability of
75 individuals to identify exotic diseases, as well as a lack of motivation to engage in disease
76 preparedness, hinders exotic disease preparedness efforts.

77 Several socio-cognitive models, such as the Health Belief Model (Rosenstock, 1974),
78 Protection Motivation Theory (Rogers, 1975), and the Theory of Planned Behaviour (Ajzen,
79 1991), highlight the role of perceived risk in practising preventive health behaviours, such as
80 disease preparedness. These theories suggest that risk perceptions, such as perceived
81 susceptibility, vulnerability, and severity, can affect an individual's intention to engage in
82 preventive health behaviours (Ferrer and Klein, 2016). Other factors that influence
83 preventive health behaviours among horse owners and farmers include demographics,
84 awareness, past experiences, and sociocultural norms (Sjoberg, 2000; Schemann et al.,
85 2013; Ritter et al., 2017; Wiethoelter et al., 2017a). Particularly among the horse industry,
86 horse use can be a major influencing factor in an owner's implementation of preventive
87 health strategies (Rosanowski et al., 2012, 2013; Spence et al., 2018). While individuals
88 within the racing industry are regulated by national and international governing bodies,
89 individuals within the leisure horse industry are less regulated and therefore might differ in
90 their motivations to implement disease preparedness strategies.

91 Given the impact of these factors on decisions surrounding health behaviours, it is
92 important to understand individuals' awareness and perceived risk of health threats as a
93 first step in determining barriers to engage in disease preparedness. Therefore, the

94 objectives of this study were to describe UK leisure horse owners' awareness and
95 perceptions of exotic diseases, and to identify clusters of horse owners characterised by
96 their awareness and perceived risk of exotic diseases.

97

98 **Materials and methods**

99 **Study population**

100 A cross-sectional study of horse owners in the UK was conducted between April and
101 July 2018. Individuals who owned or cared for horses, ponies, or donkeys were eligible to
102 participate in the study if they met the following inclusion criteria: 18 years of age or older;
103 lived in the UK at the time of the questionnaire; owned or were responsible for the care of
104 at least one horse, pony, or donkey (herein referred to as 'horses'); and only participated in
105 the leisure sector (i.e. did not participate in racing). The study protocol was reviewed and
106 approved by the Royal Veterinary College Social Sciences Research Ethical Review Board
107 (URN SR2017-1528).

108 Due to the absence of a sampling frame of UK horse owners, a variety of methods
109 were used to recruit potential participants. An electronic link to the study was publicised
110 during equestrian events and seminars, distributed via equestrian media (i.e. magazines and
111 online forums), and advertised within social media posts from equestrian organisations and
112 industry groups. Participation was therefore dependent on coming across the link to the
113 study during the recruitment period. In recognition of their participation, participants were
114 offered an entry into a draw to win an equestrian accessory item of their choice.

115

116 **Data collection**

117 An online questionnaire was developed using SurveyMonkey (Palo Alto, CA, USA) to
118 collect data about horse owners' awareness and perceived risk of exotic diseases. A pilot
119 study was performed among 11 horse owners to assess the clarity and interpretability of the
120 questionnaire. The questionnaire was refined in response to the feedback provided during
121 the pilot test. A copy of the final questionnaire is provided as supplementary material. The
122 questionnaire consisted of mostly closed-ended questions pertaining to participant
123 demographics, premises characteristics, experiences with endemic diseases (i.e. previous
124 diagnosis on premises and awareness of outbreaks in local area), awareness of exotic
125 diseases (i.e. information-seeking behaviour, ability to identify exotic diseases based on
126 their names, and awareness of current outbreaks), perceived risk of exotic diseases, and
127 preferred sources of information on exotic diseases. The questionnaire contained one open-
128 ended question regarding perceived clinical signs and symptoms of exotic diseases as well as
129 opportunities for participants to add freehand comments to certain closed-ended questions.
130 Two further open-ended questions on interpretation of the term 'exotic disease' and
131 subsequent risk factors were analysed separately and are not presented in this paper.

132 Definitions of the terms used throughout the questionnaire were included to assist
133 participants and ensure standardisation of responses. A 'premises' was defined as the
134 location where the participant kept their horse(s) for the majority of their time. Participants
135 who owned more than one horse and kept them at multiple premises were asked to provide
136 answers for the premises where most of their horses were kept. The location of the
137 premises was determined by converting its partial postcode into spatial coordinates
138 representing the centroid of the postcode coverage area using the 'PostcodesioR' package
139 (Walczak, 2018) in R version 3.5.1 (R Core Team, 2018). 'Exotic diseases' were defined as
140 equine diseases not normally found in the UK, and the definition was provided to

141 participants prior to asking them to identify which diseases they considered as exotic.
142 Participants were unable to return to previous questions in the questionnaire in order to
143 prevent the editing of previous answers.

