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Vet Record

ORIGINAL RESEARCH

Surveillance of strangles in UK horses between 2015 and 2019 based on laboratory detection of *Streptococcus equi*

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Abstract

Background: Previously national surveillance data for monitoring strangles (*Streptococcus equi* infection) in UK horses was limited. Improved awareness and knowledge of positive diagnoses would permit the optimisation of biosecurity protocols, decreasing the prevalence of strangles.

Methods: Seven UK laboratories reported positive strangles diagnoses between 1 January 2015 and 31 December 2019 based on identifying *Streptococcus equi* via agent detection assays from field-based practitioner-submitted samples. Associated clinical history and animal signalment were collected where provided, and descriptive analysis undertaken.

Results: Within the study period, 1617 laboratory-confirmed diagnoses occurred from samples submitted by 315 veterinary practices. Of these, 51.6% were swabs and 44.0% guttural pouch lavages. Diagnoses were primarily based on qPCR alone (59.6%), qPCR and culture (35.8%), or culture alone (4.6%). A total of 1791 clinical signs were reported for 713 diagnoses, where nasal discharge (31.3%) and pyrexia (20.5%) were most frequently reported. Regions with the highest number of diagnoses included North Yorkshire (n = 75, 4.6%), Staffordshire (n = 71, 4.4%) and West Sussex (North East) (n = 63, 3.9%).

Conclusion: This study presents important insights into the diagnosis and clinical features of strangles in UK horses, even though limited and/or missing clinical history and signalment on laboratory submission forms restricts the completeness of the data.

KEYWORDS
strangles, *Streptococcus equi*, surveillance

1 | INTRODUCTION

First reported approximately 750 years ago,[1] strangles, a highly infectious disease caused by *Streptococcus equi* subspecies *equi* (*S. equi*), remains a persistent problem of horses worldwide. With high morbidity rates, strangles affects horses of all ages and can present severely in naïve horses.[2] The spread of the infection can occur through direct horse-to-horse contact, or indirectly via the transfer of infectious material through fomites.[3,4] Recovery typically takes 4–6 weeks; however field studies have concluded that within an outbreak a proportion of affected horses will fail to clear the infection completely and still persistently harbour *S. equi* in their guttural pouches whilst appearing to have recovered.[5,6] Data from the Defra/Animal Health Trust (AHT)/British Equine Veterinary Association (BEVA) Equine Quarterly Disease Surveillance Reports have been used to estimate there are approximately 600 outbreaks of strangles identified in the United Kingdom (UK) annually,[7] although precise figures remain unknown without a dedicated surveillance initiative.

Disease surveillance is an important tool for ensuring equine health and welfare globally. Through monitoring reports and disease diagnoses, measures

can be taken to identify emerging or changing threats, enabling the implementation of appropriate precautions at local, national and international levels, preventing further disease spread. Through an expanding network of diagnostic laboratories, the Surveillance of Equine Strangles (SES) project, initiated in 2018, investigates where in the UK strangles is occurring through laboratory confirmation of *S. equi* infections based on agent detection assays. Through collating epidemiological information relating to strangles diagnoses, SES aims to better quantify the occurrence of strangles within the UK and examine how veterinary surgeons are approaching disease diagnosis.[8] By reviewing and summarising laboratory diagnoses of strangles and accompanying epidemiological data, veterinary surgeons, yard and horse owners can stay vigilant to the threat of strangles and implement measures to reduce the spread of disease.

This study aimed to describe epidemiological data gathered from laboratory-confirmed diagnoses of strangles based on the detection of *S. equi* across the United Kingdom for the 5 years between January 2015 and December 2019.

2 | MATERIALS AND METHODS

This cross-sectional surveillance study was both retrospective and prospective and collected data linked to field-based samples positive for *S. equi* that had been submitted by equine veterinary surgeons to seven UK diagnostic laboratories between 1 January 2015 and 31 December 2019. Full ethical approval was awarded from the AHT Clinical Research Ethics Committee (REF: 01–2017E) and the Royal Veterinary College's Clinical Research Ethical Review Board (URN 2020 1973-2).

2.1 | Diagnosis definition

A diagnosis refers to an individual horse (case) that has a laboratory result(s) confirming strangles infection based on the detection of *S. equi*. Where multiple samples from the same animal, either taken on the same date (different sample types) or on consecutive dates within a 3-month period, were confirmed as positive for *S. equi*, this counted as a single diagnosis.

