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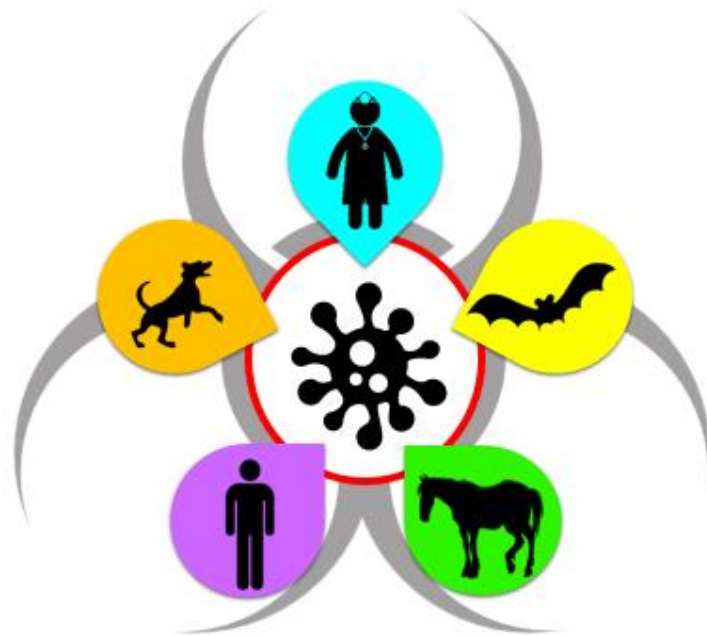
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IDENTIFYING AND UNDERSTANDING THE FACTORS AFFECTING INFECTION CONTROL AND HENDRA VIRUS RISK MANAGEMENT IN PRIVATE VETERINARY PRACTICES IN QUEENSLAND, AUSTRALIA

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Doctor of Philosophy

TOWNSVILLE, December 2015

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The research presented and reported in this thesis was conducted with the approval of the James Cook University Research Ethics Committee and in accordance with National Statement on Ethics Conduct in Human Research, 2007.

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17 December 2015

Summary

Background

Infection control (IC) is a universal health care principle. Its main aim is to prevent the transmission of infectious diseases in healthcare settings and the wider community. Failure to implement IC adequately can result in nosocomial diseases; healthcare-associated infections. Despite the evidence-based knowledge, IC gold standards are often not met in medical healthcare, with the added burden of managing nosocomial diseases in patients and healthcare workers. Similar observations have been made in the animal healthcare sector where IC is generally reported to be of a poor standard.

Although IC principles apply equally to both human and animal healthcare, the concept of IC is less well defined in the veterinary field where the terminology referring to IC is often inconsistent. Furthermore, veterinary IC practices have been less scrutinised than those in healthcare settings, and veterinary IC often appears to be benchmarked against standards of its medical counterparts. However, unlike the healthcare sector, the veterinary workforce is, for the most part, based in private practice. Thus the context in which medical and veterinary IC strategies are applied differ significantly in terms of practitioner-patient relationship, communication, and quality of work environment, as well as legal and financial structure of service delivery. It is therefore questionable whether veterinary IC standards can be evaluated against medical standards. Furthermore, despite relevant government departments and veterinary professional peak bodies providing IC guidelines, the implementation of veterinary IC is mostly left to the discretion of individual practices and individual staff; hence, there is a wide variation between IC standards adopted across veterinary practices. This lack of cohesion in IC standards within the veterinary workforce may prevent the overhaul of veterinary IC. Notwithstanding, most reports that concluded veterinary IC was generally suboptimal failed to provide an explanation or make specific recommendations about ways to improve veterinary IC standards.

From biosecurity, public health, and occupational health and safety perspectives, veterinary IC is of particular significance when managing zoonoses, which are infectious diseases transmissible from vertebrate animals to humans. Veterinarians are considered experts in the management of zoonoses and are also at a higher occupational risk of becoming infected with these diseases than other health professionals. Moreover, the majority of emerging infectious diseases are zoonotic in nature, and thus veterinarians are likely to be at an increased risk of exposure to unknown zoonoses in the future; hence the necessity to investigate and improve veterinary IC standards. Improving veterinary IC became an imperative in Australia after the emergence of a new zoonosis, Hendra virus (HeV). When managing zoonoses, veterinarians are not only considered the animal health experts but also have occupational health and safety responsibilities towards their clients, staff and themselves. When HeV first emerged it was assumed that veterinarians would implement the appropriate IC strategies to prevent transmission of HeV from horses to humans. However, the first 13 outbreaks, between 1994 and 2009, led to seven people becoming infected; four of whom subsequently died. Those infected were either veterinary staff or assisting veterinary staff (5/7), or people working in the horse industry (2/7). Knowledge about veterinary IC principles and strategies did not appear to prompt veterinary staff to take the necessary safety precautions. Consequently, the drivers of veterinary IC and HeV management were brought into question. Hence the overarching aims of this thesis were to identify and understand the factors affecting IC and HeV management in the particular context of private veterinary practices in Queensland, Australia.

Methodology

The drivers of veterinary IC behaviours have seldom been studied in-depth. Prior to 2009, the majority of studies that examined veterinary IC, quantified IC choices and outcomes without further insight. Qualitative methodologies are routinely used to study the perceptions about IC and related risks and the reasons the behaviours of healthcare workers. A mixed methods approach was chosen to investigate and understand the factors affecting veterinary IC and the management of zoonoses such as HeV. This thesis comprises four sequential studies.

Study 1 was qualitative and explored the perceived barriers to HeV management and related IC issues in equine veterinary practices in Queensland, Australia. It consisted of a series of

semi-structured in-depth interviews with 21 veterinary staff from 14 veterinary practices located within the distribution range of HeV; eastern coast of Australia between Far North and South-East Queensland. The interviews were conducted between December 2009 and September 2010.

Studies 2 and 3 were cross-sectional studies conducted concomitantly between June and September 2011. Both consisted of postal surveys. Study 2 targeted equine veterinarians in Queensland and examined the veterinarians' HeV-related risk perceptions, HeV management practices and the effect the introduction of a HeV vaccine would have on their future management of HeV. Study 3 targeted all private veterinarians in Queensland and examined the veterinarians' zoonotic risk perceptions and IC habits in relation to specific zoonotic risks.

Study 4 was also a cross-sectional study conducted in December 2013. It consisted of an online survey and targeted final year veterinary students from James Cook University in Queensland. The aim of this study was to investigate zoonotic risk perceptions and IC knowledge among final year veterinary students, as well as their experiences of IC implementation in private veterinary practices during their extramural placements.

Results

The results from Study1 showed that some of the issues surrounding the implementation of veterinary IC were specific to the emergence of HeV, while others were associated with a number of factors relating to the veterinary work culture and the service delivery business model of private practices. Veterinarians reported they felt unprepared to manage the unpredictable event that is a slowly emerging zoonosis such as HeV. Their management of HeV was further hindered by the lack of responsiveness and support from relevant government authorities and the communication issues with associated stakeholders, such as local representatives of government departments in charge of biosecurity and health and safety, diagnostic laboratories and horse owners. In some cases, managing a potential outbreak of HeV became untenable for private practices and they ceased providing veterinary services for equine

patients due to the added cost and time it required, as well as the associated issues of liability and business reputation.

The findings from Study 1 also highlighted the importance of other factors associated with the implementation of veterinary IC: low prioritization of zoonotic risks compared to other risks, such as risk of physical injury; poor IC work culture; poor professional IC mentorship; and operating a private business. Overall, participants agreed that veterinary IC required improvement but warned that it would take time.

Study 2 confirmed that some veterinarians had moved towards improving their IC and HeV management strategies. When HeV was suspected, those who were most concerned about the HeV-related risks and had had previous experience with HeV management were more likely to use more personal protective equipment. Having attended HeV management training on the other hand did not increase the level of precautions taken by veterinarians who suspected HeV in a horse. The introduction of a HeV vaccine for horses was not perceived as an alternative strategy to maintaining IC and many participants anticipated that they would require the horses they examined in the future to be vaccinated. Findings from Study 2 confirmed results from Study 1, which highlighted the issues associated with communicating about HeV-related risks and risk mitigation strategies with horse owners. These issues included: communication skills of veterinarians; clients' ability to understand veterinarians' messages; mismatch between veterinarians' motivations and clients' expectations; clients' perception of veterinarians' role; and difficulties communicating in a "crisis" situation.

Study 3 confirmed that veterinarians' perceptions of zoonotic risks affected their IC practices but not proportionally, with high levels of risk perception not guaranteeing the implementation of the highest level of IC. Veterinarians who were highly concerned about HeV were more likely to use a mask when examining horses but those who were equally concerned about Australian bat lyssavirus did not seek immunization with the cross-protective rabies vaccine. Moreover, veterinarians who worked in a practice with leadership in IC were more likely to use masks. However, IC leadership did not affect the rates of sharps injuries among veterinarians.

Results from Study 4 showed that final year veterinary students who were about to enter the workforce could assess zoonotic risks appropriately, but ranked the risk of injury higher than the risk of infection with a zoonosis. Notwithstanding, students considered IC measures as very important and had a sound knowledge of IC principles. However, they reported that there were discrepancies between their undergraduate IC training and their IC experiences during extramural placements in private practice. Some students remarked that this led them to follow substandard IC measures in order to receive approval from their professional mentors and conform to a professional identity. The transition of veterinary graduates into the workforce may be a crucial point when IC standards learnt at university are lowered and consequently poor IC work culture among veterinarians is entrenched.

Outcomes

This research has identified the many challenges faced by private veterinarians when implementing IC and managing an emerging zoonosis such as HeV. Veterinarians, associated government departments and professional peak bodies need to be better prepared to mitigate emerging zoonotic risks. Improving veterinary IC will help build the necessary capacity to manage such events as well as infectious risks encountered routinely in veterinary practice. The development and universal dissemination of evidence-based and context specific veterinary IC control gold standards would benefit the veterinary profession. This would require: further investigation into veterinary IC practices within a range of veterinary work environments and scenarios; greater communication, consultation and collaboration between veterinarians, government, professional peak bodies and relevant community groups.

Traditionally, the veterinary work culture has to a great extent helped to ignore the risk of veterinarians becoming infected with a zoonosis and consequently has not prioritised the implementation of IC measures to prevent exposure to zoonotic risks. Therefore, improving veterinary IC will also require a paradigm shift in work culture. Since the perception of zoonotic risks appears to determine risk mitigation strategies, the significance of such risks need to be reiterated and highlighted along with the relevant, most appropriate IC strategies

that should be implemented to manage these risks. Leadership in IC also needs to be promoted across all veterinary practices. A clear commitment to uphold high IC standards at the practice level will encourage individuals to use best IC practices and help improve the existing poor veterinary IC culture.

Veterinary IC is one of the major strategies workplace health and safety authorities expect veterinarians to implement at the highest possible standard. Failing to meet this expectation could have legal repercussions for private veterinarians if it leads to staff, clients or themselves becoming infected with a zoonosis. The link between veterinary IC and the legal requirements of occupational health and safety should be emphasised with a focus on “human-safety” for all those interacting in the veterinary work environment.

Although a number of recommendations made in this thesis targeted existing veterinarians, it appeared that the most effective way of improving veterinary IC may be to target veterinary students about to enter the workforce. Academic educators, veterinary mentors and professional peak bodies need to collaborate more closely in order to deliver a high level of IC knowledge and skills in early career veterinarians to provide them with the confidence to maintain the highest possible IC standards throughout their career.

Unless veterinary IC improves, veterinarians are likely to be confronted once more with issues similar to those they experienced during the emergence of HeV. With the rise in zoonotic emerging diseases, biosecurity and public health systems are increasingly recognising the necessity for a One Health approach to human and animal health. Veterinarians are likely to be key players in One Health as they are used to managing infectious diseases affecting multiple species, including humans. As such, the role of veterinarians should be more widely acknowledged and supported, and the veterinary profession should be more closely involved in biosecurity and public health decisions, policies, and the management of zoonoses.

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Finally, my last but not least thank you goes to my dearest Millers: big and small, furry and squeaky!



Art work by Ken Miller

Grâce à Qui?

In Memoriam

Emeritus Professor Rick Speare AM, PhD, MBBS (Hons), BVSc (Hons), DVSc

(August 2nd 1947-June 5th 2016)



Art work by Ken Miller

Pourquoi?

*Pour oser me prouver que j'en étais capable,
Pour prendre ma mesure de façon palpable,
Par curiosité, méticulosité et rigueur,
Pour pouvoir croire en ma valeur.*

Pour Qui?

*Pour Maya ma fille,
Pour qu'elle sache que dans le fond,
Les regards des autres n'ont pas raison.
Pour que toujours elle sache.
Comme souvent je le lui rabâche,
Sa vérité naturelle en elle scintille,
Et son bonheur de mille feux en elle brille.*

A ma Poulette adorée.

Love Mum.

