



Minerva Access is the Institutional Repository of The University of Melbourne

Author/s:

Barrett, RS;Wiethoelter, A;Halpin, K

Title:

The Hendra virus vaccine: perceptions regarding the role of antibody titre testing

Date:

2021-09-01

Citation:

Barrett, R. S., Wiethoelter, A. & Halpin, K. (2021). The Hendra virus vaccine: perceptions regarding the role of antibody titre testing. *Australian Veterinary Journal*, 99 (9), pp.412-418. <https://doi.org/10.1111/avj.13099>.

Persistent Link:

<https://hdl.handle.net/11343/298660>

Title

The Hendra virus vaccine: perceptions regarding the role of antibody titre testing

Authors

RS Barrett^{a,b}, A Wiethoelter^a and K Halpin^{c*}

*Corresponding author

^a Faculty of Veterinary and Agricultural Science, University of Melbourne, VIC 3010, Australia

^b now at Bellarine Veterinary Practice, Newcomb, Vic 3219, Australia

^c Australian Centre for Disease Preparedness, 5 Portarlington Rd, Newcomb VIC 3219, Australia;
Kim.Halpin@csiro.au

Objectives: To elucidate veterinarians' and horse owners' perceptions towards the use of Hendra virus (HeV) antibody titre testing and how it influences veterinary advice.

Methods: Six semi-structured phone interviews were conducted with veterinarians who have submitted samples for HeV antibody titre testing. Interviews were recorded, transcribed and thematically analysed to identify and report common themes within the data.

Results: Veterinarians are predominantly using the titre tests as an alternative to vaccination due to clients' fear of vaccine reactions. The high cost of titre testing, the difficulty interpreting titre results and a lack of titre test recognition by authorities were the major barriers reported to using this test. Some veterinarians detailed difficulties communicating titre test procedures and results to their clients. The majority of veterinarians accepted titres of 64 or greater as evidence of protective immunity and would rely on those results for 12 months. However, there was discrepancy of these values and the level of confidence veterinarians had in interpreting the results of HeV antibody titre tests varied.

Conclusion: This study has provided an overview of the attitudes of horse owners and veterinarians towards HeV antibody titre testing. Although evidence for HeV vaccination titres as an indication of protective immunity is still inadequate, it will assist veterinarians in interpreting and communicating titre results.

Keywords Hendra virus; vaccination; zoonosis; antibody titres; equine; communication

Abbreviations HeV, Hendra virus; ACDP, Australian Centre for Disease Preparedness; PPE, personal protective equipment; SNT, serum neutralisation test, VNT, virus neutralisation test

Introduction

HeV is a paramyxovirus that can spill over from *Pteropus* bats to horses and then be subsequently transmitted from horses to humans¹. HeV causes a lethal, sporadic disease in horses and humans. So far, HeV cases have only occurred in Queensland and New South Wales. However, the HeV reservoir, *Pteropus* bats, are widely distributed across most Australian states and territories. Thus HeV is of nationwide importance.^{2,3}

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: [10.1111/avj.13099](https://doi.org/10.1111/avj.13099)

This article is protected by copyright. All rights reserved.

HeV represents a work health and safety issue for equine veterinarians. However, the adoption of veterinary biosecurity protocols, including the use of protective personal equipment (PPE) has been a slow process for the industry.^{2,4} To minimise the risk to themselves and their employees, many equine practitioners in HeV hot spots mandate HeV vaccination and will not attend to unvaccinated, sick horses. HeV has put major stressors on the veterinary profession, even resulting in some veterinarians ceasing to work in equine practice altogether.⁵

Horse owners are at the forefront of HeV prevention, as they are responsible for the management and treatment of their animals.⁶ In 2012, a HeV vaccine for horses became available and horses are vaccinated at their owner's discretion. The vaccine is a recombinant G glycoprotein, sub-unit vaccine that stimulates a humoral immune response. After the initial immunisation sequence, a yearly booster is required to keep the HeV vaccination status up-to-date.^{6,7} There has been a low uptake of the HeV vaccine, especially when compared to other equine vaccines.⁸ Anecdotal evidence suggests that some horse owners prefer titre testing over yearly booster vaccinations but there is minimal data available supporting the use of HeV vaccination antibody titre testing.

HeV vaccination antibody titre testing involves using serum collected from a vaccinated horse in a serum neutralisation test (SNT; also known as a virus neutralisation test or VNT). This serum is serially diluted, starting at $\frac{1}{2}$, and is incubated with a standard quantity of Hendra virus. All serum-virus dilutions are put onto Vero cells which are monitored for growth of the virus after 3 days. If sufficient antibodies are present to neutralise all virus, no viral growth is observed. The neutralising titre is defined as the reciprocal of the highest dilution without evidence of viral growth. Due to the biological nature of the test, there is an inherent variability (up to 2-fold differences in repeatability between runs). The test must be performed at the highest level of biocontainment in a BSL4 laboratory due to the use of live Hendra virus. In Australia, the test is only performed at ACDP. The cost in January 2020, was \$367 per test, with this high cost reflecting the degree of difficulty of conducting this test.