Samples were diagnosed as positive for *S. equi* through either: combined bacterial culture and quantitative polymerase chain reaction (qPCR), qPCR alone, loop-mediated isothermal amplification (LAMP) alone or bacterial culture alone. The presence of *S. equi* in cultured samples was confirmed through morphological appearance of colonies and negative sugar fermentation of trehalose, sorbitol and lactose.[9]

2.2 | Surveillance methods

For field-based samples submitted between 1 January 2015 and 31 December 2017 (i.e. pre-SES), positive *S. equi* diagnoses were extracted from the AHT diagnostic microbiology laboratory's information management system (Autoscribe Matrix Gemini LIMS v. 5.3.16.1). For field-based samples submitted between 1 January 2018 and 31 December 2019 (i.e. within SES), positive *S. equi* diagnoses were reported by seven UK-based veterinary diagnostic laboratories participating in SES, including the AHT. Reporting was done via the online data collection platform Epicollect5.[10] Diagnostic laboratories recruited within SES were identified as actively reporting strangles diagnoses via the Defra/AHT/BEVA Equine Quarterly Disease Surveillance Reports and invited to join the SES project. Data were collated from the SES network throughout project development, meaning laboratories were recruited at different time points during the study (Table 1). Summary information regarding diagnostic methods and date of recruitment for each participating laboratory is available in Table 1.

2.3 | Data management

Data regarding positive samples were managed in a PostgreSQL (PostgreSQL Global Development Group – www.postgresql.org) database management system. Data included the type of samples taken, sampling date, diagnostic tests requested and veterinary practice information. Further data such as horse

TABLE 1 Summary information for seven UK diagnostic laboratories participating in the Surveillance of Equine Strangles (SES) project between 1 January 2015 and 31 December 2019 regarding recruitment date and diagnostic test information where available

SES Lab ID	Date recruited to SES	Diagnostic tests available	*S. equi* qPCR target gene(s)	Result interpretation
1	01/01/2018	qPCR & culture	*eqbE* and SEQ2190	Copy numbers
2	03/09/2018	qPCR & culture	*seeI*	CT[†] number
3	23/10/2018	qPCR & culture	*eqbE* and SEQ2190	CT number
4	31/05/2019	qPCR & culture	*eqbE*, SEQ2190 and *seeI*	CT number
5	31/05/2019	Culture only	–	CT number
6	10/06/2019	LAMP[‡] & culture	*Information unavailable*	CT number
7	18/06/2019	qPCR & culture	*eqbG*	CT number

[†]qPCR cycle threshold.
[‡]Loop-mediated isothermal amplification.

TABLE 2 Summary of descriptive data for total figures with 95% confidence intervals (CI) for sample details, diagnostic tests, horse signalment, reason for sampling and premises type reported from positive *S. equi* diagnoses made by seven UK diagnostic laboratories between 1 January 2015 and 31 December 2019

	n	%	95% CI
Total diagnoses	**1617**	**100%**	
Total positive samples[†]	2062		
Sample type information			
Guttural pouch lavage	909	44.1%	41.9–46.3
Tracheal lavage	13	0.6%	0.35–1.1
Other samples	75	3.6%	2.9–4.6
Chondroids	1	0.1%	0.002–0.3
DNA	1	0.1%	0.002–0.3
Swab (location listed below)	1063	51.6%	49.4–53.7
Nasopharyngeal	638	60.0%	57.0–62.9
Abscess material	150	14.1%	12.1–16.4
Nasal	121	11.4%	9.53–13.4
Unspecified on submission	109	10.2%	8.50–12.2
Other	45	4.2%	3.10–5.62
Diagnostic test determining diagnosis			
qPCR only	963	59.6%	57.1–62.0
qPCR and culture	579	35.0%	33.5–38.2
Culture only	74	4.6%	3.6–5.74
LAMP[‡]	1	0.1%	0.003–0.4
Reason for sampling reported	559	34.6%	32.2–36.9
Total reasons[§]	597		
Clinically ill horse	112	18.8%	15.8–22.2
Strangles specifically suspected	93	15.6%	12.8–18.8
Respiratory infection screen[¶]	71	11.9%	9.4–14.8
Seropositive strangles ELISA	51	8.5%	6.48–11.2
Post-infection screening	178	29.8%	26.2–33.7
Other	35	5.7%	4.03–7.95
Pre-/post-movement	23	3.9%	2.5–5.8
In contact	34	5.7%	4.0–7.9
Horse signalment			
Sex	1058	65.4%	63.1–67.8
Female	509	48.1%	45.1–51.2
Male	549	51.9%	48.8–54.9
Breed	926	57.3%	54.8–59.7
UK native pony	296	32.0%	29.0–35.1
UK native horse	178	19.2%	16.8–21.9
Sports horse	257	27.8%	24.9–30.8
Non-native horse	56	6.0%	4.6–7.8
Crossbreed	135	14.6%	12.4–17.1
Donkey	4	0.4%	0.1–1.2
Age	907	56.1%	53.6–58.5
Median		8 years	
Interquartile range (25th–75th)		5–12.5 years	
Range		1 month to 40 years	
Premises type	591	36.5%	34.2–38.9
Commercial	393	66.5%	62.5–70.3
Private	95	16.1%	13.3–19.3
Other	103	17.4%	14.5–20.8