Publications and presentations throughout doctoral studies

Publications

1. **Mendez D**, Judd J, Speare R. Unexpected result of Hendra virus outbreaks for veterinarians, Queensland, Australia. *Emerg Infect Dis.* 2012;18(1):83-85.
2. **Mendez D**, Judd J, Speare R. Testing for Hendra virus: difficulties experienced by veterinarians in Queensland prior to 2011. *Aust Vet J.* 2013;91:323-327.
3. **Mendez D**, Büttner P, Speare R. Response of Australian veterinarians to the announcement of a Hendra virus vaccine becoming available. *Aust Vet J.* 2013;91(8):328-331.
4. **Mendez D**, Büttner P, Speare R. Hendra virus in Queensland, Australia during the winter of 2011: veterinarians on the path to better management strategies. *Prev Vet Med.* 2014;117(1):40-51.
5. **Mendez D**, Kelly J, Buttner P, Nowak M, Speare R. Management of the slowly emerging zoonosis, Hendra virus, by private veterinarians in Queensland, Australia: a qualitative study. *BMC Vet Res.* 2014;10:215.
6. **Mendez D**. Case study 1.1: Identifying and understanding the factors affecting infection control and Hendra virus management in private veterinary practices in Queensland, Australia. In: Büttner P, Muller R. *Epidemiology*. 2nd ed. Melbourne: Oxford Press; 2015.
7. **Mendez D**, Foyle L, Cobbold R, Speare R. A survey of rabies vaccination of Queensland veterinarians and veterinary students. *Aust Vet J.* (Accepted Nov 2015, in press)

Presentations

1. **Speare R, Mendez D**, Judd J, Cox J. Challenges to infection control implementation in equine practices in Queensland: preliminary results from consultation with coastal veterinarians in Queensland. In: Department of Employment, Economic Development and Innovation, Queensland Government. Addressing barriers to veterinary infection control – workshop. Report. Brisbane: Department of Employment, Economic Development and Innovation; 2010.
2. **Mendez D**, Miller K, Judd J, Speare R. Risk communication between veterinarians and horse owners: a key factor in the management of Hendra virus. Poster presented at: The Australasian Society for Infectious Diseases Zoonoses conference; 2012 July 27-28; Sydney, Australia.
3. **Mendez D**. Is there a disconnection between veterinary undergraduate infection control training and infection control experiences during extramural professional training? Presentation given to the One Health Research Group, School of Public Health and Tropical Medicine – James Cook University; 2014 February 12; Townsville, Australia.
4. **Mendez D**, Speare R. The new face of Australian bat lyssavirus: a new emerging public health threat. Presentation given at the Queensland Tropical Health Alliance/ Australian College of Tropical Medicine “Tropical Health – Local labs: global impact” conference; 2013 September 7-8, Cairns, Australia.

Preamble

This preamble is a reflection on the journey that brought me to pursue this Doctorate of Philosophy, nicknamed “the fud” (PhD) by my husband and daughter.

I cannot recall my first tooth or my first step and I cannot remember a day in my life where I couldn't understand or speak French and Spanish; but I do recall my two first passions: mathematics and reading. I do not remember how I caught the first one; numbers and shapes seem to always have made sense to me. I do recall, however, how I caught the second one: I was about 11 and I was reading “La Gloire de mon Père” by Marcel Pagnol. I soon relapsed with “Le château de ma Mère”; and I have been a chronic reader ever since. In my early teenage years, I would avidly devour everything from classics, to historical and science fiction novels. My younger sister lost her playmate many a times to the likes of Alexandre Dumas and Isaac Asimov.

My condition soon became multicentric when I started developing an interest in Science through my readings. I caught the bug from “scientific” novels. I call them “scientific” because the science behind them seemed plausible and almost too contemporary to be futuristic. I remember in particular “L'enfant du cinquième Nord” by Pierre Billon; the story of a boy infecting and disabling all forms of technology all the while curing sick people around him. It took me four days to read it, because my sister hid the book for 2 days in protest of my lack of playfulness! Then came “Les Princes du sang” by Gilbert Schlögel after which there was no turning back. I was hooked on the medical novel genre for better or for worse.

If the readings in my younger years planted the seed of curiosity for medical mysteries, my tertiary education nurtured my growing fascination for the underworld of infectious diseases. How could Mr Van Leeuwenhoek's invisible unicellular animalcules create such havoc in more complex multicellular beings like us? How did these smooth operators disseminate, invade and conquer? How did they evade our natural and therapeutic defences? How could we, humans, the superior species, be so defenceless before these cunning nothings? My undergraduate veterinary studies taught me a lot about the dynamics and epidemiological intricacies of these microscopic undesirables and introduced me to the notion of infection control. Infection control: what a brilliant idea! Stopping the little suckers before they march onto animal or human terrain and destroy the landscape like Hannibal and his elephants!

In 1996 I moved to Australia to pursue love and happiness. After a couple of years an inspiring chance encounter with a rather unique and generous doctor of all animal species (including Homo sapiens) sealed my fate. His comprehensive approach to all infectious diseases appealed to me. After 17 years of collaboration I am not afraid to report that his way of thinking has rubbed off on me. Under his mentorship I undertook a Master of Public Health which contextualised infectious disease control into

the macroscopic realm of veterinary and public health. Infectious diseases have been around for millennia and have shaped our history. Today, as I write these lines, studying infectious diseases in isolation, without understanding how they affect our lives, our domestic or wild animals, or our environment no longer makes sense to me. This is where my PhD emerged.

One of our microbiology lecturers at the École Nationale Vétérinaire de Nantes, France, defined infection control by saying: “There is the inside world and the outside world and the two shall never meet”. In other words, there is a germ free world and a germ contaminated world and to achieve infection control, the two worlds should never cross paths. In retrospect, this was a very good way of explaining the concept of infection control within controlled laboratory settings; and I have used this definition to teach others on many occasions. However, it is difficult to see how this definition could be used outside the laboratory context where conditions are much less predictable and therefore more difficult to control.

In September 2009, the uniquely Australian emerging zoonosis, Hendra virus, claimed its fourth human victim. Five of the seven people who had so far contracted Hendra virus, did so while conducting veterinary services. These people were no ordinary members of the public. They were professionals who were aware of infection control principles and protocols, so why did they fail to implement these principles and protect themselves? Beyond knowledge and official guidelines, each of these people were individuals who made their own decisions. The question therefore wasn't what they did wrong, the consequences of their acts speak for themselves; but why they did so. Hence the motivation behind the topic of this PhD: “Identifying and understanding the factors affecting infection control and Hendra virus risk management in veterinary practices in Queensland, Australia”. The completion of this PhD required me to build bridges between my veterinary and public health skills as well as my quantitative and qualitative research skills. Although I am sure I am not the first to endeavour such a multidisciplinary approach, I have seldom come across it in my reading about veterinary infection control. I hope this work brings a new and valuable contribution to the field and helps develop better guidelines in the future.

A final note, I cannot ignore my other passion: colour. Colour is so much part of who I am that it was bound to sneak its way into this PhD too. I hope you enjoy the splashes of colour included here, courtesy of the collaboration with my cartooning husband.

On with the serious stuff now...



Art work by Ken Miller

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List of abbreviations

ABL: Australian Bat Lyssavirus

AHA: Animal Health Australia

ARIA: Accessibility/Remoteness Index of Australia

AVA: Australian Veterinary Association

CDC: Centre for Diseases Control and Prevention

CI: Confidence Interval

DAF: Department of Agriculture and Fisheries

DoH: Department of Health

EID: Emerging Infectious Diseases

EVA: Equine Veterinarians Australia

EZD: Emerging Zoonotic Diseases

HAI: Healthcare Associated Infections

HeV: Hendra Virus

HIV: Human Immunodeficiency Virus

IC: Infection Control

IQR: Inter Quantile Range

JCU: James Cook University

MDREC: Multidrug-Resistant *Escherichia coli*

MRSA: Methicillin-Resistant *Staphylococcus aureus*

NNDSS: National Notifiable Diseases Surveillance System

NSW: New South Wales

OHS: Occupational Health and Safety

PBS: Pharmaceutical Benefits Scheme

PPE: Personal Protective Equipment

QLD: Queensland

SARS: Sever Acute Respiratory Syndrome

SD: Standard Deviation

UQ: University of Queensland

VSBQ: Veterinary Surgeons Board of Queensland

WHO: World Health Organization

WHS: Workplace Health and Safety

WHSQ: Workplace Health and Safety Queensland

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INTRODUCTION

Human history has been shaped over the centuries by the intricate relationships between population dynamics, the environment and infectious diseases.¹⁻⁶ These interrelations still govern the human narrative of today and the emergence of new infectious diseases is always contextualised within human demographics, environmental and societal changes.^{4,7,8} Infectious diseases are defined as a type of illness “*caused by a specific infectious agent [bacteria, virus, parasite, fungi, or prion] or its toxic product that results from transmission of the agent or its products from an infected person, animal or reservoir to a susceptible host [human or animal], either directly or indirectly...*”;⁹ as such they are inherently indivisible from the concept of human health. Furthermore, determinants of human health frequently overlap with drivers of infectious diseases, and the World Health Organization (WHO) along with the scientific community usually address these issues concomitantly.^{10,11} For example, in some populations poverty, the high incidence of infectious diseases and generally poor health indicators are so often intertwined that WHO coined the term “*infectious diseases of poverty*” and a new scientific journal was created to report research activities in this specific field.^{11,12}

For centuries, humanity was at the mercy of the inevitability of infectious diseases which remained the leading cause of death until more recent times. But modern medicine and public health reached a turning point in the twentieth century thanks to numerous key discoveries.^{13,14} One of the most significant medical advancements of this era was the discovery and implementation of antimicrobial therapy, which saved many lives from the scourges of infectious diseases.^{13,14} The therapeutic prospects of antibiotics were so tantalising that they were thought to be the end solution to infectious diseases. In comparison pre-antimicrobial times were thereafter referred to as the “*dark ages*” of medicine; an era where a modern day minor skin lesion could have rapidly turned into a severe infection, septicaemia and death.^{13,14} However, in 1928 Alexander Fleming’s fortuitous discovery of the antibacterial properties of a fungal by-product brought to the world the promise of a reprieve from infectious diseases.¹⁵ Howard Florey later showed the efficacy of penicillin in human patients and developed the first mass production process for penicillin.^{16,17} Penicillin revolutionised the treatment of many

infectious diseases, thus contributing to the amelioration of health outcomes and indicators for humans and domestic animals. However, despite predictions that antibiotics would soon help eradicate most infectious diseases,¹⁸ Sir Alexander Fleming cautioned the scientific community in his Nobel Prize (1945) acceptance speech:

“...There is the danger that the ignorant man may easily under dose himself and by exposing his microbes to non-lethal quantities of the drug make them resistant.”¹⁹

A few years earlier (1928), another Nobel Laureate, Charles Jules Henri Nicolle, a French bacteriologist who identified lice as the vector for typhus, also predicted that:

“Si la civilisation humaine se maintient, si elle continue de se développer et de s'étendre, les maladies infectieuses augmenteront de nombre dans toutes les régions du globe.”²⁰

(“If human civilization persists, if it continues to develop and expand, infectious diseases will increase in number in all the regions of the globe”)

Fifteen years into the twenty-first century, the predictions of Fleming and Nicolle have become a reality. While the world population has grown from around 2.5 billion (in 1940) to 7.2 billion (in 2014),^{21,22} only two viral infectious diseases have been eradicated thanks to vaccines: smallpox in humans and rinderpest in livestock.^{23,24} In 2010, infectious diseases were still estimated to have caused around 13.2 million deaths worldwide.²⁵ Furthermore, the efficacy of some antibiotics is now considered to be declining and the future of antimicrobial therapy is under threat. The steady emergence of new infectious diseases (emerging for the first time); the re-emergence of old infectious diseases (known infectious diseases re-emerging with a modified epidemiological profile); the increase in resistance to antimicrobial agents; and the decreased focus of pharmaceutical companies on developing new antibiotics are viewed by leading world health authorities as a serious threat to human health.²⁶⁻³² Medical, veterinary and associated scientific experts along with health authorities are urging all health practitioners to follow more stringent antimicrobial stewardship to preserve the efficacy of currently available antibiotics.³³⁻³⁹

Although existing and re-emerging infectious diseases present significant public health challenges, the growing number of new emerging infectious diseases (EID) has the potential to overwhelm public health systems because of their unpredictability.^{31,32} Moreover, the presently available arsenal of antibiotics, vaccines and other chemotherapies are likely to be ineffectual against EID as initially their bio-molecular, pathogenicity and epidemiological characteristics are inherently unknown. Hence, preparedness of health systems is paramount to the successful management of EID and requires prompt recognition and characterisation of their causative agents in order to implement adequate control and preventive measures while tailored therapeutics are being developed.⁴⁰⁻⁴² Indeed, despite the rapid progress in the development of new therapies, the approved commercialisation of such treatments for the cure and/or prevention of new EID remains costly, time consuming and continues to present legal and technological challenges. Thus such therapeutics are unlikely to become promptly available when an EID arises.⁴³⁻⁴⁷ In the interim, the management of EID outbreaks is mostly reliant on infection control (IC) measures, which aim to prevent further transmission from index cases to at risk populations, and the provision of supportive therapy to those infected.^{42,48-50} Lessons learnt during recent significant EID outbreaks (e.g., Severe Acute Respiratory Syndrome (SARS) (2003); and Ebola virus disease (2014)), show that IC preparedness and competency of healthcare systems and healthcare workforces are crucial for mitigating public health risks in such events.⁵⁰⁻⁵⁵

Epidemiological studies dichotomise EID into two groups: zoonotic and non-zoonotic EID.⁷ Currently EID, which have been increasing in numbers since the 1940s, are predominantly zoonotic in nature (60-75%).^{7,56} It is thought that zoonoses became a more significant source of human infectious diseases with the rise of agricultural activities and domestication of animals to secure food supplies.¹⁻³ The WHO defines zoonoses as:

*“Any disease or infection of bacterial, viral, parasitic, fungal or prionic nature that is naturally transmissible from vertebrate animals to humans”.*⁵⁷

Notably, there are also infectious diseases that can be transmitted from humans to vertebrate animals, including those caused by antibiotic resistant microbes such as Methicillin-resistant

Staphylococcus aureus.⁵⁸ These infectious diseases are called zoonoses (previously anthroponoses); however, these are rarely reported in the literature.⁵⁸