It is known that the behaviour and beliefs of people have a large impact on vaccine preventable diseases, such as HeV.⁹ Therefore, by understanding horse owners' motivation in choosing to pay for a HeV titre test rather than a booster vaccination, a positive impact may be made on HeV control. The aim of this study was to gain insight into the applications of and perceptions toward post-vaccination HeV antibody titre testing. An additional objective was to gain insight into the veterinarian-horse owner relationship and the communication between them.

Methods

This qualitative research study was approved by the University of Melbourne, Veterinary and Agricultural Sciences Human Ethics Advisory Group, Ethics ID: 1749131. At the time of performing this study, 23 veterinarians had submitted samples to the National Reference Laboratory for HeV at the Australian Centre for Disease Preparedness (ACDP) for HeV vaccination antibody titre testing, forming the study population. Inclusion criteria comprised of equine veterinarians, who work in Australia. The submission of multiple samples or a recent sample submission formed the pre-selection criteria for purposeful sampling. This resulted in a sample population of eighteen veterinarians. The recruitment procedure utilised contact information from the veterinarians' submissions to ACDP and involved telephone and email contact to ask for their interest in participating in an interview.

The telephone interviews were conducted using a semi-structured format. This format was chosen to maintain consistency between interviews and to allow flexibility between participants.¹⁰ Demographic

data was initially gathered, followed by open-ended questions that focused on three main sections: (1) personal experience of HeV vaccination antibody titre testing, (2) practice policies on titre testing and (3) communication with horse owners. Each topic consisted of two to three questions that were asked in every interview and multiple prompts which were used as required (Table 1.). The topics of the interviews were designed to gather more information on the central questions of this study: *“Why are veterinarians performing titre tests?”*, *“What are the barriers to titre testing?”*, *“How are these tests performed and their results interpreted?”*, and *“How do they communicate these results to their clients?”*.

The interviews were conducted by RB at ACDP, under the supervision of KH. They were piloted over the telephone and in person with two veterinarians, to mimic true interview conditions. According to feedback received, the interview guide was modified.

The in-depth interviews lasted between 20-60 minutes and were concluded once all topics had been covered to the satisfaction of the research team. The participants had the option to offer additional thoughts or ask questions prior to the conclusion of the interview. The interviews were recorded on the WebEx recording system and stored on password coded computers at ACDP and the University of Melbourne. The audio files were reviewed and transcribed manually before each additional interview. This allowed refinement of future interviews and ensured researcher familiarity with the data. Six participants completed the study protocol and were included in the analysis.

The demographic data was summarised into a table in Microsoft Excel 2013. All transcripts were de-identified and uploaded into NVivo 11 to perform a thematic analysis. A deductive approach was used based on the guidelines set by Braun and Clark, 2006.¹¹ Transcripts were read multiple times and codes were set based on the central research questions outlined earlier. The initial codes were created by RB and they were reviewed by AW and KH to ensure that the codes accurately represented the data. The coding was adjusted accordingly and then organised into inter-related groups and over-riding themes. The resulting themes and codes were additionally reviewed by RB and KH to ensure their accuracy and completeness. After reorganisation and minor changes, the final themes, sub-themes and codes were completed. These themes are demonstrated in the results section along with their supporting quotations.

Results

The interview participants had been practicing veterinarians for a range of 10-31 years, with most of their time spent in equine only or equine predominant practice. Participants were born between the 1950s-1970s, were predominantly female (83%) and lived in Queensland and New South Wales. Half of the participants had seen a confirmed HeV case and more than half considered themselves to be working in a HeV hotspot. All participants owned horses, and all had vaccinated their horses against HeV (Table 2.).

There were four major themes identified in the thematic analysis including: (1) the triggers of titre testing, (2) the barriers of titre testing, (3) titre test performance and interpretation and (4) communication. These themes and their interactions are depicted in the final thematic map derived from the analysis (Figure 1). Quotes are used to illustrate the themes and square brackets indicate an alteration to the original quote to increase clarity.

1. Triggers of titre testing

The majority of titre tests are being performed at the request of the client rather than from veterinary recommendation. The predominant reason for client request was as an alternative to vaccination. This was most commonly due to client concern about vaccine reactions. Client fear of vaccine reactions was referenced as a trigger for titre testing by all six participants. Participants mentioned their client's concern principally about laminitis but also to other reactions which their clients have attributed to HeV vaccination, including generalised malaise, myalgia, limb oedema and epistaxis. Client concern about over-vaccination in general was an additional reason for titre testing requests.

