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

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Abstract

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

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

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

Introduction

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

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

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

Materials and methods

Study population

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

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

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

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

Descriptive analysis

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

Content analysis

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

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

Exploratory factor analysis

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

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

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

Hierarchical cluster analysis

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

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

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

Results

Questionnaire response

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

Participant demographics

Most participants identified as female (98.0%, 389/397) and were under 54 years old (74.9%, 296/395). Eighty-nine percent of participants (356/399) had over 10 years of 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

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

Exploratory factor analysis

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

Hierarchical cluster analysis

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

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

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

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

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

Demographic characteristics among clusters

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

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

Discussion

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

The large proportion of participants who identified numerous exotic diseases 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

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

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

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

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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.

	Component loadings		
Item	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 [1]Reverse scored Likert scale.
620 [2]5-point scale (strongly disagree – strongly agree).
621 [3]5-point scale (extremely unlikely – extremely likely).
622 [4]5-point scale (not at all – extremely).
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Table 2. The number (percentage) of horse owners within categories for variables regarding demographics, based on responses to a cross-sectional study on awareness and perceived risk of exotic diseases in the United Kingdom. Clusters of participants were identified using hierarchical cluster analysis.

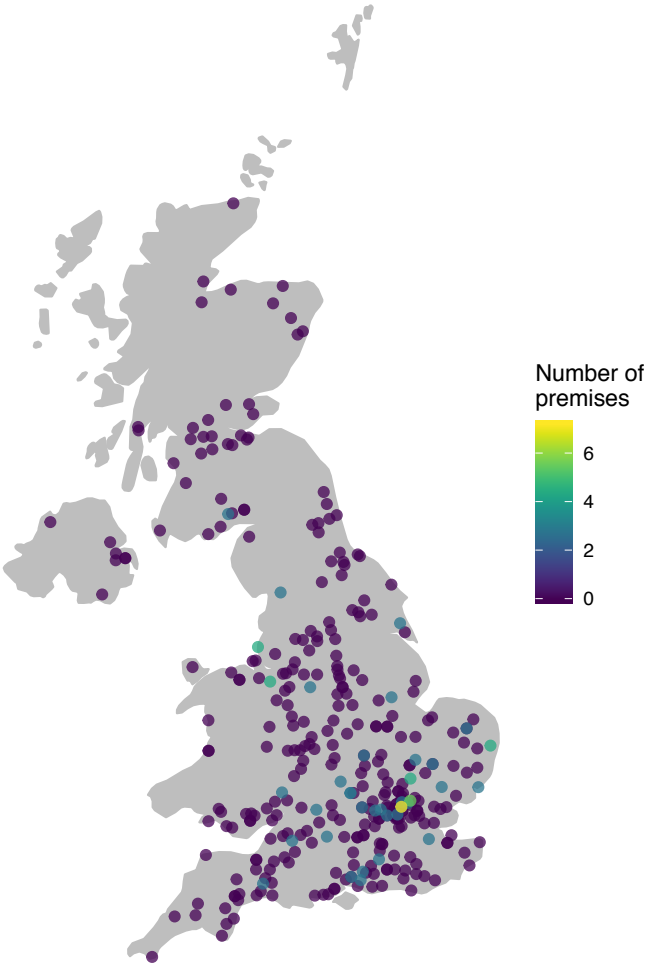
Variable	Cluster 1 (n = 78)	Cluster 2 (n = 111)	Cluster 3 (n = 214)
Age			
18 – 34	28 (35.9)	31 (27.9)	64 (29.9)
35 – 54	33 (42.3)	46 (41.4)	94 (43.9)
>54	15 (19.2)	33 (29.7)	51 (23.8)
Gender			
Female	75 (96.2)	107 (96.4)	207 (96.7)
Male	2 (2.56)	3 (2.70)	3 (1.40)
Education			
O-levels	13 (16.7)	10 (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			
$\leq$ 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)