The host ubiquity of zoonoses and their ability to adapt to new environments makes them a threat to animal as well as human health; hence their significance for public and animal health.^{8,59-64} Emerging zoonotic diseases (EZD) are mostly maintained in wildlife animal reservoirs and spill over to humans either: directly as in the case of the Australian Bat Lyssavirus (ABLV); via an intermediate animal vector such as mosquitoes transmitting West Nile virus from birds to mammals, including humans; or via an intermediate domestic animal such as pigs and horses in the case of Nipah virus. Transmission of zoonotic pathogens follow four general patterns:⁶⁵⁻⁶⁷

1. Humans are dead-end hosts because the pathogen fails to transmit beyond the initial infected human (e.g., ABLV, Leptospirosis);⁶⁸⁻⁷¹
2. Human to human transmission is limited because the pathogen may transmit through an additional or even several human to human cycles, but dies out after failing to become adapted to humans as a host (e.g., *Salmonella*, *Campylobacter*, enterohaemorrhagic *Escherichia coli*);^{72,73}
3. Zoonotic pathogens establish complex transmission webs with frequent spill over to humans and also spillback from humans to animal hosts (e.g., *Giardia*, *Cryptosporidium*, *Staphylococcus aureus*, *Clostridium difficile*);⁷⁴⁻⁷⁷
4. Zoonotic pathogens fully adapt to humans after the initial transmission from an animal host with subsequent transmission through many human to human cycles, with the pathogen becoming free of the need for an animal reservoir (e.g., SARS, Human Immunodeficiency Virus (HIV), many strains of influenza A);⁷⁸⁻⁸⁴

Scenarios 2 and 3 represent a significant but usually localised and limited burden on public health. Scenario 4 is considered the biggest infectious threat to global public health and has already proven to be a significant burden on public health systems around the world. For example, between May and July 2003 SARS reached 29 countries and 8,076 people became infected, 774 of whom died.⁸⁵ Similarly, avian influenza (H1N1) started in Mexico in April 2009 and by August 2009 170,000 people from 160 countries had become infected with H1N1 with 100 deaths worldwide.⁸⁶

In the first scenario, outbreaks may only affect a small number of people but, if highly pathogenic, can remain a serious risk to public health.⁸⁷ Furthermore, people who regularly care for wild and/or domestic animals in the course of their professional and/or volunteering occupations, are at a higher risk of exposure to EZD.⁸⁸⁻⁹⁴ Veterinarians and allied professions are, for example, more likely to come into contact with a zoonosis during the course of their career caring for domestic or wild animals, than other members of the public.^{88,94-97} However, it could be argued that since veterinarians are trained in IC and management of zoonoses, they should therefore know the principles and procedures to mitigate their own exposure and the exposure of others (animals and humans) to any zoonosis, including EZD. In theory, their specialised knowledge should protect them against EZD because it should mitigate their high occupational risk of exposure to such diseases. Indeed, veterinarians are usually considered to be more proficient at recognising and managing zoonoses than physicians.⁹⁸⁻¹⁰¹ However, a recent case has thrown doubt on the readiness and aptitude of Australian private veterinarians to manage EZD. The emergence of the Hendra virus (HeV) in 1994 in Australia proved to be a significant challenge for private veterinarians in this country. Five veterinary personnel became infected with this zoonosis while managing the health of equine patients; only two survived their infection.^{68,69,102}

The latest veterinarian who died of HeV in September 2009 was an experienced equine practitioner who had attended a HeV management training course earlier that year, yet failed to use the recommended personal protective equipment.^{103,104} Why were private veterinarians still failing to protect themselves from a zoonosis they knew to be deadly? Was this state of affairs a reflection of veterinary IC inadequacies, a lack of IC knowledge and/or practical skills,

a reluctance to implement IC measures, or a lack of veterinary preparedness to manage EZD? These questions prompted a high level of scrutiny into veterinary IC behaviours in private practices in Australia in 2009-10 by government and veterinary professional agencies, with the aim of improving these behaviours and reducing risks.

It is in this context that the work presented in this thesis was undertaken with the overall aim of identifying and understanding the factors affecting IC and HeV risk management in private veterinary practices in Queensland, Australia. Chapter One introduces the topic further, examines the definition of veterinary IC, how it is practiced in Australia and the significance to the Australian veterinary profession of the emergence of HeV. Chapter Two introduces the research methodologies used. Chapters Three to Seven present and discuss the results of the research studies that were conducted. Chapter Seven will be followed by a conclusion including recommendations for improving veterinary IC.

In the words of Jack Nicholson in "Mars Attacks!" (1996)¹⁰⁵, the question here is...



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CHAPTER 1 – Veterinary infection control and emergence of Hendra virus in Australia: status quo in 2009.

Aims of this chapter

- Define veterinary infection control.
- Assess the state of veterinary infection control practices in Australia in 2009.
- Provide an epidemiological background for Hendra virus and its emergence.
- Discuss the significance of the emergence of Hendra virus to the veterinary profession in Australia in 2009.
- Set out the research questions and aims of this thesis.



Art work by Ken Miller

Introduction

The advent of infection control (IC) in healthcare settings is generally attributed to Ignaz Philipp Semmelweis, a Hungarian physician who, in 1848, first recognised the significance of hand hygiene for the prevention of the transmission of infectious diseases within a hospital environment.¹ Semmelweis realised that women cared for by midwives had a better chance of survival than those cared for by obstetricians and their students who conducted necropsies before attending to their parturient patients, many of whom subsequently died of puerperal fever.² From these observations he theorised that the doctors and medical students, and more specifically their hands, were the probable vectors of the causative agent of puerperal fever. He confirmed this theory empirically by demanding that all doctors and students involved in post-mortem activities thoroughly wash their hands in a chlorinated lime solution before attending to any pregnant woman. He later extended this washing regime to instruments used in the labour ward. These measures led to a drop in post-partum morbidity and mortality in the women cared for by doctors and students. Semmelweis's intervention demonstrated that systematic hand hygiene could prevent puerperal fever infection. Unfortunately, his conclusions were met with contempt and disbelief by his peers because they did not fit the miasmatic view of infectious diseases of the time.^{1,2} It would take the paradigm shift brought by the Germ Theory fathered by Louis Pasteur and strengthened by Robert Koch and the introduction of surgical asepsis by Joseph Lister in the late nineteenth century, before Semmelweis's views on hygiene and antisepsis in healthcare environments became widely accepted by the medical profession.³⁻⁶

The transmission of human and animal infectious diseases are governed by the same mechanisms.⁷ In all cases, infectious diseases prevail when their causative agents (bacteria, viruses, parasites, or prions) are transmitted directly or indirectly from a source (one or more infected individuals in the population) to a susceptible host.⁷ Thus medical and veterinary IC have the same *raison d'être* which is to prevent the transmission of infectious agents in the medical and veterinary environments; they should therefore follow similar principles.

The aims of this chapter are to define IC in broad terms; to contextualise IC within the animal healthcare sector; to discuss veterinary IC in Australia as practiced in 2009; and to examine the significance of the emergence of the new Australian zoonosis, Hendra virus (HeV), for the veterinary profession.

1.1- Infection control: a definition

Since Semmeleweis's time, the concept of hygiene has morphed into the concept of prevention and control of infectious diseases; prevention before transmission of disease, and control where disease is already present. Notwithstanding this dichotomy, prevention and control are often amalgamated under the general term of "*infection control*". The Mosby's Medical, Nursing and Allied Health dictionary defines IC as:

"The policies and procedures of a health facility to minimise the risk of spreading nosocomial or community-acquired infections to patients, accompanying members of the community or members of the staff".⁸

The World Health Organization (WHO) extends the definition beyond healthcare settings and includes the principle on which it is based:

"Infection prevention and control measures aim to ensure the protection of those who might be vulnerable to acquiring an infection both in the general community and while receiving care due to health problems, in a range of settings. The basic principle of infection prevention and control is hygiene".⁹

Although IC is at the core of public health promotion in healthcare settings, the risk of hospital acquired infectious diseases is still omnipresent around the world.^{10,11} Health care-associated infections (HAI) are more commonly referred to as nosocomial diseases. The Centre for Disease Control and Prevention (CDC) distinguishes between two sources of infectious diseases: the natural microflora present on the tegument and mucosae of the body of a patient; and infectious agents mediated by healthcare workers, equipment and environment and visiting

members of the public.¹⁰ Transmission of HAIs can be: direct via person to person contact; indirect via specific medical paths such as medical devices and procedures and the administration of medical treatment; or via non-medical related paths such as air, food and beverages, fomites and the environment.¹²⁻¹⁷ From a public health perspective HAIs are a health issue for hospitalised patients and place significant financial and clinical strains on hospital systems. For example, in the United Kingdom, the yearly burden of all HAIs has been estimated at 930 million pounds (2004); in the United States this cost is estimated to be between 28 and 45 billion US dollars (2009) and in France the yearly cost of surgery-related HAIs during 2009 was calculated close to 57 million Euros.¹⁸⁻²⁰

Aside from being a major public health issue, HAIs are also a significant occupational health and safety problem for healthcare workers and allied health staff, as being in contact with infectious patients puts them at risk of also becoming infected. Despite health professionals being well aware of this occupational risk, there have been many documented reports of healthcare workers acquiring occupational infections. An Italian study found that up to 7% of all university healthcare workers reported at least one occupational exposure to human blood or bodily secretions via a sharps injury or cutaneous or mucosal splashes.²¹ Healthcare workers in the United States were found to have been exposed to the emerging influenza virus A(H1N1) because they failed to use protective masks.²² The emergence of the severe acute respiratory syndrome (SARS) also put healthcare workers at a higher risk of infection as highlighted by the number of occupational exposures to SARS in Hong Kong in 2003. The majority of these cases were mostly attributed to a lack of compliance with the use of personal protective equipment (PPE) and being unprepared to manage unknown infectious diseases.²³ In all cases, occupational exposures and/or infections occurred because the possible paths of transmission between infected patients and healthcare workers were either facilitated by procedural mishaps, were not curtailed by the implementation of IC measures such as the use of PPE, or due to a lack of competence in mitigating an emerging, and therefore previously unknown infectious risk.

From a workplace health and safety perspective IC strategies, regardless of the infectious risk being considered, are ranked according to the reliability and degree of protection they afford.²⁴ The hierarchy of IC categorises these measures from the highest and most reliable strategy,

which involves the elimination of the infectious risk altogether, to the lowest and least reliable level, which involves the use of PPE (Figure 1.1).



Figure 1.1- Hierarchy of infection control.²⁴

In practice, medical IC strategies, policies and implementation protocols are formulated at various levels: governments (national and local); professional agencies; hospitals and private practices. They are often based on the numerous recommendations and guidelines provided by two internationally recognised authorities: WHO; and the CDC.^{25,26} While some policies/guidelines are disease-specific (Ebola, tuberculosis, influenza (H1N1)), WHO also provides healthcare workers with a set of standard IC precautions which are intended for the management of any infectious disease whether the etiological agent of the disease is known or unknown.^{25,27} However, despite the evidence of a worldwide commitment to curb the prevalence of HAIs, they remain a major clinical, financial, and occupational health and safety burden on public healthcare systems.^{18-23,28} The persistence of HAIs is primarily due to the ongoing lack of, and the incomplete or inappropriate compliance with, IC guidelines by healthcare workers. Furthermore, the emergence of new infectious diseases (e.g., SARS, Ebola) and the re-emergence of others (e.g., multidrug-resistant tuberculosis, multidrug-resistant *Staphylococcus aureus*) also tested current IC standards. Infection control policies and

guidelines are constantly being revised to reflect the growing body of epidemiological knowledge about old, new and re-emerging infectious diseases.²⁹

Surprisingly, one of the most commonly neglected IC standard precautions remains the lack of adherence to the recommended hand washing regime amongst healthcare workers. On the scale of hierarchy of IC, hand hygiene would be ranked at the lower end of the IC spectrum as it does not remove the risk of infection; it only reduces the likelihood of exposure to an infectious agent. Notwithstanding, hand washing has been recognised as one of the simplest and most cost effective measures to reduce contact transmission of infectious diseases in healthcare settings and the community at large.³⁰⁻³² Despite this, suboptimal hand hygiene by healthcare staff remains an issue of concern for clinicians and public health practitioners.^{33,34} Hence, the WHO worldwide campaign promoting patient safety by the observance of hand cleanliness,^{34,35} and the ongoing study of the motivations behind hand hygiene behaviours in healthcare settings; this continues to be an active field of research more than two centuries after Semmelweis's initial recommendations.³⁶

In the medical field, patients, visiting members of the community and healthcare workers pertain to the same species, human, and are in theory susceptible to the same diseases with varying degrees of risk factors such as age, sex, occupation, or health status. In the animal healthcare sector, the situation is more complex, because more than one species is involved and not all species are susceptible to all infectious diseases. In this cases, routes of transmission of infectious diseases can be divided into three types: 1) animal to animal (within an animal family or different animal families, e.g., Canidae for canine parvovirus;³⁷ and Bovidae and Canidae for *Mycobacterium bovis*³⁸); 2) animal to human or zoonoses (transmissible from vertebrate animals to humans, e.g., Q-fever³⁹); and 3) human to animal or humanoses (transmissible from humans to vertebrate mammals; e.g., methicillin-resistant *Staphylococcus aureus*⁴⁰). The management of diseases of type 2) and 3) requires IC measures that prevent transmission between animals and humans and represent the closest scenario to the medical field because patients, accompanying members of the public and healthcare workers are all susceptible to the same diseases.

The prevention of zoonoses in veterinary healthcare settings requires similar IC strategies to those recommended in the medical field and their implementation may present the veterinary profession with similar challenges to those observed in the medical field. However, in order to understand the idiosyncrasies of veterinary IC it is necessary to examine it in its own context.