"I want my horse titre tested 'cause my other horse had a vaccine reaction" [Participant (P)5- quoting a horse owner]

"The single most common reason is that the horse is due for revaccination and the owner is reluctant to have it done and so wants to have a titre test" [P2]

"They want titre tests rather than have the risk of laminitis." [P4]

All six veterinarians preferred to manage their client's risk of HeV through current vaccination, only resorting to titre testing when a horse owner was reluctant to vaccination and resistant to veterinarian advice.

"My preference is that people vaccinate their horses rather than doing the titre testing" [P1]

"It's [titre testing] definitely a step better than not vaccinating at all." [P3]

Half of the participants mentioned the influence of social media on owner attitudes towards HeV vaccination, vaccine reactions and the veterinarian-horse owner relationship. The participants mentioned social media as a driving force for spreading fear of vaccinations, promoting perceived vaccine reactions and downplaying risk factors for HeV. This may have indirectly increased the number of requests for titre testing.

"They [horse owners] will tell you it's an unsafe, untested, un-trialled vaccine etc. but we all know that's not the case. Even with the scientific data, unfortunately social media has done a very good job. There are prominent people on social media, who are fairly influential in the horse industry, who have put a lot of false information out there." [P6]

"The customers [requesting titre tests] that I have are just genuinely worried about the horse and what they hear for, from Facebook and they are just trying to just do the right thing." [P5]

Titre tests are also being used in attempts to prove HeV immunity to enable veterinary treatment of sick horses, to allow entry into equine events and as confirmation of a response to the vaccine. Titre testing is often regarded by these clients as a compromise, a way to avoid frequent HeV vaccination but to enable access to services which are limited to horses with a current HeV vaccination.

"The fear of not being treated, then they [horse owners] say ok let's talk about titre testing." [P5]

"It gives her [the horse owner] some grounds to say that the horse has had a positive reaction to the vaccine and hopefully it is covered." [P3]

"They don't want to vaccinate and they still want to be able to take their horses to a vet clinic." [P3]

2. Barriers of titre testing

There were several titre testing barriers perceived by the participants for horse owners and veterinarians. Cost was inferred as a barrier to horse owners by some participants. The high cost of the test (approximately \$400) was associated with its low uptake.

“Once I tell them [horse owners] how much it costs, I have had all but one decline” [P1]

However, two participants reported neutral reactions from their clients with regard to the cost of titre testing. They reported that their clients were happy to do the test regardless of the cost.

A lack of recognition of the test results was reported as an additional issue. The participants referenced the inconsistent acceptance of titre tests across different competitions, veterinary practices and individual vets.

“For your \$200-300 [for titre testing], you know, you might not be able to get into vet surgeries, you might not be able to get into shows” [P3]

The difficulty interpreting titre test results was the final barrier mentioned and it was acknowledged by every participant. The veterinarians blamed this on the lack of evidence supporting the antibody titre test. Specifically, they mentioned the unknown period of antibody waning, the lack of a widely accepted titre cut off value and the lack of information linking antibody titres to horse immunity.

“Because there has been no significant research done on titre testing. I have no idea whether it is protective or not.” [P2]

“I am not necessarily routinely encouraging the titre testing because that problem of interpreting the low results.” [P1]

All participants wanted more research performed and more evidence to help them interpret the titre tests. They are eager for someone to do more research to help resolve this issue.

“Just if someone could do more research to find out [about titre tests]” [P5]

“I think if we could have more information about the rate of decline or about whether it [titres] makes any difference at all or about whether it is individually specific.” [P4]

3. Titre test performance and interpretation

Veterinarians submitted titre samples 6, 12, 18 and 24 months after previous vaccinations or titre tests. The length of time allocated depended on the previous titre level obtained. Some of the veterinarians reported rechecking titres more often when levels were below a “certain threshold”, which was variable between participants. One veterinarian retested every 24 months if a titre was greater than 2000 and one reported 6 monthly checks when titres were getting low, specifically below 264, but there was uncertainty in this value. The majority of veterinarians relied on titre results for 12 months, despite the last titre value. They rechecked titres 12 months after the previous test or when a booster vaccination was due. This was based on the current annual vaccination program and the Health4horses database. Other veterinarians based their recommendations on the initial vaccination research study at ACDP and anecdotal information from veterinary colleagues.¹

“Over a certain titre [participant was unsure of what titre when prompted] I would allow that to be considered as evidence of immunity for at least 12 months” [P1]

“Instead of having its booster we did the titre test and I’m just gauging it off the confidence that we have of our sort of senior vets in Queensland and the DEPI. They seem to be fairly confident that the 12 month interval is acceptable as a fairly current level.” [P3]