144

145 **Descriptive analysis**

146 At the completion of the study period, all participant responses were imported into
147 R and were cleaned and checked for duplicates. In order to be included in the analysis,
148 participants' data had to include all 17 variables regarding awareness and perceptions of
149 exotic diseases (the outcome variables). Participants with missing data for any of these
150 variables were excluded from analysis. Differences between participants who were included
151 in the analysis and those who were excluded based on missing data were evaluated to
152 assess whether selection bias was present. Statistically significant differences (p value <
153 0.05) between demographic variables of included and excluded participants were assessed
154 using the Wilcoxon rank-sum test for continuous data and the Chi-square test (or Fisher's
155 exact test, where appropriate) for categorical data. Descriptive statistics of the variables
156 were examined, and frequency distributions for categorical variables and median values and
157 interquartile ranges (IQR) for continuous variables were calculated.

158

159 **Content analysis**

160 Content analysis was used to analyse the responses to the question "*Which clinical*
161 *sign(s) or symptom(s) would make you worry that your horse had an exotic disease?*", as
162 well as freehand comments provided by participants on the circumstances of any
163 outbreak(s) they had been aware of within the past 12 months. Participants' comments
164 were imported into NVivo (QSR International Pty Ltd., version 12.2.0) for data management.

165 Through an iterative process of repeated reviews of the text, data were coded by assigning
166 key words or phrases to describe the topic(s) mentioned by participants in their responses
167 (Elo and Kyngäs, 2008). Coding was inductive and therefore driven by the phrasing used by
168 participants rather than pre-determined categories (Elo and Kyngäs, 2008).

169

170 **Exploratory factor analysis**

171 The questionnaire included 14 Likert-type questions regarding different constructs
172 around perceived risk of exotic diseases. Exploratory factor analysis (EFA) was used to
173 identify the main underlying constructs of perceived risk contained within the larger set of
174 variables. Exploratory factor analysis is a procedure used to condense the information
175 contained in a group of correlated variables into a smaller set of 'factors' while maintaining
176 the variability observed in the original dataset (Field et al., 2012). All 14 variables relating to
177 perceived risk of exotic diseases were subjected to EFA using the 'psych' package in R
178 (Revelle, 2018). Of the 14 variables, three negatively-worded statements were reverse
179 scored to ensure that a higher score corresponded to a higher degree of the measure.

180 Principal component analysis (PCA) was used to identify the underlying component
181 structure of the risk perception variables. The resulting component structure identified by
182 PCA represents a linear combination of the variables, which can then be represented by
183 their eigenvalues (i.e. the variance) (Field et al., 2012). Several criteria were used to
184 determine which components should be extracted for further analysis (Field et al., 2012).
185 First, all components with eigenvalues > 1.0 were retained. Next, the scree plot was
186 examined for the point of inflexion, and components to the left of the point of inflexion
187 were retained for further analysis. The extracted components were obliquely rotated using
188 the 'promax' method to simplify the component structure and enhance their interpretability

189 (Yong and Pearce, 2013). Oblique rotation is preferred over orthogonal rotation when
190 correlation could theoretically exist between components, as is the case for risk perception
191 constructs (Yong and Pearce, 2013). Variables with component loadings of ≥ 0.4 were
192 considered to contribute significantly to the given component (Field et al., 2012). Variables
193 that did not load ≥ 0.4 on any component were removed and the PCA was repeated. The
194 final components were labelled according to the theme of the variables that loaded highly
195 on each component. Component scores were calculated for each participant using the
196 regression method, which was based on the component loadings and each individual's
197 response for the constituent variables (Field et al., 2012).

198

199 **Hierarchical cluster analysis**

200 Hierarchical cluster analysis (HCA) was conducted to identify groups of participants
201 according to their similarities in awareness and perceived risk of exotic diseases.

202 Participants' responses to six variables were used as input for the HCA; three variables
203 described exotic disease awareness (number of exotic diseases identified, awareness of
204 disease outbreaks outside of the UK, and whether they previously sought information on
205 exotic diseases) and three variables described the resulting scores of the risk perception
206 components identified during EFA. Hierarchical cluster analysis was conducted based on
207 Euclidean distance and Ward's agglomeration method using the 'cluster' package in R
208 (Maechler et al., 2018). The optimal number of clusters was chosen by examining the
209 resulting dendrogram.

210 Lastly, we examined differences and similarities between clusters according to the
211 HCA input variables and the remaining participant and premises demographic variables. The
212 Kruskal-Wallis test was used to examine statistically significant differences in continuous

213 variables among clusters, and the Chi-square test (or Fisher's exact test, where appropriate)
214 was used to examine differences in categorical variables among clusters.

215

216 **Results**

217 **Questionnaire response**

218 A total of 532 questionnaire responses were received, of which 403 (75.8%) met the
219 inclusion criteria for the study. The median time to complete the questionnaire was 13 min
220 (IQR 9 – 18 minutes). Of the 129 individuals excluded from analysis, 19 did not progress in
221 the questionnaire after providing consent to participate, three did not own or provide care
222 for any horses, and two had horses located outside of the UK. A further 105 individuals were
223 excluded due to non-response on the questions about awareness and perceived risk of
224 exotic diseases. There were no significant differences in age ($p = 0.17$), education ($p = 0.41$),
225 role ($p = 1.0$), geographic location ($p = 0.31$), or equestrian discipline ($p = 0.71$) between
226 participants who were included in the study and those who were excluded. However, there
227 was a difference in length of horse experience between participants who were included in
228 the study and those who were excluded ($p = 0.01$). A higher proportion of excluded
229 responses were from individuals with 10 or fewer years of horse experience ($n = 21, 20.8%$)
230 compared to those who were included in the analysis ($n = 43, 10.8%$).