1.2- Veterinary infection control: a definition in its own context

The overarching aim of veterinary IC is similar to that of IC in the medical field; preventing and controlling the spread of infectious disease in a healthcare environment. Consequently, one could assume that veterinary and medical IC are the same, and thus defining veterinary IC would simply require adding the term “veterinary” to the above mentioned definition:

*“The policies and procedures of a **veterinary** health facility to minimise the risk of spreading nosocomial or community-acquired infections to patients, accompanying members of the community or member of the staff”.*⁸

Indeed, the similitudes in principles often lead to the use of a common IC vernacular in both healthcare sectors, with veterinary IC often appearing to be benchmarked against medical IC.^{41,42} This is particularly evident when examining studies that evaluate veterinary IC by assessing the rates of mask and glove usage, hand washing or needlestick injuries.^{41,43-46} However, upon closer examination, the context in which veterinary and medical IC are applied are very different (Table 1.1).

For example, veterinarians deal with more than one species including humans, giving them animal health as well as public health responsibilities. Animal patients are generally much less compliant and have a reduced ability to communicate. Furthermore, each animal species will also present with its own challenges such as anatomical attributes, behaviour, diseases, and emotional or monetary value to its owner. For instance, the rationale behind the choice of a handling method for a cat, a dog, a cow, a snake, a rabbit, a horse or a wild animal can vary greatly.

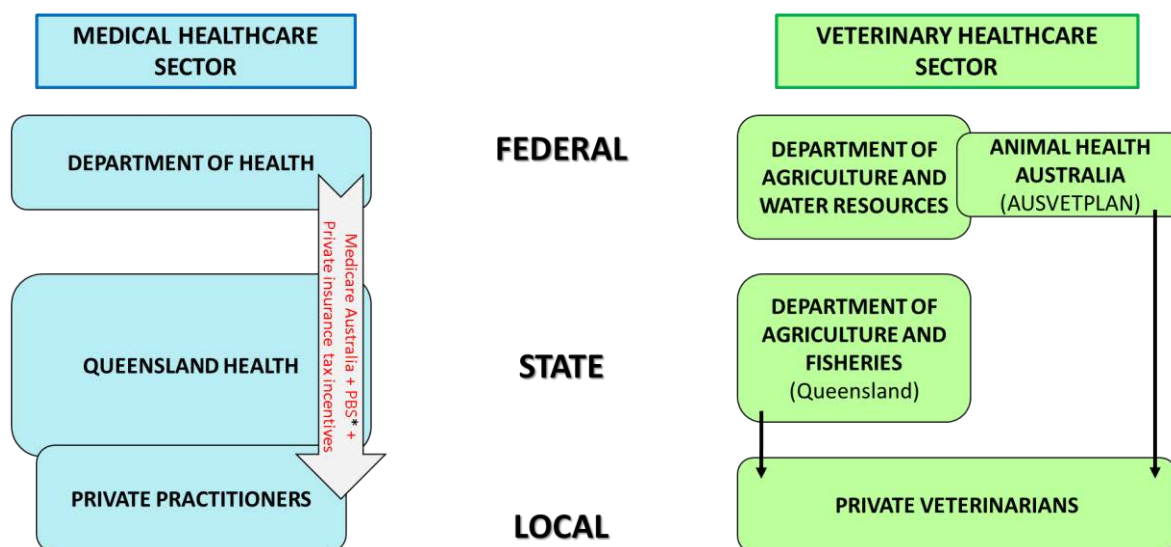
Table 1.1- Contextual differences between medical and veterinary infection control.

Points of difference	Medical infection control	Veterinary infection control
Target population	1 Species (humans) Public health Workplace health and safety	Multiple species (humans & animals) Biosecurity & Public health Workplace health and safety
Communication challenges between healthcare workers & patients	Motivated to comply & good communicators (exceptions: emergency room, paediatrics and mental health)	Poor compliers & communicators (animals)
Quality of work environment	Stable: Mostly clean & controllable (clinical settings)	Variable/unpredictable: Clean & controllable (clinical settings) <i>versus</i> Dirty & unpredictable (field settings)
Risk of trauma caused by patients	Patients' behaviour self-controlled (exceptions: emergency room, paediatrics and mental health)	Patients' behaviour unpredictable Size/strength of patient may be an issue
Legal and financial structure	Strong government involvement (In Australia: Medicare, PBS*, Tax incentives) ⁴⁷⁻⁵⁰	Mostly Private

*PBS: Pharmaceutical Benefit Scheme.

The veterinary work environment can also be very variable and unpredictable and range from the clean setting of a consultation room to the dusty and weather dependent setting of a paddock. Veterinary practices and hospitals also operate on a private business model unlike their medical counterparts which are usually strongly supported by government agencies. In Australia for example, visits to a general practitioner (private or not) or hospitalisation in a public hospital are subsidised by the government through Medicare, i.e. the Australian health

care system, the Pharmaceutical Benefits Scheme (PBS) subsidises the cost of prescription medicines (Figure 1.2).⁴⁷⁻⁴⁹



* PBS: Pharmaceutical Benefit Scheme

Figure 1.2 - Differences in government involvement between medical and veterinary healthcare sectors in Australia.^{48,51-55}

The Australian public health care system is further supported by tax incentives to taxpayers who subscribe to a private health insurance scheme.⁵⁰ Another point of difference is that while isolating index cases in both healthcare settings is a common IC practice, it is not ethically acceptable to use euthanasia to eliminate the source of infection in the medical field. This is a common infectious disease containment strategy used in the veterinary field during epidemic outbreaks.⁵⁶⁻⁵⁸ So, although medical and veterinary IC are based on the same principles, they are definitely not the same. Despite these contextual divergences, transmission of nosocomial diseases have been reported from animal healthcare settings, indicating that veterinary IC behaviours may have some commonalities with those observed in the medical field.⁵⁹⁻⁶⁴

Defining veterinary IC presents a further challenge as the veterinary profession is not always consistent in the terminology they use to refer to IC. The terms “biosecurity” and “infection

control” are sometimes used interchangeably. A biosecurity study conducted in the United Kingdom showed that while farmers included the terms “disease prevention” and “animal husbandry” into the notion of biosecurity, veterinarians mostly included IC terms: “disinfection of equipment” and “use of PPE”.⁶⁵ Another study defined IC as the set of strategies to prevent and control biosecurity risks such as animal HAIs and the transmission of zoonoses.⁶⁴ In Australia, the Australian Veterinary Association (AVA) has a Code for Infection Control and Guidelines for Veterinary Personal Biosecurity; both contain IC protocols to prevent occupational health and safety issues in the veterinary work environment.^{66,67} However, the Merck Veterinary Manual defines biosecurity as:

“Any management practice or systematic application that prevents the spread of pathogens from infected animals to susceptible animals and that prevents the introduction of pathogens or infected animals into a herd, region, or country where the pathogen or disease is not prevalent.”⁶⁸

In this definition, biosecurity focuses on animal health, and more particularly livestock health, and seeks to prevent introduction into and/or dissemination of known or unknown pathogens within animal populations and the subsequent effects on food security and the agricultural economy of a farm, region, or country.⁶⁸ Additionally, biosecurity does not only apply to animal health, it also applies to plant and human health.⁶⁹⁻⁷³ The definition and scope of the term “biosecurity” is therefore not only ambiguous but also extends beyond veterinary IC. There seems to be an overlap in principles and functionality between the two terms which may be the reason why the distinction between “biosecurity” and “infection control” appears blurred. Although biosecurity uses many veterinary IC principles and strategies and is often initiated by veterinarians, it will not be equated to veterinary IC in this thesis. Veterinary IC will be understood as the policies and measures taken to prevent and control infectious diseases in animal patients, clients and staff interacting in a veterinary work environment *sensus lato* which could include clinical and field settings.

Beyond its clinical, agricultural and wider public health significance, veterinary IC also has an occupational health and safety dimension when it comes to the prevention and control of zoonoses. According to Keeling and Rohani (2008), there are around 868 known zoonotic

pathogens in the world, representing 61% (868/1415) of all known human pathogens.⁷ From a veterinarian's perspective there are many possible sources of zoonoses amongst vertebrate animals: traditional small companion animals; farm/livestock animals; unconventional exotic pets; free roaming wildlife; or wild animals kept in captivity.⁷⁴⁻⁸⁸ In most cases, when an animal is recognised as being in poor health by humans, the role of the veterinarian is to assess and identify the cause of the health issue and to provide care for the patient. If the animal's illness is caused by an infectious disease, veterinarians usually have close contact with infected animals from the onset of clinical signs, putting them at higher risk of exposure to animals in the infective phase of the disease. If the infectious disease is a zoonosis, veterinarians are then at higher occupational risk of contracting the disease as evidenced by many serological studies on zoonoses in veterinarians,^{80,83,87,89-92} and confirmed by the many reported cases of work-related zoonotic infections in veterinarians.^{64,84,85,94-97} Baker and colleagues reviewed 44 seroprevalence studies for a range of zoonoses; 84% of them concluded that veterinarians were at higher risk of zoonotic infection.⁸⁹ Other studies that surveyed veterinarians from around the world found that between 19.1% and 64.5% of participants had been infected with at least one zoonosis during their career.^{75,91,93,95,98-101} Furthermore, opportunities for direct and indirect exposure to zoonoses can be facilitated by occupational injuries which breach the tegument such as animal bites and scratches and sharps injuries.^{43-46,88,95,99,102,013} Additionally, veterinarians often perform in house bacteriological culture for diagnostic purposes; this may be another source of zoonotic infection.¹⁰⁴ Although veterinarians recognise their role in managing zoonoses in their work environment and beyond,¹⁰¹ many studies and case reports that have examined veterinary IC practices for the management of zoonoses have concluded that veterinary IC standards are generally less than optimal and require improvement. Veterinary IC failures that have been documented include a lack of: in-house IC policies; IC training and professional experience in managing zoonoses; lack of hand hygiene and usage of PPE; high rates of needlestick injuries; and poor microbiology protocols.^{43-46,64,84,91,94,101,104,105}

Overall, the implementation of IC principles in the veterinary environment appears to be subject to challenges, just as in medical settings. Some of these challenges are different and inherent to the nature of its context, others are similar and linked to human behaviour. Ultimately, it is globally recognised that veterinary IC is in need of improvement on multiple levels. The following section focuses on the *status quo* of veterinary IC standards in Australia compared to those observed in other countries.

1.3- Veterinary infection control in Australia in 2009

Unlike medical IC, veterinary IC received little scrutiny until more recent years when the number of reports about nosocomial and occupational transmission of infectious diseases in veterinary healthcare settings increased.^{46,75,87,91,94,106-108} In Australia, pre-2009, the terms “infection control” or “biosecurity”, a term used in lieu of IC in some publications, in relation to private veterinary practice were seldom encountered in the literature. In 2006, Sidjabat and colleagues reported the nosocomial emergence and transmission of multi-drug resistant *Escherichia coli* (MDREC) clones amongst dogs, veterinary staff and their work environment; a veterinary teaching hospital.^{109,110} These reports focused on the bio-molecular characteristics of a possible zoonotic agent and remarked that isolation of MDREC from various sources in this environment was reduced when some IC measures were implemented. Furthermore, the authors discussed some IC measures as disease prevention strategies borrowed from human medicine rather than routine strategies used in veterinary practice. Similar studies preceded and followed this particular study but with no mention of the terms IC, biosecurity or recommendations to implement better IC measures.^{111,112} One method of controlling the spread of animal diseases used in Australia is the “humane killing” of infected/sick or susceptible animals.¹¹³ While this approach may protect domestic animals and associated human populations from infection, it does not preclude veterinarians from becoming exposed to potential zoonotic agents as veterinarians often conduct such cullings.^{114,115}

Other studies, contemporary to those described above, investigated the occupational physical, chemical and biological risks and related incidents in the veterinary work environment.¹¹⁶⁻¹²³ One study examined the work compensation claims data for occupational incidents in veterinary practices between 1991 and 1996 in Western Australia.¹²² Claims were made most commonly for injuries caused by animals such as bites and blunt trauma. These results were confirmed by a cross-sectional study of Western Australian veterinarians in 1993.¹²³ While a majority of participants (71%) reported having sustained a physical injury, 8% recognised zoonoses as an occupational hazard and 4% reported having acquired a zoonosis. The authors of these studies recommended the development of a veterinary occupational incident reporting system, providing specialised training to veterinary personnel to mitigate workplace health and safety issues and the use of protective clothing and equipment.^{122,123} They also emphasised the

health and safety legal responsibilities of veterinary employers. However, no specific recommendations were made in regard to zoonotic risks and the terms IC and biosecurity were not used. With only 4% of participants reportedly having been affected by a zoonosis, this risk may not have been perceived as significant. Later studies supported the view that animal and equipment related physical injuries were the most frequent occupational issues encountered by veterinarians and their staff.¹¹⁶⁻¹²¹ Two studies discussed briefly the inadequacy or the lack of use of PPE but not in direct relation to risk of infectious.^{118,119} One study noted that most physical injuries sustained in the veterinary work environment involved an open wound but did not allude to the associated potential zoonotic risk.¹²⁰ This study also observed that very few veterinarians wore gloves or any other PPE at the time they sustained their injuries, even when conducting veterinary procedural activities such as obstetrics, surgery, animal examination and post-mortem. The authors of this study recommended the usage of PPE, however, this was to prevent injuries not infection. None of these studies used the terms IC or biosecurity.