Most of the veterinarians made use of cut off values to help them interpret the titre tests. Titres above the cut off values were often interpreted as evidence of sufficient immunity. Titres below the cut off value indicated an insufficient level of immunity and prompted the need for additional vaccination. Four out of the six veterinarians used a cut off value of 64. The level of confidence in their cut off value varied between participants. Some lacked confidence in their cut off values, stating that they would do a literature search prior to interpreting the tests. One veterinarian didn't have a cut off value they used and another mentioned multiple cut off values, 264 and 64. Alternatively, some participants were confident in their interpretation of the test. The original vaccine efficacy study was referenced by two of the veterinarians, in this study horses with pre-exposure vaccine antibody levels of 16 and 32 were protected.¹ An error margin of one to two dilutions was then used by these veterinarians to result in a cut off value of 64.

"I would say, I would make my cut off 64" [P5]

"I'm pulling figures out of the air because if it came to the punch I would go back to my original reading and research, but I'm thinking in my mind it was below 64" [P1]

The effect of titre test results on the likelihood of the veterinarians to treat an unvaccinated, sick horse or to wear PPE was also investigated. Three of the veterinarians said that the titre result had no influence on their level of PPE or treatment of sick horses. Two were unsure of the impact a titre level would have on these decisions. One veterinarian reported that antibody titres were useful in deciding what level of PPE was required when treating a sick horse. This demonstrates the variability between the participants in their interpretation of titre tests.

"So I think regardless of the titre level, I just want them to be currently vaccinated [within 12 months]" [P2]

"I think if they're in the low 100s then I would be more inclined to wear PPE gear. I think if they're in the 1000s, I'd still wear gloves" [P4]

4. Communication of titre test results

The veterinarians found that the immunology principles of titre testing were difficult to explain to horse owners. Specifically, they acknowledged the challenge of explaining low antibody titres, the relationship between titres and protective immunity and titre cut off values. The lack of research and evidence supporting HeV antibody titre testing made this more problematic, thus making it challenging for veterinarians and horse owners alike to interpret and understand titre test results. This has resulted in horse owners being confused and frustrated.

"They [horse owners] basically say at the end [of titre test result discussions], what do I need to do and they are frustrated." [P5]

"I communicate the fact that at this stage I can't give them [horse owners] any idea as to how rapidly these levels are declining and so I say to them that I can't be the voice of what the competition organiser might say or what a hospital might say but I am obviously happy to come and treat your horse as it stands." [P4]

The veterinarians used a combination of communication techniques. This usually involved a verbal discussion of the test results and their explanations, as well as distributing a copy of the titre test results. Most of the veterinarians discussed the results over the phone, then the results document

was either emailed to clients or a hard copy was handed out in person. Despite the use of multiple communication techniques, the veterinarians reported a low degree of client understanding. The aforementioned difficulty in communicating titre test results has translated into poor owner understanding.

"I don't think any, not many of them understand that at all." [P3]

However, there was some discrepancy between the veterinarians surrounding their communication experiences. The one veterinarian that claimed no difficulty in communication or owner understanding of titre test results had an immunology/science background prior to their veterinary studies.

"I haven't had any difficulty explaining to them [horse owners] at all" [P6]

Overall, the lack of evidence for HeV vaccination antibody titre testing has resulted in difficulties for veterinarians interpreting test results, explaining them to horse owners and minimal horse owner comprehension.

Discussion

This is the first qualitative study investigating the use of HeV vaccination antibody titre testing in Australia. Through interviews and thematic analysis, the triggers and barriers of titre testing have been explored. The titre test parameters most utilised by participants were a titre cut off value of 64 with a retest interval of 12 months. However, there was variability between participants in the values used and their level of confidence in them. By investigating the challenging communication experiences of the veterinarians and horse owners, further insight was gained into the veterinarian-horse owner relationship and their shared struggle of interpreting and communicating titre test results. Multimodal communication techniques were used in an attempt to abate some of these difficulties.

The risk of side effects and vaccination safety concerns were the major barriers to HeV vaccination experienced by horse owners and they unsurprisingly served as the triggers of titre testing.⁶ Social media coverage of vaccinations has been shown to focus more on vaccine reactions and the negative aspects of vaccination. This is easier for the general public to perceive rather than the absence of a preventable disease, especially for sporadic diseases such as HeV.^{12,13} Therefore it was not surprising that social media was mentioned as a driving force of fear of HeV vaccination, indirectly acting as a trigger for titre testing. The barriers to HeV vaccination antibody titre testing revolved around its expense and the lack of guidelines for interpreting results and their subsequent implications. Cost is often a major consideration for any veterinary work¹⁴ as well as for HeV vaccination^{6,9} so it is expected that it serves as one of the major barriers to HeV titre testing.