231

232 **Participant demographics**

233 Most participants identified as female (98.0%, 389/397) and were under 54 years old
234 (74.9%, 296/395). Eighty-nine percent of participants (356/399) had over 10 years of
235 experience working with horses, and 66.5% of participants (268/403) had received specific

236 training on horse care or management. Types of training undertaken by horse owners
237 included courses offered by businesses and/or organisations within the equine industry
238 (81.0%, 217/268), courses at equine colleges (23.1%, 62/268), and equine-specific training
239 at the university-level (13.4%, 36/268). Participants reported owning or providing care for a
240 median of 2 horses (IQR 1 – 4) at the time of the questionnaire. Eighty-eight percent of
241 participants (354/402) were horse owners, while 11.9% (48/402) were equine professionals
242 (e.g. managers, breeders, trainers, grooms, and veterinary surgeons). Most participants did
243 not receive any income from their involvement with horses (76.7%, 309/403). Participants
244 kept their horses at premises distributed throughout the UK (Figure 1). Most participants
245 (68.2%, 275/403) kept their horse(s) for leisure activities, such as pleasure riding (hacking)
246 or companionship, while 26.6% of participants (107/403) kept their horse(s) for competition
247 activities. Other activities for which participants kept their horse(s) included breeding,
248 carriage driving, education/training purposes, and breed-specific activities (5.21%, 21/403).

249

250 **Content analysis**

251 Ninety-three percent of participants (376/403) responded to the open-ended
252 question regarding perceived clinical signs and symptoms thought to be associated with
253 exotic diseases. The most frequently mentioned clinical signs and symptoms included high
254 temperature (215/376, 57.2%), discharge (175/376, 46.5%), lack of energy (155/376, 41.2%)
255 and loss of appetite (94/376, 25.0%). Fourteen percent of participants (53/376) mentioned
256 that these clinical signs and symptoms were not specific to exotic diseases, as many could
257 also be caused by non-exotic diseases. In addition, 12.7% of participants (48/376) indicated
258 that they would be more inclined to consider an exotic disease in certain circumstances; for
259 instance, if their horse had been in contact with unknown horses or if the clinical signs and

260 symptoms had a rapid onset. Twelve percent of participants (46/376) mentioned they
261 would not assume that any clinical signs or symptoms indicated an exotic disease and would
262 instead rely on their veterinary surgeon to make that distinction.

263

264 **Exploratory factor analysis**

265 Fourteen variables regarding perceived risk were subjected to EFA; however, one
266 variable regarding likelihood of risk compared to others was excluded from analysis because
267 it did not load significantly onto any component. The 13 variables included in the final EFA
268 resulted in a three-component solution explaining 54.7% of the cumulative variance (Table
269 1). Component 1 explained 21.2% of the cumulative variance and included six items related
270 to the *perceived likelihood of being affected by an exotic disease*. Component 2 explained
271 14.1% of the variance and included four items related to the *perceived control over*
272 *preventing exotic diseases*. Lastly, component 3 explained 19.5% of the variance and
273 included three items related to the *emotional response to exotic diseases*.

274

275 **Hierarchical cluster analysis**

276 Hierarchical cluster analysis based on variables regarding exotic disease awareness
277 and perceptions resulted in three clusters of participants: 78 (19.4% of the sample) were
278 included in cluster 1, 111 (27.5%) were included in cluster 2, and 214 (53.1%) were included
279 in cluster 3. Clusters were similar in terms of the number and type of exotic diseases
280 identified. Participants in all clusters identified a median of 3 (IQR 2 – 4) exotic diseases,
281 with the most recognised exotic diseases being AHS and WNV (Figure 2). However, clusters
282 differed in terms of their previous information-seeking behaviour, awareness of outbreaks
283 outside of the UK, and their perceived risk of exotic diseases.

284 Cluster 1 was characterised by participants who were aware of exotic diseases and
285 perceived a high amount of risk. This cluster contained the highest proportion of
286 participants who had previously sought information on exotic diseases (46/78, 59.0%). Of
287 the participants who had previously sought information, most had identified their own
288 internet searches as their information source (39/46, 84.8%). Furthermore, a lower
289 proportion of participants in cluster 1 had sought information from the government (8/46,
290 17.4%, $p = 0.007$) or their veterinary surgeon (19/46, 41.3%, $p = 0.002$) compared to the
291 other clusters. Half of participants in cluster 1 (39/78, 50.0%) had heard of an outbreak
292 outside of the UK within the past 12 months. When asked to describe these outbreaks,
293 participants focused on outbreaks of strangles (*Streptococcus equi* subspecies *equi*
294 infection), equine herpesvirus, and EIA across Europe, Africa, and the United States of
295 America (USA). Participants in cluster 1 perceived a higher likelihood of being affected by an
296 exotic disease but they perceived a lower degree of control over preventing exotic diseases
297 (Figure 3). In addition, participants in cluster 1 scored highly on the emotional response
298 component, indicating that they felt fearful, worried, or anxious when they thought about
299 exotic diseases.