The terms IC and biosecurity, and associated recommendations and guidelines, rarely appeared in publications prior to 2009. Leggat and colleagues observed a high rate of needlestick injuries in Australian veterinarians; they indirectly equated this to poor IC standards.⁴⁶ They advised the need for evidence-based IC guidelines for Australian veterinarians.⁴⁶ There were also very few documented instances of zoonotic diseases amongst Australian veterinarians in the literature. Branley and colleagues reported psittacosis in three veterinary personnel associated with the management of a sick wild bird that subsequently died.¹²⁴ Of the three humans infected only one used gloves and a mask while handling the bird during a post-mortem examination despite psittacosis being part of the initial differential diagnosis. The authors recommended that veterinarians and allied staff use appropriate PPE when examining sick or dead birds. Thompson made similar recommendations about the veterinary occupational risk of acquiring Australian bat lyssavirus when handling bats and encouraged veterinarians to seek pre-exposure prophylaxis.¹²⁵ Interestingly, most descriptions and comments about Australian veterinarians, allied staff or lay assistants being infected with a zoonosis were related to the emergence of an Australian zoonosis: Hendra virus. Of the 15 publications reporting veterinary staff or lay assistants being infected with HeV: two discussed the putative source of human exposure (blood and upper respiratory horse secretions); two described HeV having low infectivity in humans; two observed that a veterinarian and a veterinary lay assistant had become infected after conducting post-mortems on horses with minimal or no PPE; one

concluded that veterinarians needed to be better prepared to mitigate HeV related risks; and only two advocated the need for HeV management guidelines about required PPE and sampling protocols.¹²⁶⁻¹⁴⁰ Another report published by WHO warned of the dangers of handling bats but did not mention the risks involved in handling horses.¹⁴¹ Thornley quoted the 2005 president of the Australian Veterinary Association Queensland Division who pointed out that HeV is rare but has severe consequences and recommended the adherence to official HeV management guidelines including the use of masks and gloves to avoid contact with infective horse blood.¹³⁶ However, none of these reports use the term IC and only one uses the term “biosecurity” when discussing the prevention of HeV infection in horses and humans.

Although IC concepts and strategies implemented in veterinary practices in Australia before 2009 seem to have generated some concern, they were generally poorly documented. Prior to this time, the occupational risk of zoonoses received little attention in the literature. Similarly, veterinary IC did not seem to be of great concern. Before 2009, Australian veterinarians may not have been subjected to significant zoonotic risks thus may not have considered this a major issue requiring action. This belief may have been reinforced by the lack of an occupational zoonoses reporting system in Australia, and the veterinarians’ tendency to self-diagnose and self-treat zoonotic infections.^{122,142,143} However, concerns about the adequacy of veterinary IC in Australia increased with the emergence of HeV. The emergence of this new zoonosis holds a particular significance for the veterinary profession and its implementation of IC measures.

1.4- Significance of the emergence of Hendra virus for the Australian veterinary profession in 2009

The Australian Department of Health currently (November 2015) includes 72 diseases on the Australian national notifiable diseases list.¹⁴⁴ The National Notifiable Diseases Surveillance System (NNDSS) further divides these diseases into nine groups: blood-borne, gastrointestinal, requiring quarantine, sexually transmitted, vaccine preventable, vector-borne, zoonoses, other bacterial diseases and diseases under national surveillance other than by the Department of Health.¹⁴⁵ Of these 72 notifiable diseases only eight are categorised as zoonoses.¹⁴⁵ However,

from an epidemiological point of view, of all these notifiable diseases 25 of them have a strong likelihood of being zoonotic. For example, non-typhoid Salmonellosis, Cryptosporidiosis and SARS which are infectious diseases of animal origin that affect humans.¹⁴⁶⁻¹⁴⁹ Veterinary programmes to control and eliminate zoonoses such as bovine tuberculosis (*Mycobacterium bovis*) and bovine brucellosis (*Brucella abortus*) from the Australian continent have been successful in the past.¹⁵⁰⁻¹⁵³ Furthermore, a vast majority of new and emerging infectious diseases have been identified as being zoonotic in nature.^{154,155} This not only poses a challenge for public health and biosecurity authorities but also for private veterinarians who hold a strategic role in the management of these infectious diseases as they work at the coalface of most animal health incidents. By definition, the emergence of new zoonoses is unpredictable and the related infectious risk is initially uncharacterised. In these circumstances, the observance of adequate standard veterinary IC precautions are paramount. In Australia, as in the rest of the world, veterinary IC has been described as less than optimal and it may be inadequate to manage emerging zoonoses. Deficiencies in veterinary IC in Australia were highlighted by the recent emergence of a new zoonosis; HeV.

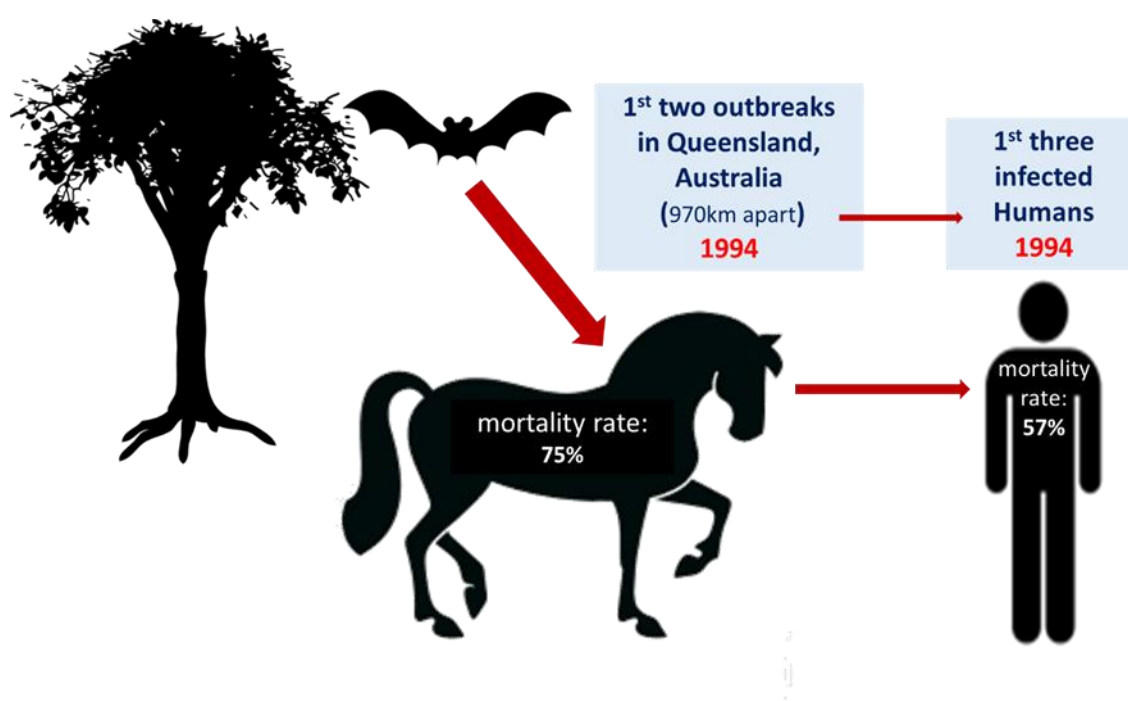


Figure 1.3 – Summary of early Hendra virus epidemiology.¹⁶⁹

Hendra virus is a uniquely Australian paramyxovirus; it is an enveloped negative-strand RNA virus in the genus *Megamyxovirus*, the largest of the Paramyxoviridae.¹⁵⁶⁻¹⁶⁰ It is related to two other paramyxovirus that emerged in the same decade and affected pigs and humans; Nipah virus in Malaysia and Menangle virus in Australia.¹⁶¹⁻¹⁶⁴ Hendra virus is a pleomorphic virus that can take on filamentous or spherical shapes and can grow *in vitro* on a variety of animal cells; mammalian, avian, reptilian, amphibian, and fish cells.^{157, 165} It is a virus that can be easily destroyed by heat, lipid solvents, non-ionic detergents, formaldehyde and oxidizing agents.¹⁶⁶ Hendra virus is closely related to Nipah virus antigenically and cross reacts with Nipah virus antibodies.^{166,167}

Hendra virus was first isolated and characterised in 1994 from samples collected during the first recognised HeV outbreak in Hendra, a suburb of Brisbane, Queensland (QLD), Australia.^{126-129,156-160} This outbreak resulted in 20 horses and two humans becoming infected with this novel virus (Figure 1.3).^{126-129,169} Hendra virus has been isolated from blood and foetal samples from two species of pteropid bats (*Pteropus alecto*, Black flying-fox; and *Pteropus poliocephalus*, Grey-head flying-fox) and two other species of pteropid bats (*Pteropus scapulatus*, Little red flying-fox; and *Pteropus conspicillatus*, Spectacled flying-fox) have also been identified as seropositive.¹⁷⁰⁻¹⁷² The distribution range of HeV, overlaps with the distribution of pteropid bats on the Eastern coast of Australia between Far North QLD and Northern New South Wales (Figure 1.4).^{169,170} Between 1994 and 2009 there were 13 outbreaks of HeV, involving 28 confirmed equine cases and 19 unconfirmed HeV equine cases.¹⁶⁹ All but one of these outbreaks occurred on the Eastern coast of QLD (Figure 1.4).¹⁶⁹ Serological studies conducted in the QLD equine population showed that HeV is not endemic in horses.¹⁷³ Despite a high proportion of seropositive wild pteropid bats, a serological survey of wildlife carers who had regular close contact with these animals did not yield any positive results.¹⁷⁴ Hendra virus is not considered to be transmitted directly from bats to humans. By 2009, the mode of transmission between bats and horses had not yet been fully elucidated. The most likely route of transmission was thought to be via contamination of horse-feed with bat excreta (urine, faeces, blood) and birthing materials (tissue, fluids, aborted foetuses).^{169-172,175} Humans were thought to become infected via exposure to the bodily fluids, including blood, of infected horses, however, this was considered a rare event.^{169,175,176} In animal reservoirs, vertical transmission through the placenta has been demonstrated.¹⁷⁷ Experimentally, cats have been shown to be susceptible to HeV and capable of transmitting the virus to other cats and horses

living in close contact.^{178,179} Guinea pigs and hamsters have also been shown to be susceptible and trans-placental transmission of HeV has been reported in guinea pigs.^{177,180} Other mammalian species (rabbits, mice, rats, dogs) and birds (chickens) have been experimentally inoculated with HeV without developing clinical signs.¹⁶⁵

The *Guidelines for veterinarians handling potential HeV infection in horses* published in April 2009 also mentioned a CSIRO report which stated that horses infected with HeV may excrete viral particles up to 2 days prior to the onset of the first clinical signs.¹⁸¹ However, these findings were not published until 2011.¹⁸² Horse-to-horse transmission has occurred in at least three outbreaks among horses kept in close contact in stables.^{126-129,183,184,185}

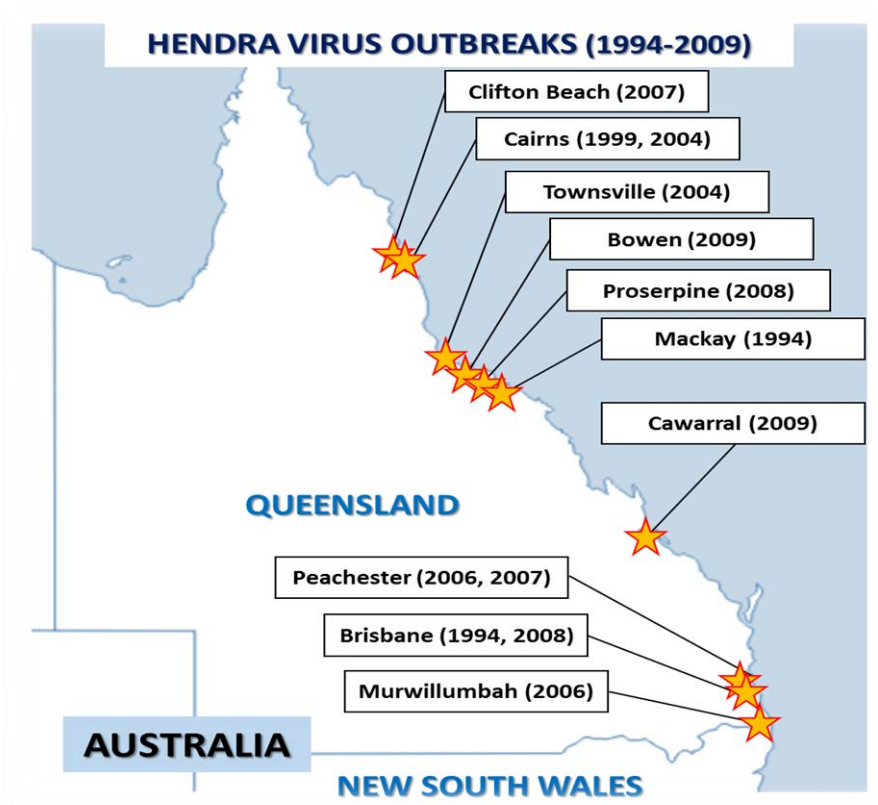


Figure 1.4 – Location of Hendra virus outbreaks between 1994 and 2009.¹⁶⁹

The clinical signs of HeV in horses varies and is non-pathognomonic. Possible clinical signs associated with HeV in horses include a rapid onset of a febrile illness accompanied by

tachycardia, physical discomfort, depression followed by a rapid deterioration with either respiratory or neurological signs.¹⁸⁶ Neurological signs may include: ataxia and behavioural changes; muscular spasms; apparent loss of vision; and urinary incontinence.¹⁸⁶ Respiratory signs may include: hyperventilation, respiratory distress; and clear nasal discharge progressing to blood-stained discharge in terminally ill animals.¹⁸⁶ The main pathological characteristics of HeV in equine tissue are: disseminated vasculitis; haemorrhages; and visceral oedema.^{126,128,130,187-189}