The overall poor uptake of the HeV vaccine and other vaccines by horse owners provides an opportunity for titre testing to be used as an alternative by particular horse owners. Despite the low rate of HeV vaccine reactions, reported as 0.2% by the Australian Pesticides and Veterinary Medicine Authority, the vaccination rate against HeV in horses has been reported as 57%, compared to an 85% vaccination rate against tetanus.^{7,8} The attitude and beliefs of horse owners have a considerable influence on the uptake of vaccinations and biosecurity involving preventable diseases. Effective

communication combined with an established and trusting veterinarian-horse owner relationship has demonstrated positive effects on disease mitigation practices.¹⁵

Antibody titre levels have been used as an indication of immunity in multiple studies of the HeV vaccine. In the initial vaccine efficacy study, pre-challenge antibody titres were tested in horses of two groups at 21 days and 194 days after the second HeV vaccination.¹ The lowest antibody titres detected in this study were 16 and 32. All ten vaccinated horses of varied antibody titres were protected from lethal exposure to HeV and no vaccinated horses had a rise in HeV antibodies post exposure.¹ In another study, HeV vaccination antibody levels were measured over time in a herd of 61 horses that received the primary vaccination course and annual boosters.¹⁶ All horses had an antibody titre of at least 32 after the second vaccination. Vaccination antibody titres were maintained at 16 or above with annual boosters after the primary vaccination course in all but one of the 37 horses remaining in the study.¹⁶ A post vaccination antibody titre of 32 was protective against clinical disease of Nipah virus in a henipavirus vaccine efficacy study in cats which used the same soluble G antigen.¹⁷

Though no published guidelines exist on the interpretation of HeV titre tests, most of the veterinarians in this study used comparable titre cut off values and recheck intervals. The predominant titre recheck interval was 12 months and most veterinarians are replicating the current annual HeV vaccination booster schedule.⁷ The majority of the veterinarians used a titre cut off value of 64. It is challenging to equate antibody titres to a level of protection from disease and utilising dichotomous thresholds is just one method of relating immunological markers to vaccine efficacy.¹⁸ Antibody titres are one immunological marker and protective responses involve both the humoral and cellular immune systems. Vaccine efficacy depends on the anamnestic response and antibody avidity to antigens, in addition to pre-existing neutralising antibodies.¹⁹ For example, for Bovine Viral Diarrhoea Virus (BVDV) there is minimal correlation between vaccination antibody titres and protection from disease.²⁰ Steers with no detectable antibody titres post-vaccination were protected from exposure. Furthermore, steers with lower antibody titres to a modified live virus vaccine were better protected than steers with higher antibody titres to an inactivated virus vaccine.²⁰ Pre-existing antibody titres correlate variably with the level of protection from a disease. Additionally, antibody waning and the period of time a titre will provide adequate immunity is individually variable. Vaccination efficacy is not solely related to antibody titres and titres should not be used alone to indicate the level of protection from HeV. There is no evidence that a titre of 64 will be ≥ 32 12 months later. It will likely be lower after 12 months and the rate of decline and individual variation that is likely to occur between horses warrants further research.²¹ More longitudinal field studies, like Tan et al.¹⁶, looking at responses to the vaccine in the field over time will contribute to this knowledge. Until then, the titre of 64 remains an arbitrary value.

This study is based on a relatively small number of participants and the results may have been influenced by selection and information bias. Practitioners that have strong views on HeV vaccination or titre testing and difficulties with clients could have been more likely to partake in this study, resulting in possible selection bias. The semi-structured nature of the interviews did allow for more variability between interviews and the potential influence of information bias. This was attenuated by utilising a set interview guide and the same researcher conducting all interviews. The low number of HeV vaccination antibody titre tests submitted during the study period resulted in a small sample population and limited diversity in the interview participants. Despite the limitations of this study, the overall conclusions generated should not have been fundamentally impacted.

The difficulties in communication encountered by veterinarians in this study are applicable to the wider veterinary population, especially with the previously documented strain on the veterinarian-client relationship.⁶ Veterinarians in this study have dealt with these issues by utilising multiple communication methods, including use of both a verbal discussion and written information. It identifies their attempts to dissipate this issue and tools that could be utilised by others. Providing written and verbal information is the most common communication format when discharging human patients from hospital. Multimodal communication has been shown to be superior to solely verbal communication by improving patient knowledge and satisfaction.²² Well-developed non-verbal communication skills, including a warm tone of voice, have improved the veterinarian-client relationship and client satisfaction. These are skills which can be identified and improved to enhance this relationship.²³ Problematic communication topics identified by the veterinarians included immunology, protective immunity along with the limitations and shortage of research. They could serve as topics for further research or topics that veterinarians can take extra care with and put additional effort into explaining.