300 Cluster 2 was characterised by participants who were aware of exotic diseases but
301 did not perceive a high amount of risk. Compared to cluster 1, a similar proportion of
302 participants in cluster 2 had previously sought information on exotic diseases (52/111,
303 46.8%, $p = 0.14$) and had been aware of an outbreak outside of the UK within the past 12
304 months (56/111, 50.5%, $p = 1.0$). Of the participants who had previously sought information,
305 most had identified their own internet searches (38/52, 73.1%) or their veterinary surgeon
306 (34/52, 65.3%) as their information source. Similar to those in cluster 1, participants in
307 cluster 2 who had heard of an outbreak outside of the UK also named strangles, equine

308 herpesvirus, and EIA outbreaks across Europe and North America. While participants in
309 clusters 1 and 2 were similar in regard to their awareness of exotic diseases, they differed
310 considerably among certain components of perceived risk (Figure 3). Participants in cluster 2
311 estimated a similar likelihood of being affected by an exotic disease ($p = 0.4$), but they
312 perceived a higher degree of control over preventing exotic diseases ($p < 0.001$) and
313 reported a lower emotional response to exotic diseases ($p < 0.001$).

314 Cluster 3 was characterised by participants who were less aware of exotic diseases
315 and did not perceive a high amount of risk. Compared to clusters 1 and 2, a lower
316 proportion of participants in cluster 3 had previously sought information on exotic diseases
317 (66/214, 30.8%, $p < 0.001$). However, similar to those in the other clusters, participants in
318 cluster 3 who had previously sought information also identified their own internet searches
319 as their information source (47/66, 71.2%). A lower proportion of participants in cluster 3
320 had been aware of an outbreak outside of the UK within the past 12 months (85/214,
321 39.7%), although this difference was not statistically significant ($p = 0.10$). Participants that
322 had been aware of an outbreak outside of the UK within the past 12 months named
323 outbreaks similar to those identified by participants in clusters 1 and 2. Compared to the
324 other clusters, participants in cluster 3 perceived a lower likelihood of being affected by an
325 exotic disease ($p < 0.001$), a lower degree of control over preventing exotic diseases ($p <$
326 0.001), and a lower emotional response to exotic diseases ($p < 0.001$).

327

328 **Demographic characteristics among clusters**

329 Clusters were similar in terms of their participant demographics (Table 2) and
330 premises characteristics (Table 3). Cluster 1 contained the highest proportion of participants
331 who were unsure of whether horses at their premises moved internationally (12/78, 17.9%,

332 $p = 0.01$) (Table 3). Participants in cluster 1 indicated that resident horses travelled to
333 various European countries within the past year, while participants in clusters 2 and 3
334 indicated a wider geographic range of travel, including countries in Europe, North America,
335 and South East Asia. Furthermore, cluster 2 contained the highest proportion of participants
336 who competed at the national/international level (20/33, 60.1%), while cluster 3 contained
337 the highest proportion of participants who competed at the local/regional level (26/33,
338 78.8%) ($p = 0.006$). Although a distinction between the terms was not provided in the
339 questionnaire, a higher proportion of participants in all three clusters reported that they
340 were often or always responsible for hygiene (224/401, 55.9%) compared to biosecurity
341 (172/399, 43.1%) on their premises ($p < 0.001$) (Table 3).

342

343 **Discussion**

344 In this study, we described awareness and perceived risk of equine exotic diseases in
345 a sample of UK horse owners. Most horse owners could identify that diseases such as AHS
346 and WNV were considered exotic in the UK. Horse owners expected exotic diseases to have
347 non-specific clinical signs and symptoms, with many noting that they would only consider an
348 exotic disease in certain circumstances or if it was suggested by their veterinary surgeon.
349 Horse owners grouped into three clusters distinguished by differing levels of awareness and
350 perceived risk of exotic diseases. Participants among the clusters were most different in
351 terms of their perceived risk of exotic diseases, highlighting important implications for
352 exotic disease preparedness.

353 The large proportion of participants who identified numerous exotic diseases
354 suggests that horse owners are able to determine which diseases are not currently present

355 in the UK. Participants' ability to identify these diseases as exotic might be influenced by
356 recent media coverage of the risk of AHS in the UK, in addition to current outbreaks of WNV
357 and EIA in Europe (Roberts, 2017; Sansom et al., 2018). One limitation of this assessment is
358 that the names of the diseases were provided in a list rather than allowing participants to
359 name an exotic disease in an open-ended question. Terms like 'African' and 'West Nile',
360 which name an overseas location, contain inherent clues compared to other options such as
361 EIA or glanders. Therefore, the proportion of participants who recognised these diseases as
362 being exotic likely overestimates the true proportion of participants who could have named
363 an exotic disease without being prompted.