[†]Can include multiple samples per diagnosis.
[‡]Loop-mediated isothermal amplification.
[§]Can include multiple reasons per diagnosis.
[¶][Equine influenza, *Streptococcus equi*, *Streptococcus zooepidemicus*, equine herpes virus (1 and 4) and equine rhinitis virus (A and B)] .

signalment, premises type, clinical signs observed and reason for sampling were extracted from laboratory sample submission forms where provided by the submitting veterinary surgeon, either through relevant checkboxes or hand-written notes.

2.4 | Data analysis

Descriptive outputs were compiled using R[11] through RStudio version 1.1.463.[12] Proportions were presented as percentages with 95% confidence intervals (95% CI). The continuous variable age was graphically assessed for normality and as it was not normally distributed, it was summarised by its median, range and interquartile range (IQR). Additional analysis was undertaken comparing sample types with the reason for sampling where only one of the three primary reasons for sampling was given for a diagnosis: clinical illness investigation, post-strangles infection screening, or further testing following a positive strangles iELISA serology result.

Choropleth maps were produced using submitting veterinary practice postcodes summarising the total number of positive strangles diagnoses, the total number of submitting veterinary practices and the mean number of laboratory-positive strangles diagnoses per submitting veterinary practice, all for each region of the United Kingdom. Maps were produced using QGIS (Version 3.4.12- Madeira) and regions of the United Kingdom were classified by Nomenclature of Territorial Units for Statistics Three, a geocode standard for referencing the subdivisions of countries for statistical purposes, with some minor amendments to include the Isle of Man and the Channel Islands.

3 | RESULTS

3.1 | Sample and diagnostic information

Descriptive information regarding sample types submitted and diagnostic procedures requested by submitting veterinary surgeons is summarised in Table 2. During the study period, there were 1617 laboratory diagnoses of *S. equi* recorded in the AHT and SES databases, with 536, 389, 177, 236 and 279 positive diagnoses made in each year between 2015 and 2019, respectively.

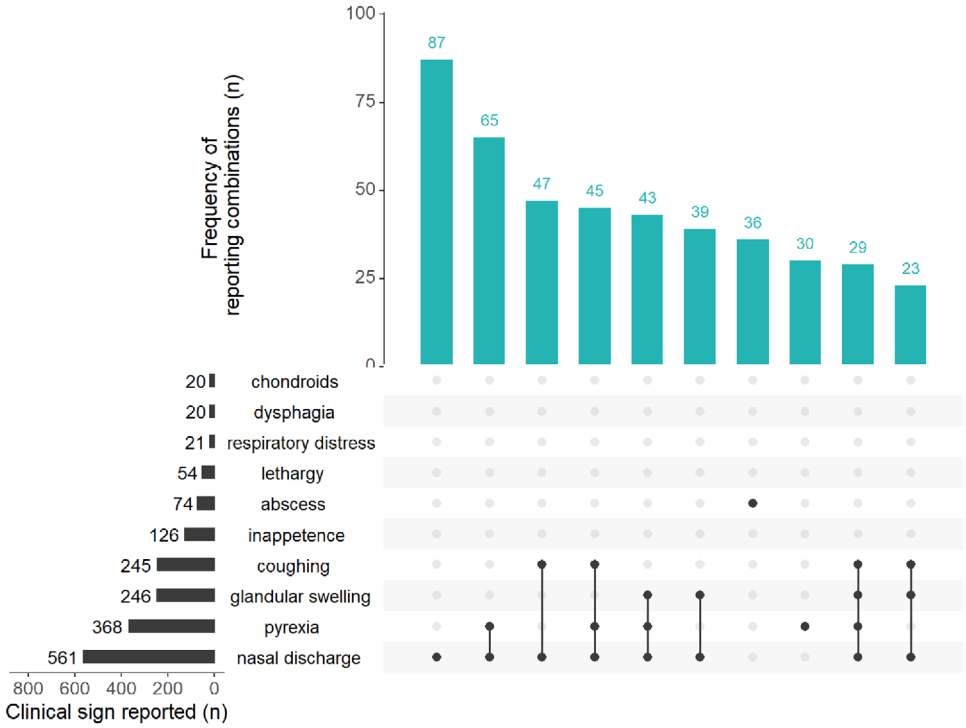

FIGURE 1 Veterinary-reported clinical signs from positive S. *equi* diagnoses made by seven UK diagnostic laboratories between 1 January 2015 and 31 December 2019, displayed as the 10 most frequently reported clinical signs across the data (left) and their frequency of reports in combination (top right), with the combination of clinical signs represented by the dots and lines on the bottom right