Although occurring rarely, HeV has a case fatality rate of 75% in horses and 57% in humans (Figure 1.3).¹⁶⁹ Of those most at risk of becoming infected with HeV, i.e. people coming into contact with horses, veterinarians have been the most affected subgroup to date (Table 1.2). All seven human cases so far recorded occurred in the state of QLD, Australia. Of these five were veterinary personnel or assisting a veterinarian; two veterinarians and one lay veterinary assistant consequently died (Table 1.2).^{126,130,132,133,137,138,140,169,175,183,184,190} The route of transmission from horses to humans occurs from close exposure to bodily fluids (respiratory secretions and saliva), including blood from a live or dead infected horse. The incubation period in humans is between 5 and 21 days and clinical signs are characterised by the onset of an influenza-like illness, which in some patients progresses rapidly to severe pneumonia or encephalitis (Table 1.2).¹⁷⁵ One patient, apparently recovered from an initial aseptic meningitis, only to relapse 13 months later into fatal severe encephalitis.^{130,132,133,175} In 2009, there was no therapeutic treatment or immune-prophylaxis available for humans. However, human neutralising monoclonal antibodies against HeV showing potential as a therapeutic agent for the treatment and prophylaxis of HeV in humans had been identified.¹⁹¹ The 2008 and 2009 human HeV-related fatalities involved two equine veterinarians who failed to implement appropriate safety procedures (Table 1, Figure 1).^{138,183,184,190} The former did not follow safety instructions while the latter failed to implement the safety protocols recommended at an IC workshop for the management of HeV he attended shortly before his death.¹³⁸ During the 2004 outbreak another veterinarian became infected with HeV while conducting a post-mortem examination of an infected horse without wearing adequate PPE.¹³⁷

Table 1.2- Summary of all reported human cases of Hendra virus in Australia since 1994.^{169,175}

Date	Location (all in QLD*)	Number of HeV confirmed cases	People affected	Clinical presentation	Outcome for people affected
Aug 1994	Mackay	2	1 lay person who assisted a veterinarian conducting a necropsy on a horse	<i>Initial aseptic meningitis followed by apparent recovery. Relapsed a year later with severe encephalitis.</i>	Died after long incubation period (13months)
Sept 1994	Hendra, suburb of Brisbane	7 (+ 13 untested but considered positive)	1 stable hand who dealt with sick horses	<i>Self-limiting influenza-like illness</i>	Survived
			1 horse trainer who dealt with sick horses	<i>Initial influenza-like illness that progressed rapidly into severe pneumonic illness</i>	Died after short incubation period
Oct 2004	Gordonvale, suburb of Cairns	(1 unconfirmed case)	1 veterinarian who conducted a necropsy on a horse	<i>Self-limiting influenza-like illness</i>	Survived
June 2008	Redlands	5	1 veterinarian who performed a procedure involving the upper respiratory tract of a horse	<i>Acute influenza-like illness followed by encephalitis</i>	Died after short incubation period
			1 veterinary nurse who assisted a veterinarian performing procedure involving the upper respiratory tract of a horse	<i>Acute influenza-like illness followed by encephalitis</i>	Survived with lasting sequelae
July 2009	Cawarral	3	1 veterinarian who performed a procedure involving the upper respiratory tract of a horse	<i>Acute influenza-like illness followed by encephalitis</i>	Died after short incubation period

Since 2009, the body of knowledge about HeV has expanded considerably in several areas relevant to this doctoral thesis, including:

- Epidemiology of virus in flying foxes, horses and humans;
- Mode of transmission from animal reservoirs to horses;
- Susceptibility of other species (pigs and dogs);
- Viral properties of HeV (pathogenesis, ecology, virulence);
- Clinical presentation in horses and humans;
- Diagnostic methods;
- Immunotherapy for humans;
- Vaccination for horses;
- Perception of the HeV associated risk among veterinarians and horses owners;
- Risk communication;
- Risk management including necessary IC measures.

New knowledge will be presented and discussed throughout this thesis where relevant.

Veterinarians are recognised as experts in terms of the management of zoonoses.^{192,193} Routine equine veterinary procedures involving the upper respiratory, urinary and reproductive tracts, the management of wounds, and sampling of tissues and bodily fluids during necropsy represent a high risk of exposure for veterinarians. Furthermore, the absence of clinical signs in a horse does not reliably identify horses without disease or low risk of exposure for those handling them since viral excretion may occur up to two days prior to onset of illness.¹⁸¹ In spite of the high risk of exposure, the high case fatality rate with HeV, and the official management recommendations available at the time,¹⁸¹ in 2009 veterinarians were still failing to implement adequate IC precautions to protect themselves and others against potential exposure to HeV. It was unclear if these failures were due to a lack of knowledge, experience with IC procedures, negligence, or some other unknown factors either unrelated to HeV or specific to the disease.

Conclusion

The aims of this chapter were met in the following manner:

- Define veterinary infection control.

⇒ The term “veterinary infection control” although not universally used by the profession was defined in the context of veterinary practices.

- Assess state of veterinary infection control practices in Australia in 2009.

⇒ In 2009, veterinary infection control was considered substandard.

- Provide epidemiological background about Hendra virus and its emergence.

⇒ Hendra virus emerged in 1994 as a new Australian zoonosis affecting horses and humans that came into close contact with infected animals. It sporadically spills-over from native bats to horses and in some cases from horses to humans.

- Discuss the significance of the emergence of Hendra virus to the veterinary profession in Australia in 2009.

⇒ Hendra virus represents a high occupational and potentially lethal zoonotic risk for private veterinarians. Veterinarians have been the most affected subgroup of at risk population; in most cases this was due to poor standards of infection control.

- Set out the research questions and aims of this thesis.

⇒ Included in the conclusion below.

The emergence of HeV in Australia sparked scrutiny into veterinary IC practices and the realisation by government agencies and the veterinary profession that IC standards needed to be improved. In the medical field, clinical professional behaviours, including IC, have been

attributed, amongst other factors, to individual and organisational motivators and it has been recognised that changing healthcare professionals' behaviours requires programs that include these issues.¹⁹⁴ In order to implement sustainable improvements to veterinary IC practices, the reasons behind the gap between expected and/or recommended IC standards and veterinary clinical practice needs to be better understood. Therefore, the overarching aim of this thesis was based on the following two research questions:

- 1- What are the factors affecting veterinary infection control behaviours amongst private veterinarians in Queensland?
- 2- How do these factors affect veterinary infection control behaviours amongst private veterinarians in Queensland?

The aims of this thesis are as follows:

- 1- Peruse the available literature to determine the best methodological approach to identify factors affecting Veterinary IC behaviours among private veterinarians.
⇒ This is addressed and discussed in **Chapter 2**.
- 2- Use a mixed method approach to identify and understand the factors affecting IC for the management of HeV in equine private veterinary practices in coastal Queensland.
⇒ This is addressed in Studies 1 and 2 and findings are presented and discussed in **Chapters 3, 4 and 5**.

3- Use a cross-sectional study design to identify and understand the factors affecting IC in general private veterinary practices in Queensland.

⇒ This section is addressed in Study 3 and findings are presented and discussed in **Chapters 6 and 7.**

4- Use a cross-sectional study design to investigate possible discrepancies between veterinary IC taught at the undergraduate level and veterinary IC experienced by final year veterinary students during their extramural clinical placements.

⇒ This is addressed in Study 4 and findings are presented and discussed in **Chapter 7.**

5- Make recommendations about ways to develop future improvement programmes in veterinary IC; in general and in particular for the management of emerging zoonoses.

⇒ This will be addressed and discussed in **Conclusion and Recommendations.**

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CHAPTER 2 – Investigating veterinary infection control and Hendra virus management behaviours amongst private veterinarians in Australia: research methodology.

Aims of this chapter

- Present rationale and chronology of research methodologies.
- Discuss challenges posed by the use of an untraditional approach in veterinary research.



Art work by Ken Miller

Introduction

Until 2009, veterinary infection control (IC) was appraised directly or indirectly from four different perspectives:

- **From the infectious risk perspective:**
 - Sero-prevalence surveys of veterinarians and domestic animals were looked for evidence of exposure and/or carriage of infectious agents that were zoonotic in nature or had the potential of becoming zoonotic pathogens.^{1,7}
 - Prevalence studies and reviews of known zoonoses in domestic and wild animals highlighted the potential sources of zoonotic risks for veterinarians.^{8,16}

These studies did not directly evaluate the existing standards of veterinary IC; however, they emphasised the higher occupational risk of veterinary personnel acquiring a zoonosis and promoted the need to use recommended veterinary IC standards. They did not refer to a particular document outlining the required IC standards.

- **From the injury risk perspective:**
 - Injuries resulting from animal bites and scratches are frequent in veterinary practice and represent a significant occupational risk; more so because these injuries can be the port of entry for zoonotic agents.¹⁷⁻²⁴ The risk of becoming infected with a zoonosis was here considered as secondary to animal inflicted injuries.^{13,21,25}
 - The zoonotic risk can also be secondary to sharps injuries, such as by needle stick or surgical blade; these are very common in veterinary practice.²⁶⁻²⁹ Some studies deemed needle stick injuries as an indication of poor IC practice, while others moderated the significance of these common injuries suggesting that blood borne zoonoses are not frequent in veterinary practice.²⁹⁻³¹ Such injuries were seen as seldom representing a health and safety occupational issue for veterinarians.

These studies underlined another significant source of zoonotic risk and also advocated the observance of adequate veterinary IC standards without indicating what those standards may or should include.

- **From the perspective of veterinarians infected with zoonoses:**

- There were many case reports of veterinarians and allied veterinary staff and students becoming infected with a zoonosis.³²⁻⁴² Some of these reports linked the transmission of zoonoses to veterinary personnel to IC failures, but did not investigate the cause of these failures.
- Several studies examined the zoonotic infection history of veterinarians over their careers and have reported that up to 64.5% of participants had been infected with at least one zoonosis during their career.^{8,21-23,43-46} There was great variation in percentages of occupational zoonotic infection amongst veterinarians between studies, perhaps due to the differences in methods used and/or recall bias. However, high rates of occupational zoonotic infections amongst veterinary personnel was generally equated to poor IC practices.

The majority of these studies associated zoonotic infections amongst veterinarians and allied staff to substandard IC practices. While they did recommend the improvement of veterinary IC quality, they did not give any reason for the current low levels of veterinary IC.

- **From the perspective of veterinary IC practices:**

- This category mostly included either surveys of veterinarians and their staff or observational studies of veterinary IC habits, which in most cases were deemed insufficient and/or inadequate.^{1,22, 26-29,31,46-50} The IC practices examined most often were: hand hygiene, sharp injuries, usage of personal protective equipment (PPE), access to an in house set of IC policies, IC knowledge and prior IC training.

These studies identified and quantified veterinary IC behaviours but did not explain the motivation behind these behavioural choices.

Although all of the above approaches have proven valuable in highlighting various issues with veterinary zoonotic occupational risks, IC compliance and its consequences, they mostly have failed to elucidate the causes of veterinary IC deficiencies. Compliance with recommended IC standards remains an issue in healthcare settings and it has been established that IC knowledge is not sufficient to foster high levels of compliance.⁵¹⁻⁵³ For example, Pittet explains that the three key determinants of infection control programmes are: microbiology, epidemiology and behavioural sciences.⁵¹ Following IC best practice is an individual choice. However, the studies presented above considered IC solely from the perspective of education, guidelines and policies. This essential aspect of veterinary IC has been overlooked; the drivers behind veterinary IC control are behavioural decisions. Without gaining a better understanding of these motivations it is unlikely that IC improvement programmes and strategies will achieve positive and sustainable veterinary IC changes; the required changes hinge on the modification of human behaviours. In order to identify and understand this aspect of veterinary IC a different research approach is needed.

This chapter presents the rationale of the research methodology used in this thesis and overviews the challenges encountered when using non-traditional methods in veterinary health research, which is traditionally, a quantitative field of research.

2.1- Research into veterinary infection control:

a different approach

The aim of social sciences such as anthropology is to understand human behaviours within the context of their environment, social values, belief systems and cultural characteristics.⁵⁴ Social scientists observe (e.g., observational studies) and question behaviours (e.g., interviews, focus groups), or facilitate behaviour modification (e.g., participatory action research) of study

subjects without controlling the context or the subjects. Such data collection is sought for its subjectivity and the light it sheds on a particular situation. Quantitative research on the other hand, observes (e.g., sero-prevalence studies), inquires (e.g., case-control or cross-sectional studies) or modifies traits or factors (e.g., experimental studies) under study by controlling certain variables and altering others with the intention of isolating an association between two or more variables in an objective repeatable way. In the former, the enquiry is often guided by the subjects, while in the latter, the enquiry is determined by the enquirer. Beyond the ongoing debate about which method is the most rigorous and reliable, some view these methods as being part of a continuum of research that helps to explain different aspects of an issue and therefore consider them complementary.⁵⁵⁻⁵⁷

Qualitative investigative methodologies are commonly used to study phenomena that affect the lived experiences of humans, as individuals or as a group, in a particular cultural and social environment. One key element of a qualitative approach is in-depth consultation with relevant people within a relevant context. This is an investigative method often used to understand human behaviours and interactions in healthcare contexts. They are often the precursors to quantifying behaviours and implementing strategies to modify human behaviours. For example, qualitative methods have been successfully used, on their own or in combination with quantitative methods, to study aspects of general medical practice: general practitioners reporting notifiable diseases to public health authorities; doctor-patient misunderstandings around prescription decisions; or quality of the patient-doctor relationship as a way to improving medical care.⁵⁸⁻⁶⁰ Qualitative studies have been undertaken to help understand how communities react to epidemic events and how healthcare workers manage such events, or how social determinants may affect the health management of an infectious disease in an individual.⁶¹⁻⁶⁴ Qualitative researchers have also gained valuable insights into IC practices, and hand hygiene in particular, amongst nursing students and staff and other healthcare workers.⁶⁵⁻⁷⁰ The contextualised results of these studies and the recognition of factors influencing human health behaviours have allowed the development of readily relevant and applicable IC/hand hygiene improvement programmes, which in turn, have been evaluated using similar methodologies.⁷¹⁻⁷³

Qualitative inquiry has been used in veterinary sciences to investigate therapeutic decisions and ethical issues in veterinary practice, such as the client-veterinarian relationship and veterinarians' uptake of continuing professional education.⁷⁴⁻⁷⁸ However, according to the literature this approach has seldom been used to study IC perceptions, beliefs and behaviours in the veterinary healthcare sector, prior to 2009.