364 While the current study focused on understanding horse owners' awareness of the
365 concept of exotic diseases, the findings are complemented by other research on the
366 knowledge of specific diseases of interest. In a survey of UK horse owners' knowledge of
367 equine arboviruses, only a few horse owners could correctly identify the transmission
368 mechanism of AHS or WNV (Chapman et al., 2018). Furthermore, many horse owners were
369 unaware of the likely consequences of an AHS or WNV outbreak in the UK, such as whether
370 the disease could spread across the UK or if a movement ban would be implemented
371 (Chapman et al., 2018). While our findings suggest that horse owners are aware that AHS,
372 WNV, and EIA are not currently found in the UK, further communication efforts are likely
373 required to provide horse owners with appropriate information about these diseases.

374 Although participants were similar in terms of their awareness of exotic diseases,
375 they differed in their previous information-seeking behaviour. In Australia, horse owners
376 who had previously sought information on disease control measures had perceived a higher
377 level of vulnerability to an equine influenza outbreak (Schemann et al., 2013). The
378 association between information-seeking and perceived vulnerability aligns with our

379 findings, as a higher proportion of participants who previously sought information on exotic
380 diseases were in the high perceived risk cluster. Most horse owners who had previously
381 sought information on exotic diseases relied on their own internet searches rather than
382 information provided by their veterinary surgeon. However, previous studies have found
383 that horse owners might be more inclined to seek advice from their veterinary surgeon
384 during an outbreak rather than at the preparedness stage (Schemann et al., 2012). Research
385 among pig producers demonstrated a lack of desire to directly seek scientific information on
386 biosecurity, with most producers relying on information provided by their veterinarian or
387 the press (Alarcon et al., 2014). Additional research is required to determine which online
388 sources horse owners are using to receive information about exotic diseases and guidance
389 may be required to ensure that they are evidence-based.

390 When asked about the clinical signs or symptoms that might indicate an exotic
391 disease, the majority of horse owners mentioned non-specific signs such as high
392 temperature, discharge, and a lack of energy. This finding demonstrates that horse owners
393 are aware that many exotic diseases exhibit non-specific clinical signs and have differential
394 diagnoses that include endemic diseases (Duggan, 2008; Copas, 2013). While some horse
395 owners provided specific clinical signs of certain exotic diseases, such as neurological signs
396 and facial swelling, many noted that the expected clinical signs would depend on the
397 disease. Furthermore, some horse owners mentioned a reliance on their veterinary surgeon
398 to distinguish between an endemic and an exotic disease, highlighting the importance of
399 veterinary surgeons having up-to-date clinical knowledge of exotic diseases. Stakeholders
400 within other agricultural industries have reported that lacking knowledge of clinical signs of
401 exotic diseases was a barrier to reporting their suspicions to authorities (Elbers et al., 2010;
402 Delgado et al., 2014; Guinat et al., 2016). Thus, ensuring that horse owners and veterinary

403 surgeons can identify clinical signs of exotic diseases is an important component of early
404 detection. Although horse owners may be aware of the clinical signs of exotic disease,
405 endemic diseases are likely to be higher on an owner's list of differential diagnoses.
406 Prioritisation of endemic diseases by horse owners may delay time until reporting, a
407 phenomenon that has already been identified in other agricultural industries (Bronner et al.,
408 2014; Guinat et al., 2016).

409 While horse owners were highly variable in terms of their awareness of exotic
410 diseases, most did not perceive them to be a risk to their horse. Horse owners that
411 perceived their horse could be affected by an exotic disease differed in regard to their
412 perceived control over preventing exotic diseases and their degree of emotional response
413 towards these diseases. Horse owners with high levels of emotional response also perceived
414 less control over preventing exotic diseases. A perceived lack of control has been previously
415 associated with higher feelings of vulnerability to a future equine influenza outbreak in
416 Australia (Schemann et al., 2013). Models of risk perception suggest that emotional risk
417 judgements play an important role in deciding to engage in preventive health behaviours
418 and may be a better predictor of behavioural intentions compared to an individual's actual
419 risk of a threat (Sjoberg, 1998; Loewenstein et al., 2001; Ferrer and Klein, 2016). An
420 increased sense of risk and a low expected success in dealing with an exotic disease
421 outbreak might invoke a sense of 'helplessness' (van der Pligt, 1998), leading to a reduced
422 likelihood of implementing disease control measures (O'Kane et al., 2017). Additional
423 research is required to explore how horse owners evaluate their risk of exotic diseases, and
424 whether this impacts their implementation of biosecurity practices.

425 It is important to note that the largest cluster of horse owners perceived a lack of
426 control over preventing exotic diseases but did not feel that their horse would be affected.

427 One possible explanation is a lack of awareness of what is involved in preventing exotic
428 diseases or the ways in which they could affect a participant's horse (Chapman et al., 2018).
429 In addition, discrepancies in numbers of horse owners indicating they were responsible for
430 hygiene compared to biosecurity suggests a perception that the terms imply different
431 actions. Previously held beliefs towards actions recommended to prevent disease can
432 influence whether individuals intend to engage in preventive measures (Sok et al., 2016,
433 2018). Given the importance of socio-cognitive factors such as attitudes, perceptions, and
434 beliefs, additional research is necessary to determine how these factors might influence
435 horse owners' intention to engage in exotic disease preparedness. While these findings may
436 have limited generalisability due to non-random sampling, increasing awareness of exotic
437 diseases may still be beneficial. In Australia, horse owners who were aware of Hendra virus
438 and perceived some level of risk were more likely to engage in preventive health behaviours
439 (Kung et al., 2013; Manyweathers et al., 2017; Wiethoelter et al., 2017b). Although
440 providing information on exotic disease risk may not be sufficient to influence behavioural
441 change on its own (van der Pligt, 1996), the development of an effective strategy to
442 communicate information on exotic diseases should contribute to exotic disease
443 preparedness.