For the 1617 diagnoses, a total of 2062 samples were submitted which subsequently tested *S. equi* positive, with most samples comprised of either swabs (subcategorised into nasopharyngeal, nasal, abscess site, other or unspecified on the submission form) or guttural pouch lavages. Over half of diagnoses were made using qPCR alone; nearly all other samples were diagnosed by combined culture and qPCR testing. Diagnosis via culture alone was requested by veterinary surgeons in a small number of samples (Table 2).

When evaluating individual samples (not diagnoses) that were diagnosed based on requesting both qPCR and culture (n = 1348), 44.2% (n = 597, 95% CI 41.6, 46.9) were culture-negative and qPCR-positive and 55.7% (n = 751, 95% CI 53.0, 58.3) were culture-positive and qPCR-positive.

3.2 | Signalment and premises types

Descriptive information supplied by submitting veterinary surgeons regarding sex, breed, age and premises types is summarised in Table 2. Just under two-thirds of samples had sex information provided with an almost equal split between male and female horses. Breed type and age data were available for less than 60% of the diagnoses. Native UK pony types, sports horses and UK native horse types were the breeds most frequently diagnosed with strangles in the study period. Strangles was confirmed in horses ranging in age between 1 month and 40 years, with the median age of sampled horses being 8 years. Overall, less than 40% of premises types could be classified; of these, approximately two-thirds were classified as commercial with the remainder approximately evenly split between private premises and 'other'.

3.3 | Clinical signs

Figure 1 presents the most frequent veterinary-reported clinical signs, individually and in combination, where these were provided from positive strangles cases confirmed during the study period. A total of 1791 separate clinical signs were reported for 713 of the 1617 diagnoses (44.1%, 95% CI 41.6, 46.5). The most frequently reported clinical signs included nasal discharge (n = 561, 31.3%, 95% CI 29.2, 33.5), pyrexia ≥38.5°C (n = 368, 20.5%, 95% CI 18.7, 22.5), coughing (n = 245, 13.7%, 95% CI 12.1, 15.4) and glandular swelling (n = 246, 13.7%, 95% CI 12.2, 15.4). When considering combinations of clinical signs reported: nasal discharge reported alone was most common (n = 87), while combinations of 'nasal discharge and pyrexia' (n = 65), 'nasal discharge and coughing' (n = 47) and 'nasal discharge, pyrexia and coughing' (n = 45) were the three most commonly reported multiple clinical sign combinations.

3.4 | Reason for sampling

Just over one-third of all diagnoses had a reason for sampling provided (Table 2). The two most frequent