When veterinarians make an IC decision about a zoonotic risk, they are firstly making a health choice for themselves, with their decisions being the result of a risk assessment based upon their knowledge, perceptions, and beliefs about a particular situation. Each of these aspects inform a behaviour. In theory, IC knowledge should not differ significantly within a particular cohort of veterinarians. However, beliefs and perceptions may vary greatly with individuals. Therefore, it is appropriate to initially use a qualitative approach in order to gain an in-depth understanding of veterinarians' IC behavioural motivations.

2.2- Research studies: a mixed methods approach

In total four studies were undertaken during this doctoral thesis (Figure 2.1). These studies were conducted sequentially with results from each study informing the design of and tools used in the subsequent studies.

2.2.1 Study 1

In Australia, the emergence of Hendra virus (HeV) brought to light the shortfalls of veterinary IC. The management of a previously unknown zoonosis is probably the most challenging situation in which to implement veterinary IC measures because the presence of the risk is unpredictable, decisions are not evidence-based in relation to the epidemiology of the zoonotic agent, and healthcare workers are unprepared to deal with the specific risk. The case of the emergence of the severe acute respiratory syndrome (SARS), which took healthcare workers by surprise, illustrates these challenges.⁷⁹⁻⁸¹

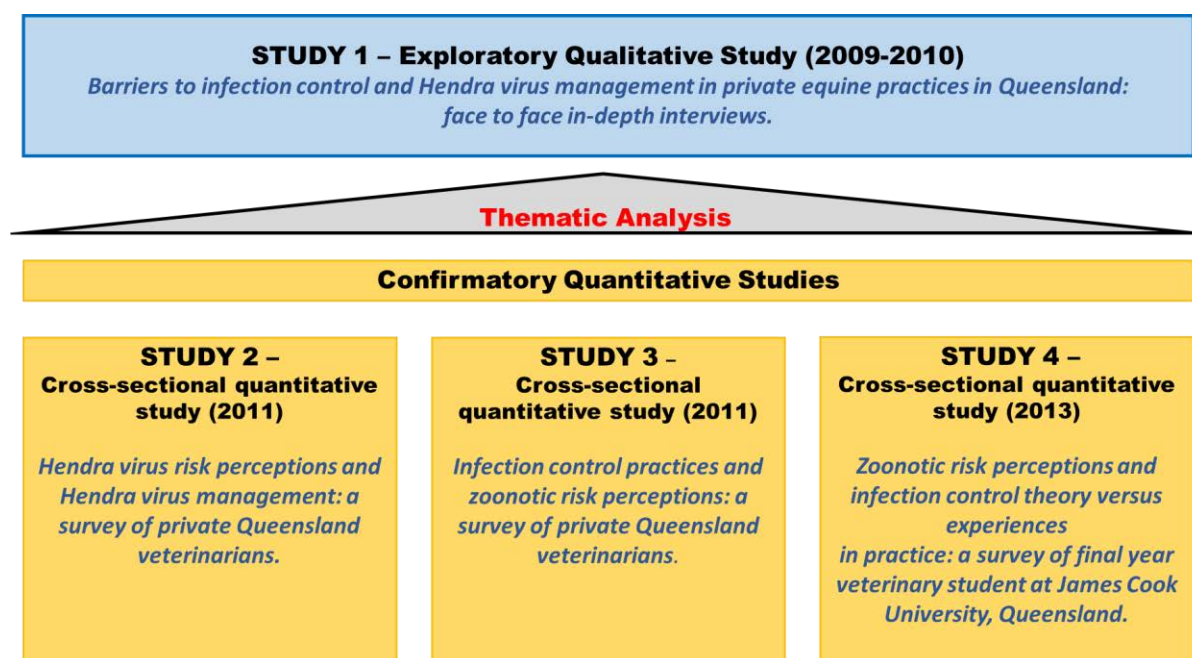


Figure 2.1. Overview and chronological sequence of studies undertaken for the doctoral thesis.

The aim of Study 1 was to use the HeV management crisis to gain an understanding of the driving forces behind veterinary IC attitudes. This qualitative, exploratory study aimed to identify and understand the barriers to IC specifically related to the management of HeV as perceived by private equine veterinarians in coastal Queensland (QLD), Australia. A series of face-to-face, in-depth, semi-structured interviews were conducted with 21 veterinary personnel from 14 equine or mixed practices located within the known distribution range of HeV; the eastern coast of Australia between Far-North and South-East QLD (Figure 2.2).⁸²

The interview questions were developed after consultation with a reference group which included: private veterinarians, public health, biosecurity and government workplace health and safety representatives, veterinary professional agencies, and veterinary and public health academics. The interview guide included eight open-ended questions. All participants were asked all questions. However, during the interviews, participants were free to lead the conversation according to their particular interest in veterinary IC and HeV management and

questions were not always worded in the same manner or asked in the same order. Participants were asked about their perceptions about the management of HeV, related IC and workplace health and safety issues and ways that veterinary IC could be improved (Appendix B1).

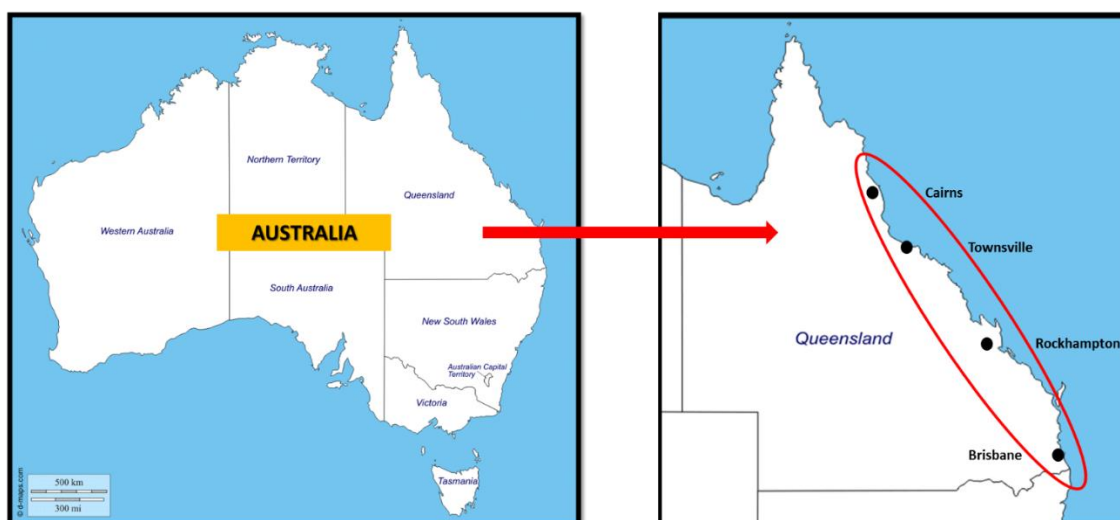


Figure 2.2. Geographic location of study site.

The 21 interviews were conducted between December 2009 and September 2010. Interviewees were from a range of metropolitan, urban, peri-urban and rural and remote areas and included principal, associate and employee veterinarians, equine veterinary nurses and a practice manager. Participants were recruited on the basis of their geographic location, and the type of their practice (purely equine or mixed practice) according to the information available on an online business phone directory.⁸³ More than half the participants had dealt with at least one suspicious case of HeV prior to being interviewed. This study was approved by the James Cook University Human Ethics Committee (Approval N^o H3513; Appendix A1). The results from this study are presented in Chapters 3 and 5.

2.2.2 Study 2

Study 1 revealed that risk perception was a significant driver of IC and HeV management amongst private equine veterinarians in QLD. On the basis of these findings, the aim of Study

2 was to evaluate HeV-related risk perceptions and risk management strategies amongst all private equine veterinarians in QLD, Australia. Study 2 was conducted as a cross-sectional postal survey. Private veterinarians were eligible if they were registered with the Veterinary Surgeons Board of Queensland (VSBQ), worked in private practice in QLD and had attended a horse patient at least once in the 12 months prior to answering in the survey.⁸⁴ The questionnaire for this survey was developed based on the results obtained for Study 1, and the official HeV management recommendations and workplace health and safety legislation in place at the time.^{85,86} The questionnaire was piloted with six veterinarians from the target population. Participants were asked a series of multiple-choice and open-ended questions about their socio-demographic, professional and practice profile, as well as their HeV-related risk perceptions and management strategies and experiences (Appendix B2). The survey questionnaire was sent to 1604 private veterinarians in June 2011, followed by monthly reminders for three months to those who had not returned a questionnaire. This study was approved by the James Cook University Human Ethics Committee (Approval N^o H3687; Appendix A2). The results for this study are presented in Chapters 4 and 5.

2.2.3 Study 3

Study 3 investigated how the factors shown to affect veterinary IC during the management of HeV influenced veterinary IC in general and during the management of other zoonoses. Study 3 evaluated zoonotic risk perceptions and IC habits amongst all private veterinarians in QLD, Australia, regardless of the type of practice and services provided. Study 3 was a cross-sectional survey and was conducted concurrently with Study 2 (June 2011), i.e. both surveys, and reminders, were sent at the same time (in the same envelope) to the same target population (1604 private veterinarians) and potential participants self-selected to complete one or both surveys according to the eligibility criteria provided with the surveys. Eligibility criteria for this survey were being registered with the VSBQ and working in private practice in QLD. The questionnaire for Study 3 was developed based on the results of Study 1 and the survey conducted by Leggat and colleagues in 2006 (Appendix B3).²⁹ This questionnaire was piloted with six veterinarians from the target population. The questionnaire included similar multiple-choice and open-ended questions about socio-demographic, professional and practice type questions to Study 2, as well as questions about zoonotic risk perceptions and related IC

strategies implemented in general veterinary practice. Ethics approval for this study was obtained from the James Cook University Human Ethics Committee (Approval N^o H3687; Appendix A2). The results of this study are presented in Chapter 6.

2.2.4 Study 4

Study 1 indicated that early career veterinarians tended to model their professional habits on those of their professional mentors. Undergraduate veterinary training encompasses a substantial number of extramural professional placements which increase in frequency towards the final year of undergraduate studies.^{87,88} The quality of training received during these placements was questioned by some private veterinarians interviewed during Study 1. Of particular interest were the possible discrepancies between formal IC taught at university and practical IC training experienced by veterinary students during their extramural professional placements. The aim of Study 4 was to evaluate final year veterinary students' zoonotic risk perceptions and the differences between the IC training that they experienced during their undergraduate studies and their experiences during their placements in private veterinary practices. Study 4 was conducted during December 2013, as an online cross-sectional survey of final year veterinary students from James Cook University, QLD, Australia. All students from the target population (60) were invited to participate via an email containing a link to a Survey Monkey® site where the survey was made available to prospective participants. The survey occurred after students had completed their final exams.⁸⁹ The questions were developed based on the questionnaire used for Study 3, Leggat and colleagues' survey and results from Study 1 (Appendix B4).²⁹ The survey contained multiple-choice and open-ended questions that asked students about their socio-demographic and prior educational characteristics, their intended area of veterinary work, their zoonotic risk perceptions and IC experiences. This study was approved by the James Cook University Human Ethics Committee (Approval N^o H3586; Appendix A3). The results from this study are presented in Chapter 7.

2.3- Qualitative research in veterinary science: challenges and strategies.

Since these studies were undertaken, Christley and Perkins made the observation that “*qualitative research is a vital component of human health research...and...these methods have been largely overlooked in veterinary sciences*”, and concluded that some areas of veterinary research would benefit from using a combination of qualitative and quantitative approaches, particularly when studying people’s perceptions, beliefs and behaviours in the veterinary environment.⁹⁰ The results of Studies 1-4 support this view. Janes and colleagues recently highlighted the importance of social sciences in the management of emerging infectious diseases.⁹¹ Qualitative research will undoubtedly continue to provide insightful information about infectious diseases and their management dynamics in a range of human communities.