444

445 **Conclusions**

446 This study highlights important considerations for equine exotic disease
447 preparedness in the United Kingdom. Socio-psychological factors, such as disease awareness
448 and perceived risk, can influence horse owners' willingness to implement disease
449 prevention and control practices. While there was a varying degree of exotic disease

450 awareness among horse owners, most did not perceive exotic disease to be a risk to their
451 own horse(s). Therefore, efforts to encourage exotic disease preparedness should focus on
452 communicating the risks and relevance of exotic diseases to horse owners. Future research
453 should explore the relationship between awareness and perceived risk of exotic diseases
454 and the uptake of biosecurity practices.

455

456 **Acknowledgements**

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459 assisted with participant recruitment.

460

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615 **Table 1.** Questionnaire items regarding perceived risk of exotic diseases that loaded highly
 616 (≥ 0.4) on three rotated principal components identified in the exploratory factor analysis.
 617 Statements were provided to horse owners during a cross-sectional study of awareness and
 618 perceived risk of exotic diseases in the United Kingdom.

Item	Component loadings		
	1	2	3
I feel that the chance of my horse getting an exotic disease during his/her lifetime is small ^{1,2}	0.691		
I feel that my horse is vulnerable to exotic diseases ²	0.747		
When I think about an exotic disease outbreak, my first reaction is that it could affect my horse someday ²	0.461		
I am confident that my horse will not get an exotic disease ^{1,2}	0.752		
In your opinion, how likely is it that an exotic disease outbreak will occur in the UK within the next 5 years? ³	0.594		
In your opinion, how likely is it that your horse(s) will get an exotic disease within the next 5 years? ³	0.744		
The government is responsible for preventing exotic diseases in horses ²		0.548	
I am responsible for taking measures to prevent exotic diseases in horses ²		0.801	
There are a lot of things I can do to reduce my horse's risk of getting an exotic disease ²		0.808	
There isn't much anyone can do to control whether an equine exotic disease enters the UK ^{1,2}		0.451	
When you think about exotic diseases, to what extent do you feel worried (i.e. they occupy your mind in a negative way)? ⁴			0.865
When you think about exotic diseases, to what extent do you feel fearful (i.e. afraid of them)? ⁴			0.930
When you think about exotic diseases, to what extent do you feel anxious (i.e. dreading the inevitable)? ⁴			0.899

619 ¹Reverse scored Likert scale.
 620 ²5-point scale (strongly disagree – strongly agree).
 621 ³5-point scale (extremely unlikely – extremely likely).
 622 ⁴5-point scale (not at all – extremely).
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629 **Table 2.** The number (percentage) of horse owners within categories for variables regarding
 630 demographics, based on responses to a cross-sectional study on awareness and perceived
 631 risk of exotic diseases in the United Kingdom. Clusters of participants were identified using
 632 hierarchical cluster analysis.

Variable	Cluster 1 (n = 78)	Cluster 2 (n = 111)	Cluster 3 (n = 214)
Age			
18 – 34	28 (35.9)	31 (27.9)	64 (29.9)
35 – 54	33 (42.3)	46 (41.4)	94 (43.9)
>54	15 (19.2)	33 (29.7)	51 (23.8)
Gender			
Female	75 (96.2)	107 (96.4)	207 (96.7)
Male	2 (2.56)	3 (2.70)	3 (1.40)
Education			
O-levels	13 (16.7)	10 (9.01)	30 (14.0)
A-levels	24 (30.8)	34 (30.6)	67 (31.3)
Undergraduate degree	19 (24.4)	41 (36.9)	72 (33.6)
Postgraduate degree	17 (21.8)	23 (20.7)	37 (17.3)
Role			
Owner	64 (82.1)	97 (87.4)	193 (90.2)
Professional	13 (16.7)	14 (12.6)	21 (9.81)
Income generated from involvement with horses			
None	63 (80.8)	88 (79.3)	158 (73.8)
Partial source	3 (3.85)	11 (9.91)	20 (9.35)
Main source	12 (15.4)	12 (10.8)	36 (16.8)
Length of horse experience			
≤ 10 years	11 (14.1)	7 (6.31)	25 (11.7)
> 10 years	65 (83.3)	104 (93.7)	187 (87.4)
Main horse activities			
Leisure	52 (66.7)	69 (62.2)	154 (72.0)
Competition	20 (25.6)	37 (33.3)	50 (23.4)
Other	6 (7.69)	5 (4.50)	10 (4.67)
Highest level of competition*			
Local / regional	9 (50.0)	13 (39.4)	26 (78.8)
National / international	9 (50.0)	20 (60.1)	7 (21.2)
Received training on horse management	53 (67.9)	83 (74.8)	132 (61.7)