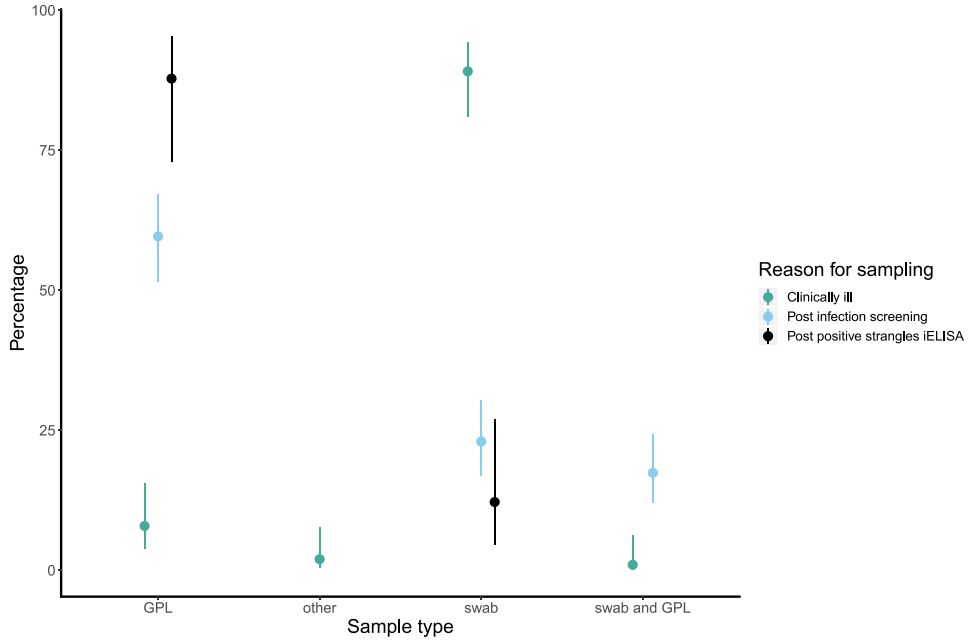

FIGURE 2 Comparing the three primary reasons for sampling and the type of sample taken (GPL=guttural pouch lavage), presented with 95% confidence intervals, from positive *S. equi* diagnoses made by seven UK diagnostic laboratories between 1st January 2015 and 31st December 2019 where diagnoses had just one reason for sampling provided (each totalling 100%)

reasons for sampling were post-strangles infection screening and sampling a clinically ill horse. When comparing the three primary reasons for sampling and the type of sample taken (Figure 2), the majority of clinically ill horses were sampled using swabs ($n = 90$, 89.1%, 95% CI 81.0, 94.2), whereas horses screened as part of post-strangles infection clearance or following positive iELISA serology results were predominantly sampled by guttural pouch lavage ($n = 96$, 59.6%, 95% CI 51.6, 67.2 and $n = 36$, 87.8%, 95% CI 73.0, 95.4, respectively).

3.5 | Spatial information

Samples were submitted from 315 veterinary practices across all four countries of the United Kingdom (Figure 3a), with 61.7% ($n = 103/167$) of UK regions having strangles diagnoses confirmed within the study period (Figure 3b). The mean of the mean number of diagnoses per submitting veterinary practice per region was 4.9 (SD ± 3.5), ranging from one diagnosis to 15 (Figure 3c).

4 | DISCUSSION

This is the first review of epidemiological data relating to laboratory-confirmed strangles diagnoses from field-based samples across the United Kingdom providing important insights into this endemic disease circulating amongst UK horses.

Swabs were the most common sampling method, of which over half were nasopharyngeal, while guttural pouch lavages were the second most common. Due to the pathogenesis of strangles, taking the recommended sample type for a particular stage and site of infection enhances the sensitivity and specificity of diagnostic testing, optimising the accuracy of diagnosis.[6,13] During acute presentation, nasopharyngeal swabs or aspirates from lymph node abscesses are optimal methods to confirm *S. equi* infection, whereas guttural pouch lavage is the most effective and efficient method to screen for *S. equi* carriers. It is also noted that more rostral nasal samples may be more likely to have environmental contaminants present, which may make confirmation more difficult where only bacterial culture is requested. When comparing reasons for sampling against the type of sample taken, it is encouraging to see that veterinary surgeons are largely applying these sampling recommendations.

Laboratory methods for diagnosing strangles have been refined and improved in the last decade. However, it is acknowledged that there is likely to be variation in diagnostic performance between the different qPCR and LAMP assays utilised by the laboratories in this project. As strangles is not recognised by the OIE there are no reference laboratories, no standardised molecular assays recommended for use and no system for inter-laboratory ring trials to compare their performance. This does mean that variation in performance between the qPCR assays currently being used is difficult to meaningfully assess.

Advances in molecular techniques such as qPCR provide rapid diagnostic tests with sensitivity and specificity in excess of 90%,[14] albeit qPCR can identify live and dead bacterial DNA, therefore added caution must be taken when interpreting low qPCR positive results. However, the rapidity of testing via