Titre testing only provides a momentary indication of a horse's antibody levels and is therefore insufficient evidence of protective immunity. As more titre tests are performed and interpretation becomes standardised, it will reduce the barriers towards HeV vaccination antibody titre testing. However, the public health risks of HeV make it unlikely, at a formal level, that titre testing will ever be relied upon as sole evidence of protective immunity. There is a plethora of research into protective antibody titres post-vaccination for rabies, such that booster vaccination of at-risk humans is performed when titre levels are below 0.5IU/ml.²⁴ Despite this, it is still mandatory to vaccinate companion animals against rabies virus in the United States to safeguard public health.²⁵ Therefore, with similar fatal public health risks, relying on HeV antibody titres as sole evidence of protective immunity is unsound. Still, HeV vaccination antibody titre testing could be used in the management of horses where HeV vaccination has proven unsafe, involving numerous or severe vaccine reactions.

Conclusions

Horse owners are turning to titre testing as an alternative to HeV vaccination, predominantly due to fear of vaccination side effects. They are using these tests in an attempt to prove HeV immunity, but titre levels should not be relied upon as sole evidence of protective immunity. By understanding the motivation and reasoning of horse owners who are turning to titre testing over HeV vaccination perhaps a positive impact can be made on people who are resistant to HeV vaccination and potentially other vaccine-preventable diseases.

Acknowledgements

The authors thank the interview participants for their involvement and insight.

Conflict of interest and sources of funding

The authors declare no conflicts of interest or sources of funding for the work presented here.

References

1. Middleton D, Pallister J, Klein R et al. Hendra virus vaccine, a one health approach to protecting horse, human, and environmental health. *Emerg Infect Dis* 2014;20:372-379.

2. NSW Government Department of Primary Industries. *Hendra Virus*. Primefact. NSW. https://www.dpi.nsw.gov.au/_data/assets/pdf_file/0019/310492/Hendra-Virus-Primefact-970-1.pdf. 2018. Retrieved 25 August 2019.
3. Field H, de Jong C, Melville D et al. Hendra virus infection dynamics in Australian fruit bats. *Plos one* 2011;6:12. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0028678>. Retrieved 20 November 18.
4. Mendez DH, Kelly J, Buttner P et al. Management of the slowly emerging zoonosis, Hendra virus, by private veterinarians in Queensland, Australia: a qualitative study. *BMC Vet Res* 2014;10:215-229
5. Mendez DH, Judd J, Speare R. Unexpected result of Hendra virus outbreaks for veterinarians, Queensland, Australia. *Emerg Infect Dis* 2012;18:83-86.
6. Manyweathers J, Field H, Longnecker N et al. “Why won’t they just vaccinate?” Horse owner risk perception and uptake of the Hendra virus vaccine. *BMC Vet Res* 2017;13:103-114.
7. Australian Pesticides and Veterinary Medicines Authority. Hendra virus vaccine product registration. <https://apvma.gov.au/node/12876>. 2020. Retrieved 30 April 2020.
8. Goyen KA, Wright JD, Cunneen A et al. Playing with fire – What is influencing horse owners’ decisions to not vaccinate their horses against deadly Hendra virus infection? *Plos One* 2017;12,6. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0180062>. Retrieved 13 July 18.
9. Wiethoelter AK, Sawford K, Schembri N et al. “We’ve learned to live with it”—A qualitative study of Australian horse owners’ attitudes, perceptions and practices in response to Hendra virus. *Prev Vet Med* 2017;140:67-77.
10. Gill P, Stewart K, Treasure E et al. Methods of data collection in qualitative research: interviews and focus groups. *Brit Dent J* 2008;204:291-295.
11. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006;3:77-101.
12. Betsch C, Brewer NT, Brocard P et al. Opportunities and challenges of Web 2.0 for vaccination decisions. *Vaccine* 2012;30:3727-3733.
13. Arede M, Bravo-Araya M, Bouchard É et al. Combating vaccine hesitancy: Teaching the next generation to navigate through the post truth era. *Front Public Health* 2019;6:381. <https://www.frontiersin.org/articles/10.3389/fpubh.2018.00381/full>. Retrieved 20 March 20.
14. Coe JB, Adams CL, Bonnett BN. A focus group study of veterinarians’ and pet owners’ perceptions of the monetary aspects of veterinary care. *JAVMA-J Am Vet Med A* 2017;231:1510-1518.
15. Hii C, Dhand NK, Toribio JA et al. Information delivery and the veterinarian-horse owner relationship in the context of Hendra virus in Australia. *Prev Vet Med* 2020;179:1-9.
16. Tan RHH, Hodge A, Klein R et al. Virus-neutralising antibody responses in horses following vaccination with Equivac® HeV: a field study. *Aust Vet J* 2018;96:161-166.