*Chi-square p value < 0.05

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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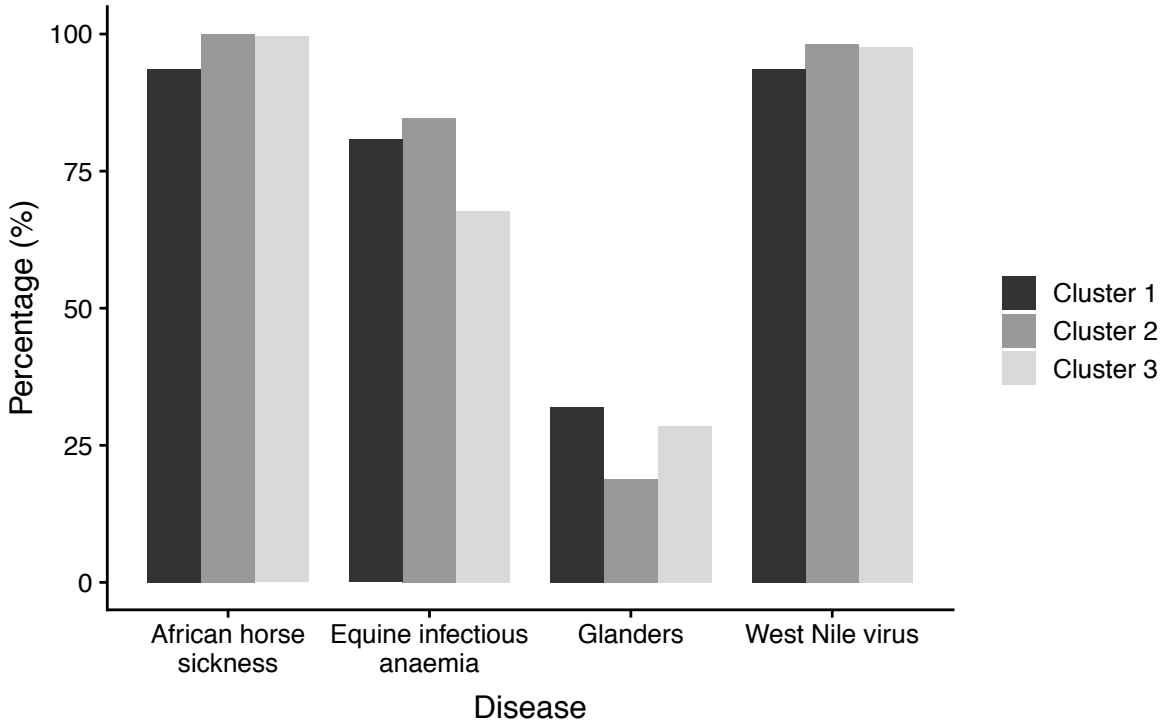

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652 **Figure 2**. Percentage of participants (n = 403) from a cross-sectional study on awareness and

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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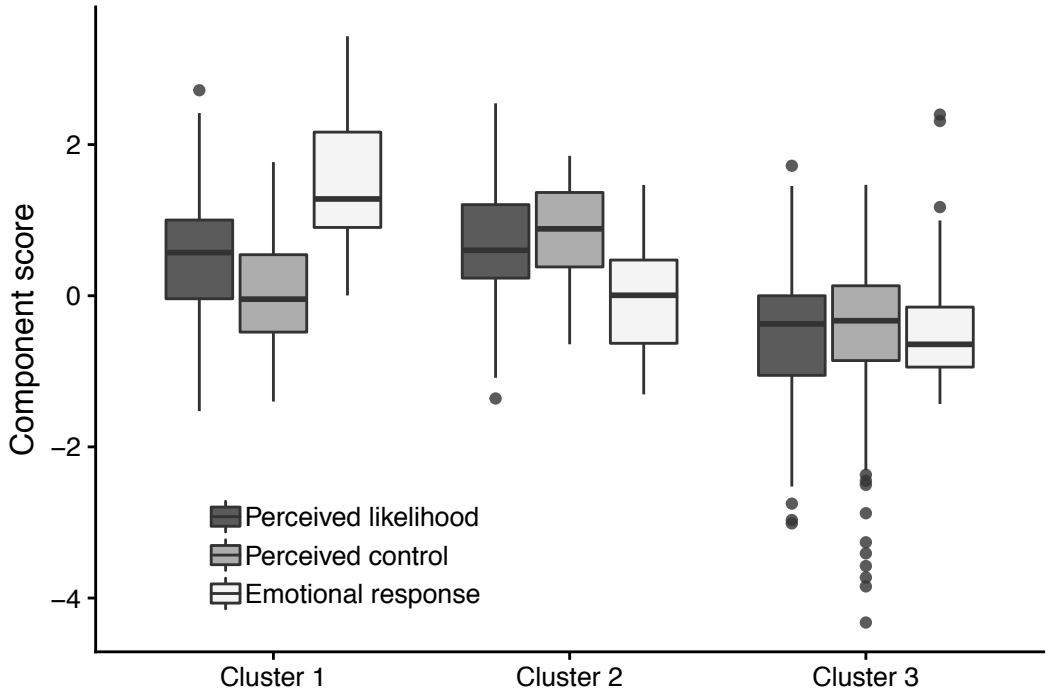

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667 **Figure 3.** Distribution of component scores representing risk perceptions within clusters of

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.