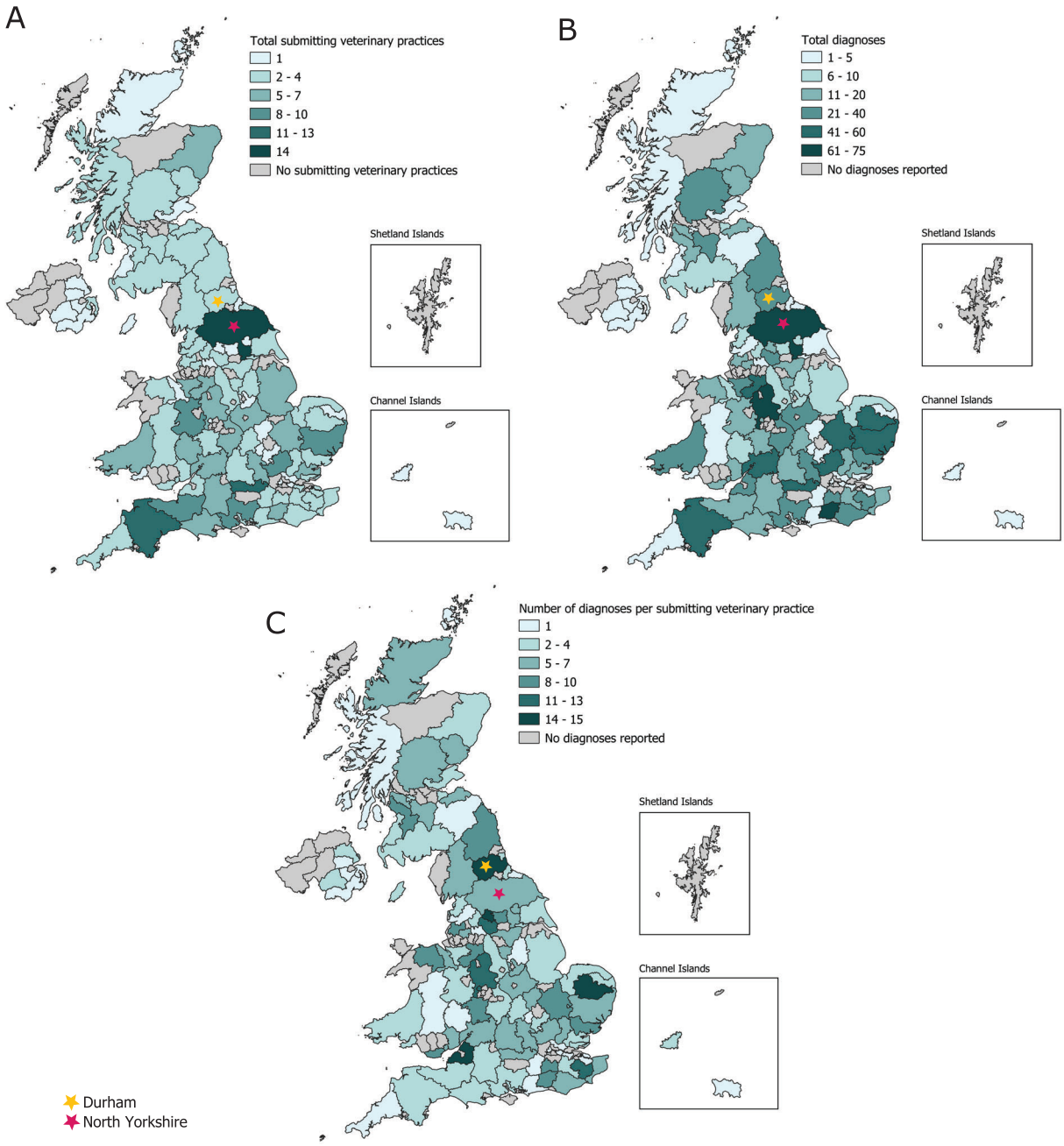

FIGURE 3 Mapping outputs for positive *S. equi* diagnoses made by seven UK diagnostic laboratories between 1st January 2015 and 31st December 2019, mapped using submitting vet practice location. Outputs are displayed as three different choropleth maps, each with a unique figure legend. **A.** Total number of submitting veterinary practices per region. **B.** Total number of positive diagnoses per region. **C.** Number of positive diagnoses per submitting practice per region (derived by dividing B over A). Darker coloured regions on the maps indicate higher numbers of either submitting veterinary practices (A), or diagnoses (B, C)

qPCR enables veterinary surgeons to relatively quickly and very accurately identify infected horses and prevent spread of disease through prompt isolation and appropriate management of these horses. Within the 5-year study period, over 95% of samples had qPCR confirmation of *S. equi* infection, and just under 5% were diagnosed using culture alone. Loop-mediated isothermal amplification (LAMP) assays for rapidly detecting *S. equi* gene targets seM[15] and eqbE[16] have only recently become commercially available in the United Kingdom and were only used to detect one case of strangles in this study. However, this number is expected to increase as and when LAMP is more widely requested by UK equine practitioners. Encouragingly, within the study period, the majority of veterinary surgeons requested *S. equi* confirmation through the use of sensitive and specific molecular detection laboratory methods.