17. McEachern JA, Bingham J, Crameri G et al. A recombinant subunit vaccine formulation protects against lethal Nipah virus challenge in cats. *Vaccine* 2008;26:3842-3852.
18. World Health Organization. *Correlates of vaccine-induced protection: methods and implications*. Immunization, Vaccines and Biologicals. https://www.who.int/immunization/documents/WHO_IVB_13.01/en/. 2013. Retrieved 15 April 20.
19. Siegrist CA. Vaccine immunology. *Vaccines* 2008;5,17-36.
20. Downey-Slinker ED, Ridpath JF, Sawyer JE et al. Antibody titers to vaccination are not predictive of level of protection against a BVDV type 1b challenge in Bos indicus-Bos taurus steers. *Vaccine* 2016;34:5053-5059.
21. Yuen KY, Fraser NS, Henning J, Halpin K, Gibson JS, Betzien L, Stewart AJ. Hendra virus: Epidemiology dynamics in relation to climate change, diagnostic tests and control measures. *One Health* 2021; 100207. doi: 10.1016/j.onehlt.2020.100207.
22. Johnson A, Sandford J. Written and verbal information versus verbal information only for patients being discharged from acute hospital settings to home: systematic review. *Health Educ Res* 2005;20:423-429.
23. McArthur ML, Fitzgerald JR. Companion animal veterinarians' use of clinical communication skills. *Aust Vet J* 2013;91:374-380.
24. Australian Government Department of Health. Rabies and other lyssaviruses. <https://immunisationhandbook.health.gov.au/vaccine-preventable-diseases/rabies-and-other-lyssaviruses>. 2018. Retrieved 12 April 20.
25. Brown CM, Slavinski S, Ettestad P et al. Compendium of animal rabies prevention and control, 2016. *JAVMA-J Am Vet Med A* 2016;248:505-518.

Tables

Table 1. Interview topics and questions

Interview topic	Questions
Personal experience with HeV vaccination antibody titre testing	Can you tell me a little bit about your experience with Hendra virus vaccination antibody testing?
	In your experience – what triggers Hendra virus vaccination antibody testing?
	Do you personally think it is worthwhile doing the test?
Practice Policies around HeV vaccination and titre testing	What is your clinic's policy on HeV vaccination?
	What is your clinic/practice advising in regard to HeV vaccination titre testing?
	How do you interpret the HeV vaccination antibody titre test results?

Communication of titre test results

How do you communicate HeV vaccination antibody titre test results to the horse owner?
How do the results influence your advice to horse owners'?

Table 2. Demographic data and background information of the interview participants

Variable Category	Number (%) or median (range)
Gender (%)	
Female	5 (83%)
Male	1 (17%)
Location (%)	
New South Wales	1 (17%)
Queensland	5 (83%)
Type of practice (% equine)?	97.5 (80 – 100)
Length in practice (years)	23 (10 – 31)
Years in equine practice	17 (9 – 31)
Decade born	1970 (1950-1970)
Assessed a positive HeV case	3 (50%)
Practice in a HeV hot spot	4 (67%)
Own a horse/s	6 (100%)
HeV vaccinate own horse/s	6 (100%)