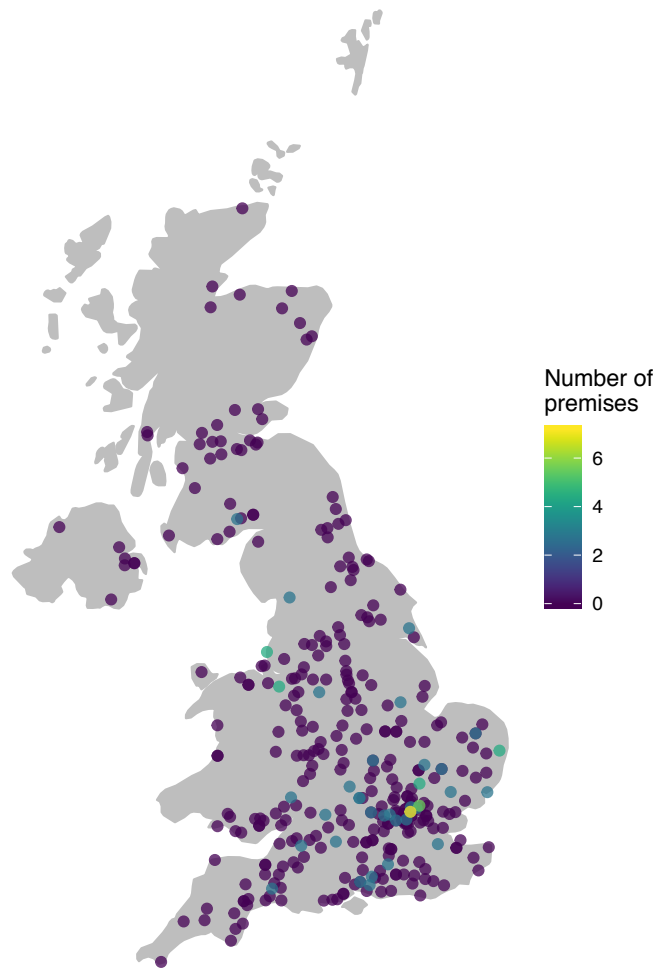
633 *Chi-square *p* value < 0.05

634

635 **Table 3.** The number (percentage) of horse owners within categories for variables regarding
636 premises characteristics, based on responses to a cross-sectional study on awareness and
637 perceived risk of exotic diseases in the United Kingdom. Clusters of participants were
638 identified using hierarchical cluster analysis.

Variable	Cluster 1 (n = 78)	Cluster 2 (n = 111)	Cluster 3 (n = 214)
Premises location			
England	64 (82.1)	90 (81.1)	176 (82.2)
Scotland	8 (10.3)	12 (10.8)	17 (7.94)
Wales	2 (2.56)	5 (4.50)	13 (6.07)
Northern Ireland	3 (3.85)	0 (0)	4 (1.87)
Premises type			
Commercial	43 (55.1)	54 (48.6)	106 (49.5)
Private (shared)	13 (16.7)	23 (20.7)	38 (17.8)
Private (not shared)	22 (28.2)	34 (30.6)	67 (31.3)
Resident horses move on/off premises	67 (85.9)	99 (89.2)	191 (89.3)
Resident horses move internationally*			
Yes	7 (10.4)	10 (10.1)	22 (11.5)
No	48 (71.6)	82 (82.3)	161 (84.3)
Don't know	12 (17.9)	7 (7.07)	8 (4.19)
Case of infectious disease on premises in past 12 months	4 (5.13)	8 (7.21)	21 (9.81)
Aware of outbreak in area near premises in past 12 months	50 (64.1)	71 (64.0)	126 (58.9)
Responsible for biosecurity on premises			
Not applicable	12 (15.4)	14 (12.6)	18 (8.41)
Never/rarely	26 (33.3)	35 (31.5)	72 (33.6)
Sometimes	7 (8.97)	10 (9.01)	33 (15.4)
Often/always	32 (41.0)	50 (45.0)	90 (42.1)
Responsible for hygiene on premises			
Not applicable	6 (7.69)	7 (6.31)	10 (4.67)
Never/rarely	18 (23.1)	28 (25.2)	59 (27.6)
Sometimes	10 (12.8)	10 (9.01)	29 (13.6)
Often/always	44 (56.4)	65 (58.6)	115 (53.7)

639 *Chi-square p value < 0.05



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641 **Figure 1.** Location of the premises in the United Kingdom where participants of a cross-
642 sectional study on awareness and perceived risk of exotic diseases kept their horse(s). Point
643 colour represents the cumulative number of premises within that postcode area.