Due to limited controls governing horse ownership and movement, the true number and location of UK horses remains poorly understood.[17] Studies have captured data through surveys, disease surveillance and consultation with sporting bodies, which offer knowledge towards the types of horses residing

in Great Britain.[18–22] The three breed types that were most frequently *S. equi* positive in our study were UK native pony types, UK native horse types and sport horses, which likely reflects their popularity within the UK equine population rather than an inherent increased susceptibility to strangles.[18–20]

The wide age range of horses diagnosed with strangles within the study period is consistent with that reported in a recent consensus statement.[4] Severity of infection varies between individuals but is probably also dependent on bacterial dose, immune status and age, with younger horses typically more severely affected than older horses which tend to show milder clinical signs and recover sooner.[2] Further data regarding the veterinary assessment of the clinical severity of these cases would have provided additional information into disease presentation among different ages of horses; however, such data are generally not requested of nor provided by veterinary surgeons on laboratory submission forms.

Classical description of the clinical presentation of strangles includes pyrexia, nasal discharge and swelling and/or abscessation of the submandibular and retropharyngeal lymph nodes, with reference to these signs made in 13th- and 17th-century literature.[1,23] The three most prevalent clinical signs reported in this study were consistent with this conventional presentation, although abscesses were less frequently reported. Analysing the combination in which clinical signs are reported together can offer an indication of the severity of infection occurring in the field. The combination 'nasal discharge, pyrexia and glandular swelling' was reported 43 times, whereas the less specific combination 'nasal discharge and pyrexia' was reported 65 times, and nasal discharge alone reported 87 times. A milder form of infection has been described in previous work as 'atypical strangles', in which horses develop transient fever and nasal discharge.[24] Our data indicate that the milder clinical signs of pyrexia and nasal discharge are observed alone and in combination more than the 'typical' classical presentation of glandular swelling and/or abscessation. This may suggest that owners are calling veterinary surgeons for clinical assessment in the earlier stages of infection prior to the development of abscesses and possible infection complications, or less virulent strains of *S. equi* may be circulating amongst horses. Reviewing these combinations provides up-to-date information on how circulating strains of *S. equi* are presenting clinically. Importantly, these data show that strangles should not be ruled out when more general clinical signs of nasal discharge, with or without pyrexia, occur in the absence of abscessation/swelling of the submandibular and retropharyngeal lymph nodes, and perhaps the description of 'classical' and 'atypical' clinical signs needs reviewing.

Following active *S. equi* infection in which horses demonstrate clinical signs, a proportion of animals within an outbreak will often develop into subclinical carriers.[5,6] These horses appear to have recovered but are still infected and can shed bacteria into their local environment, infecting other horses. Therefore, understanding the reasons why veterinary surgeons are sampling horses offers the opportunity to evaluate what stage of infection horses were likely to be in, that is active infection, recovery phase or the subclinical carrier state. In recent years, the importance of testing for persistently infected horses at the end of an outbreak has been highlighted as a crucial step to eradicating strangles from a premises, preventing long-term carriers developing and avoiding the subsequent spread of *S. equi* into new populations.[25] Therefore, it is promising to see that 42% of all positive samples were recovered from sub-clinically infected horses through post-strangles infection screening, pre-/post-movement screening or following a positive iELISA serology result. Although a recent case series has questioned the usefulness of the iELISA in detecting *S. equi* carriers,[26] these surveillance data indicate that, where information was provided, the assay contributed to identifying 8.5% of positive diagnoses by detecting *S. equi*. Extrapolating the 95% confidence limits around this estimate to all 1617 diagnoses, this would equate to between 105 and 181 seropositive animals being subsequently confirmed with *S. equi* infection. By identifying these horses, action can be taken to isolate them and treat their infections, thereby minimising the possibility of further transmission events amongst populations and premises.

Two-thirds of strangles diagnoses were from horses residing on commercial premises. Our findings provide an initial insight into which premises types within the equine sector future awareness and education campaigns should be directed to yield the greatest benefit to horses and their owners. These data highlight the need for robust biosecurity, screening and isolation measures on commercial premises, which may have a higher turnover of horses and people visiting.

When creating mapping outputs for UK equine surveillance initiatives, horse location information is invariably not provided on laboratory submissions. Therefore, diagnoses were mapped according to the submitting veterinary practice location, enabling broad geographical distribution data to be presented consistently. Figure 3c demonstrates the density of strangles diagnoses based on both the number of diagnoses (Figure 3b) and the number of submitting veterinary practices (Figure 3a) within each region of the United Kingdom. For example, North Yorkshire had a high number of diagnoses ($n = 75$) but also a large number of submitting veterinary practices ($n = 14$) and therefore had a relatively lower density of diagnoses. In contrast, Durham had 30 diagnoses but only two submitting veterinary practices, making this area relatively denser in diagnoses. However, this approach still has limitations, as regions vary in the number of veterinary practices based within them and practices vary not only in the numbers of both veterinary surgeons and horses attended but also the extent of their 'cross-border' coverage. Within a practice variation may also be seen between veterinary surgeon sampling behaviour as well as an owner's preference to sampling.