Figures

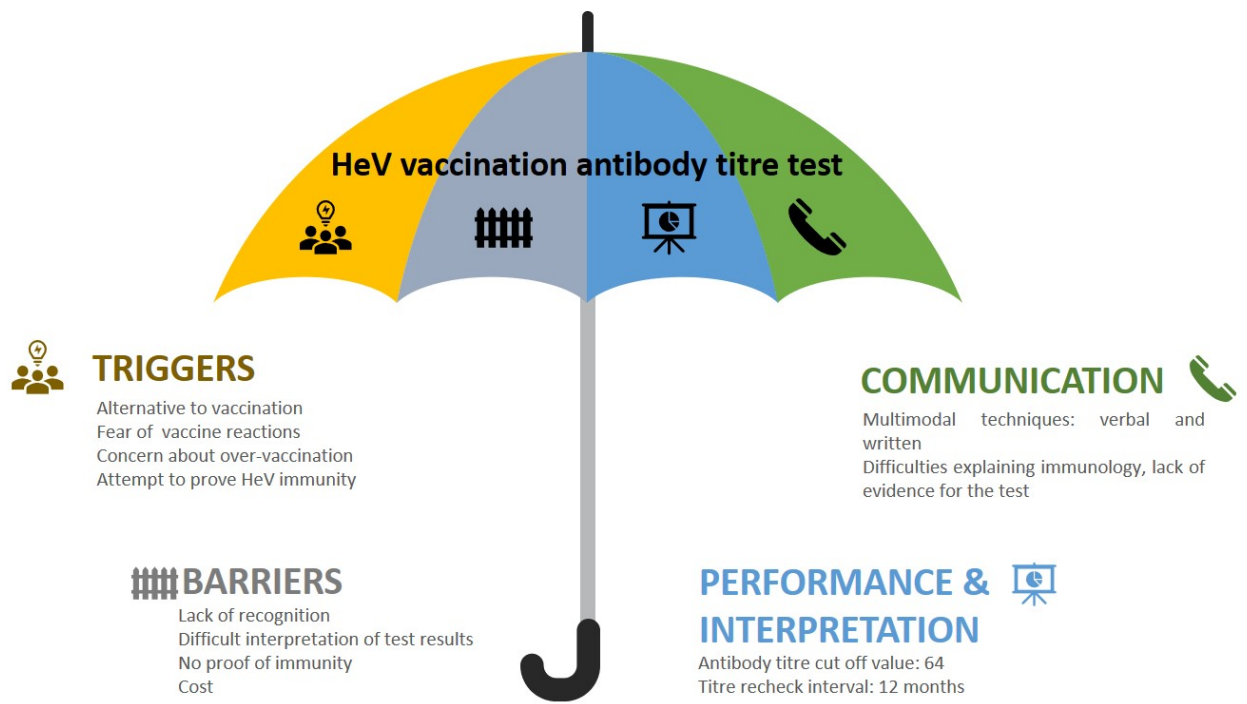
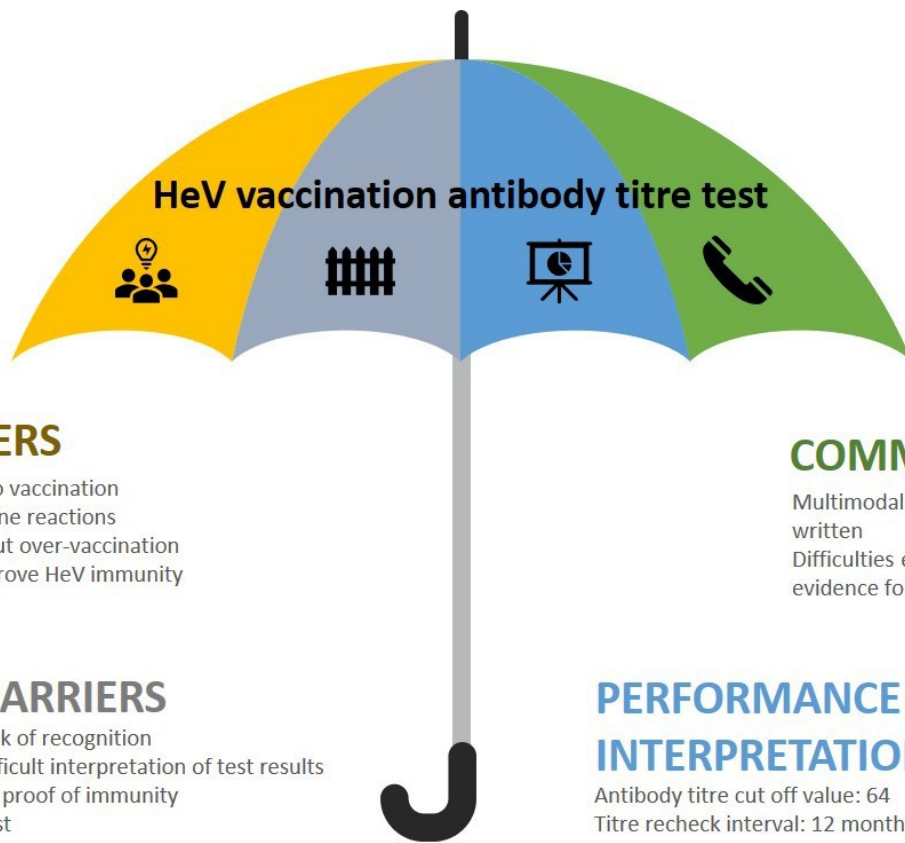


Figure 1. Final thematic map.



TRIGGERS

- Alternative to vaccination
- Fear of vaccine reactions
- Concern about over-vaccination
- Attempt to prove HeV immunity

COMMUNICATION

- Multimodal techniques: verbal and written
- Difficulties explaining immunology, lack of evidence for the test

BARRIERS

- Lack of recognition
- Difficult interpretation of test results
- No proof of immunity
- Cost

PERFORMANCE & INTERPRETATION

- Antibody titre cut off value: 64
- Titre recheck interval: 12 months

AVJ_13099_AVJ_13099_Figure 1 Thematic Map.jpg