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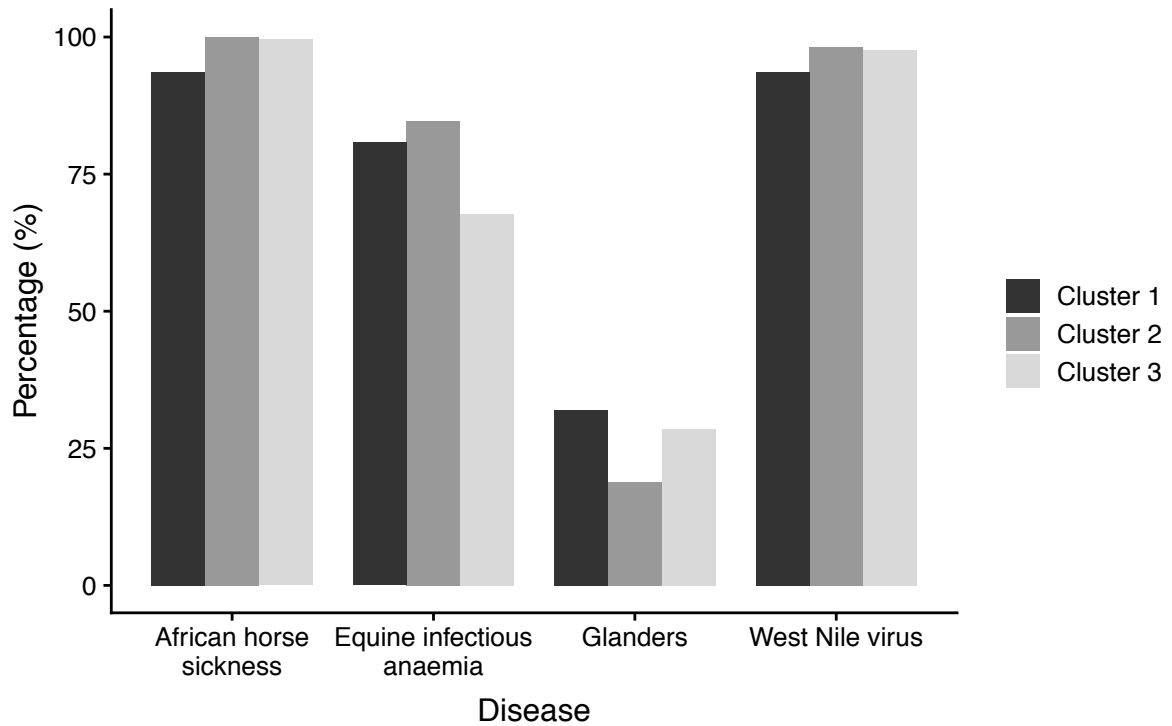
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652 **Figure 2.** Percentage of participants (n = 403) from a cross-sectional study on awareness and
 653 perceived risk of exotic diseases that identified each disease as being exotic to the United
 654 Kingdom, stratified by clusters identified during hierarchical cluster analysis.

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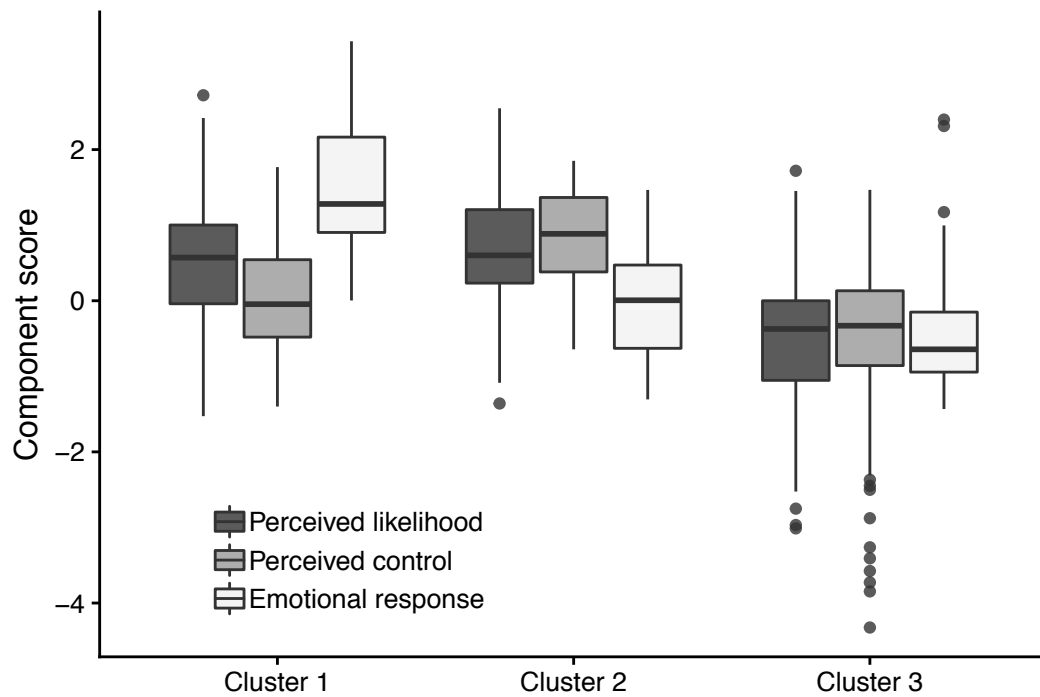
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667 **Figure 3.** Distribution of component scores representing risk perceptions within clusters of
 668 participants from a cross-sectional study on awareness and perceived risk of exotic diseases
 669 in the United Kingdom. The bottom and top of each box represent the 25th and 75th
 670 percentiles, respectively, and the horizontal line within the box represents the median.