Static maps summarising laboratory-confirmed strangles diagnoses provide information not previously reported, however, they only give information for a fixed period. Using an interactive online platform (www.jdata.co.za/ses) SES can publish near real-time information, including mapping UK diagnoses, enabling the equine industry to engage with SES and help protect horses and yards. This information can be used for broad risk assessment purposes, thereby allowing users to enhance biosecurity practices, for example, if they know they are in, travelling to or receiving horses from a region with recently increased numbers of strangles diagnoses and particularly where premises, clinical, or reasons for sampling information may be consistent with heightened risk.

4.1 | Provision of information and study limitations

This study offers an overview of all information provided by veterinary surgeons when submitting clinical samples for diagnostic testing and it is acknowledged that laboratory-based surveillance initiatives are heavily reliant on information provided by submitting veterinary surgeons. While every effort was made to consolidate data accurately, the information provided with diagnostic samples is often limited, even when standardised submission forms that allow such information to be readily conveyed are available. For this study to provide the most accurate information regarding strangles diagnoses, a single diagnosis could have included multiple sampling events/dates if consecutive sampling occurred less than 3 months apart. However, due to limited information on submission forms, including missing signalment details, it may not have been possible to identify consecutive sampling events in all cases. Furthermore, it is possible that multiple veterinary practices attend different clients within one yard and submit samples to different diagnostic laboratories. These diagnoses would appear as different outbreaks within the surveillance network and may artificially inflate the density of diagnoses. Data captured in this study focused on horses confirmed with strangles based on laboratory detection of *S. equi*, the bacterium that causes the disease. For a laboratory diagnosis to be made, owners must firstly recognise that their horse is clinically ill, have their veterinary surgeon examine the animal, agree to have samples taken and submitted for testing, which in turn needs to include *S. equi* among the pathogens tested for, or owners to have agreed to have samples taken either post-infection or as part of routine screening protocols. In some circumstances, owners may choose not to have laboratory confirmation of strangles, particularly where it is clinically strongly suspected resulting in the disease being diagnosed by clinical presentation alone. Furthermore, some owners may not have their horse examined by a veterinary surgeon as they are confident of their own clinical diagnosis. This has been recognised with laminitis and mild colic cases, suggesting owners' opinions and knowledge impact both decisions to seek veterinary help[21,27] and consequently disease surveillance outputs. This may mean a subpopulation of horses that are affected with strangles are not being identified in surveillance initiatives that rely on sequential completion of veterinary attendance, sampling and laboratory testing. Previous efforts to gather information on strangles diagnoses made on clinical presentation alone via an SES sentinel veterinary network were unsuccessful due to lack of engagement and reporting in the early stages of development.

5 | CONCLUSION

Since commencing in 2018, SES has established a network that collates laboratory-diagnosed strangles in UK horses based on detection of *S. equi* using conventional culture and modern molecular methods. This study, which includes data collated between 2015 and 2019, inclusively, presents important insights into clinical features of, and veterinary approaches to, the diagnosis of strangles in UK horses. However, it is acknowledged that missing data on clinical history and animal signalment on laboratory sample submission forms limits the completeness of the data.

Through its online platform, SES will continue to share regular updates on laboratory-confirmed strangles diagnoses, enabling veterinary surgeons, horse and yard owners and paraprofessionals to remain appraised of the ongoing strangles status across the United Kingdom.

AUTHOR CONTRIBUTIONS

AM completed all data collection and interpretation and drafted the manuscript. JG designed the custom database, assisted with data analysis and contributed to the final manuscript. DA provided support towards project design and software usage and contributed to the final manuscript. AW and RN oversaw and assisted in project design and methodologies and contributed to the final manuscript. KV and JS oversaw the project and contributed to the final manuscript.

FUNDING

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CONFLICT OF INTEREST

A Waller is CSO at Intervacc.

ETHICAL ANIMAL RESEARCH

Full ethical approval from the Animal Health Trust's Clinical Research Ethics Committee (REF: 01–2017E) and the Royal Veterinary College's Clinical Research Ethical Review Board (URN 2020 1973-2).

OWNER INFORMED CONSENT

Indirect consent for samples to be used for research and surveillance purposes was provided through submitting laboratories.

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DATA AVAILABILITY STATEMENT

The data and code that support the findings of this study are openly available in Zenodo at https://doi.org/10.5281/zenodo.3998351, reference jdatarsa/sesdata.

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