However, publishing the outcome of qualitative research conducted in the veterinary field has proven to be a challenge, as most veterinary target journals, as well as their reviewers, were unfamiliar with the methodology. Reviewers tended to be critical of the method and appraised results and conclusions from a quantitative research perspective. On the other hand, public health journals, which had access to reviewers familiar with qualitative approaches, viewed the topics investigated in Studies 1-4 as only relevant to veterinarians and related academic fields. This is despite the research presented showing the significant public health role played by private veterinarians in the management of zoonoses. This issue was overcome using the following strategies: 1) patience and persistence; 2) provision of additional educational information about the research methods to reviewers and 3) the maintenance of qualitative research method integrity. In one case, the authors were asked to justify the rigour of the qualitative approach by answering a set of questions the purpose of which was to ascertain the rigour of the qualitative approach. The authors were provided with a set of guidelines for reporting qualitative research and a list of information to be included in the manuscript.⁹² This step by step review procedure was not only helpful to the authors and reviewers but also enhanced the final manuscript.⁹³ As a result, outcomes from Study 1 were published in two veterinary journals and an infectious disease journal (See Chapter 3). A case study of this

particular challenge was published in the second edition of *Epidemiology* by Büttner and Muller (Appendix C1).⁹⁴

Overall, the mixed methods approach used for these doctoral studies proved valuable as it broadened the understanding of IC and HeV issues in private veterinary practices in Australia. The outcomes from the initial qualitative study concurred with results from the three subsequent quantitative studies (Studies 2-4) and several other reports about the management of HeV and equine influenza. The high degree of congruence between my results and other independent reports strengthen the overall outcomes and conclusions presented and discussed in this thesis.

Conclusion

The aims of this chapter were met in the following manner:

- Present rationale and chronology of research methodologies

⇒ The rationale of a mixed methods approach was discussed and Studies 1-4 were presented in their chronological context.

- Discuss challenges posed by the use of an untraditional approach in veterinary research

⇒ Challenges encountered, strategies used and ensuing benefits of a mixed methods approach were discussed and summarised in a published case study.

The initial qualitative approach to these doctoral studies was effective and provided useful information about the barriers to HeV management and more generally to IC in private

veterinary practice. This methodology helped to identify and contextualise private veterinarians' experiences and beliefs in regards to HeV management and IC. The issues identified were subsequently confirmed and expanded upon in the follow up studies. The conclusions and recommendations stemming from Study 1 were also similar to those of other independent and government enquiries into veterinary management of HeV and equine influenza.^{41,42,95-97} The triangulation of results between the present studies and previous, concurrent and subsequent reports underpinned overall conclusions of this thesis.

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CHAPTER 3 – Barriers to veterinary infection control for the management of Hendra virus in Australian private veterinary practices.

Aims of this chapter

- Identify the perceived barriers to infection control for the management of Hendra virus in private equine veterinary practices.
- Understand the identified perceived barriers to infection control for the management of Hendra virus in private equine veterinary practices.



Art work by Ken Miller

Introduction

Following the Hendra virus (HeV) infection and subsequent death of equine veterinarian Dr. A. Rodgers in Rockhampton, Queensland (QLD), Australia, biosecurity government authorities questioned the motivations behind infection control (IC) and HeV management choices among private veterinarians.¹⁻⁴ On July 27, 2009, Dr Rodgers examined a febrile horse with respiratory distress at a Cawarral property on the Eastern Coast of QLD and performed an upper respiratory tract examination by endoscopy without wearing any personal protective equipment (PPE).^{2,3} This horse collapsed and died the next day and the cause of death was thought to be due to a snake bite.¹⁻⁴ This horse could not be tested for HeV for lack of biological samples (horse buried on the property without post-mortem).³ In retrospect, the circumstances of its death and the subsequent confirmation of the HeV outbreak on this property strongly suggested that this horse was infected with HeV.^{1,3} Within a few days another two horses on the same property became ill and displayed clinical signs consistent with HeV before dying on August 7 and 8, respectively.^{1,3} These horses were examined by a different veterinarian who suspected HeV as the cause of death and notified relevant government authorities on August 8.³ It was later confirmed that the cause of death of both of these horses was HeV.¹⁻³ While other horses that had been in contact with the infected horses were being investigated, a fourth horse tested positive for HeV and was euthanased on August 24, 2009.^{1,3} Several weeks prior to this outbreak, Dr. Rodgers had attended a specialised IC-HeV day-long workshop jointly organised by the Australian Veterinary Association and Biosecurity Queensland, a government authority (Dr B. Pott pers. comm.). After examining the first horse, Dr Rodgers contacted a colleague and raised concerns that this horse may have in fact been infected with HeV (Dr B. Pott pers. comm.). Three weeks post-exposure, Dr Rogers started displaying influenza-like clinical signs and was confirmed infected with HeV on August 20.^{2,3} He later died on the first of September, 2009.¹⁻⁴

Knowledge of HeV did not appear to have been sufficient to motivate this experienced equine veterinarian to use the appropriate PPE when performing a high risk veterinary procedure involving upper respiratory tract secretions. As this was not the first instance of veterinarians choosing to disregard personal safety when dealing with a sick horse, the rationale behind such behaviour needed further investigation.⁵⁻⁷ After the Cawarral outbreak (2009), the Australia

Biosecurity Cooperative Research Centre for Emerging Infectious Diseases commissioned Professor Rick Speare to investigate the barriers to IC and HeV management implementation in private equine veterinary practices in QLD. An exploratory qualitative approach was chosen as the research method (see description in Chapter 2) in order to identify and understand the IC and HeV management challenges as perceived and experienced by private equine veterinarians in this region (Study 1).

Publications and outputs for Chapter 3

This chapter includes results from Study 1 presented as three peer-reviewed papers, a workshop presentation (co-presented with first author) and a conference poster. I was the lead author of the three peer-reviewed papers. My overall contribution to Study 1 and subsequent outputs was as follows:

- I participated in the preparation of the ethics application for this study.
- I attended a consultative meeting with various stakeholders from the veterinary profession, biosecurity and workplace health and safety governmental agencies, horse industry and academic colleagues before drafting the first list of questions for the intended interviews.
- I attended a number of workshops about how to conduct qualitative research, including in-depth interviews, and how to use the N-Vivo software to analyse qualitative data.
- I participated in the first pilot interview, after which I reviewed the list of questions for the subsequent interviews.
- I recruited all participants, organised all interviews and was the lead interviewer for all subsequent interviews.
- I took notes during each interview and transcribed some of the written notes and audio recordings taken during interviews.
- I used a N-Vivo software package to organise the data collected and proceed with the coding of the data. I conducted the thematic analysis mostly independently with outcomes being reviewed by a subset of my supervisory panel.

- I was the lead author of the three manuscripts which I initially drafted. I managed the submission of these manuscripts which were accepted for publication in peer-reviewed journals (see below).
- I prepared a presentation that included the early results of Study 1 for a workshop run by the Queensland Department of Employment, Economic Development and Innovation: “*Addressing the barriers to veterinary IC*”; held in August 2010 in Brisbane (Appendix C1). I co-presented this presentation with my main supervisor (RS).
- I prepared a poster that I presented at The Australasian Society for Infectious Diseases Zoonoses Conference held in July 2012 in Sydney (Appendix C2).

Results from Study 1 are included in the following peer-reviewed publications and conference presentations:

- **Mendez D**, Judd J, Speare R. Unexpected result of Hendra virus outbreaks for veterinarians, Queensland, Australia. *Emerg Infect Dis.* 2012;18(1):83-85.
- **Mendez D**, Judd J, Speare R. Testing for Hendra virus: difficulties experienced by veterinarians in Queensland prior to 2011. *Aust Vet J.* 2013;91:323-327.
- **Mendez D**, Kelly J, Buttner P, Nowak M, Speare R. Management of the slowly emerging zoonosis, Hendra virus, by private veterinarians in Queensland, Australia: a qualitative study. *BMC Vet Res.* 2014;10:215.
- **Speare R, Mendez D**, Judd J, Cox J. Challenges to infection control implementation in equine practices in Queensland: preliminary results from consultation with coastal veterinarians in Queensland. In: Department of Employment, Economic Development and Innovation, Queensland Government. *Addressing barriers to veterinary infection control – workshop. Report.* Brisbane: Department of Employment, Economic Development and Innovation; 2010. (Appendix C2)
- **Mendez D**, Miller K, Judd J, Speare R. Risk communication between veterinarians and horse owners: a key factor in the management of Hendra virus. Poster presented at: The

**Australasian Society for Infectious Diseases Zoonoses conference; 2012 July 27-28;
Sydney, Australia. (Appendix C3)**

Unexpected Result of Hendra Virus Outbreaks for Veterinarians, Queensland, Australia

Diana H. Mendez, Jenni Judd, and Rick Speare

A qualitative study of equine veterinarians and allied staff from Queensland, Australia, showed that veterinarians are ceasing equine practice because of fears related to Hendra virus. Their decisions were motivated by personal safety and legal liability concerns.

In the mid-1990s, Hendra virus (HeV) emerged as a new pathogen that spilled over from bats to horses to humans (1,2). All 7 cases of HeV infection among humans in Australia occurred in Queensland. Five of these cases involved equine veterinary personnel who conducted routine necropsies or endoscopies; 3 of the 5 cases were fatal (2–6). In Australia, equine clinical services are mostly delivered by veterinarians working in private practice. The 3 deaths prompted government and veterinary professional agencies to promote the overhaul of infection-control measures in veterinary practice (3,4) and increase auditing of veterinary infection-control strategies in private equine practice by Workplace Health and Safety Queensland (7). In 2011, HeV outbreaks multiplied throughout Queensland and New South Wales, and samples from a dog were positive for HeV (8,9).

With the approval of the James Cook University Human Ethics Committee (permit H3513), we interviewed veterinarians and allied staff from veterinary practices with the aim of capturing the HeV-related infection-control and workplace health and safety issues faced by equine practices. We report on 1 unexpected emerging issue: the departure of veterinarians from equine practice as a result of HeV outbreaks.

The Study

During 2009–2010, we conducted face-to-face, in-depth interviews with 21 veterinarians and allied staff from 14 equine and mixed private veterinary practices

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from a range of urban and rural areas between Cairns and Brisbane, Queensland, Australia (Table 1) (10). We asked a series of open-ended questions to determine what HeV-related infection-control and workplace health and safety issues confront equine practices (Table 2). Interviews were recorded, transcribed, and analyzed for themes.

Of the 20 veterinary professionals interviewed, 12 (60%) had dealt with ≥ 1 suspected cases of HeV, and 7 (35%) had dealt with a confirmed case of HeV. Of the 18 veterinarians interviewed, 4 (22%) reported having ceased equine practice, and as many as 8 (44%) knew of ≥ 1 colleagues who had done so in the previous 12 months. The decisions to quit were mostly motivated by the HeV-related fear for personal safety and legal liability.

Under the current Queensland legislation governing private businesses, private veterinarians are responsible for the safety of all persons in their workplace, both in the clinic and the field (11). Ten (47.6%) of the study participants were principal veterinarians (Table 1) who carried the highest degree of legal responsibility within their veterinary practice; they were quite concerned about their HeV-related legal liability. Four of these principal veterinarians reported ceasing equine practice because of the difficulty in enforcing infection control–related workplace health and safety compliance among their staff, because the logistical outlay of bringing change to their practice was too costly, or both. One participant declared, “The HeV situation was the last straw that made us stop equine practice... We put it in the too hard basket.” Their fear of prosecution became too big a threat for their business. However, ceasing this high-risk activity does not result in improved infection-control standards.

Principal veterinarians from other practices preferred to personally deal with all equine patients, thus taking the highest risk themselves rather than putting their staff at risk or not providing the service. In some instances, staff and principal veterinarians resorted to working in suboptimal personal safety conditions to fulfill their legal

Table 1. Location of participants in a study of Hendra virus–related safety issues faced by equine practices, Queensland, Australia, 2009–2010*

Zone, category	No. (%) participants
Metropolitan zone	
Capital cities	3 (14.30)
Population >100,000	6 (28.55)
Rural zone	
Population 25,000–99,999	6 (28.55)
Population 10,000–24,999	0
Population <10,000	3 (14.30)
Remote zone	
Population >4,999	3 (14.30)
Population <5,000	0

*Location zones and categories are according to the Australian Rural, Remote and Metropolitan Areas classification system (10).

Table 2. Demographic characteristic of participants in a study of Hendra virus–related safety issues faced by equine practitioners, Queensland, Australia, 2009–2010

Study participants	No. (%)	Age, y (range)*	Years since graduation* (range)†	% Time spent doing equine work* (range)‡	Distribution by job title, no. (%)			
					Principal veterinarian	Partner/associate or employee veterinarian	Veterinary nurse	Practice manager
Female	8 (38.1)	35.8 (31–48)	13.1 (4–27)	30.4 (2–95)§	1 (4.8)	5 (23.8)	2 (9.5)	0
Male	13 (61.9)	48.5 (28–63)	22.9 (4–40)	52.1 (2–100)¶	9 (42.8)	3 (14.3)	0	1 (4.8)
Total	21 (100.0)	42.2 (28–63)	19.0 (4–40)	47.3 (2–100)	10 (47.6)	8 (38.1)	2 (9.5)	1 (4.8)

*Average.

†The practice manager interviewed was not a veterinarian and did not wish to supply this information.

‡Self-reported.

§One female participant did not provide this information.

¶The 1 participant who was a practice manager but not a veterinarian had not spent any time with animals and therefore was not included.

and ethical responsibility to their patients and clients, thus jeopardizing the legal situation. As one participant pointed out, “Veterinarians usually end up with less authority... taking the risk out of concern for the welfare of the horse.” Veterinarians have a legal right to refuse service if safety is compromised; however, this would mean forfeiting immediate and future income through the loss of a client(s) and, possibly, reputation. In such instances, the staff and the business remain safe, but the principal veterinarian may not, and the overall standards of infection control within the practice do not improve.

Up to 6 (60%) of the interviewed principal veterinarians had embraced the need for improvement of infection-control practices and had made major changes to their protocols and premises, but they felt that the best level of compliance would not be legally protective because of the unpredictable character of the veterinary work environment. Another participant expressed concern over this legal uncertainty: “You still have to worry about what might occur out of the blue.... With workplace health and safety we are very aware that complying is often not enough if an incident occurs.” In this scenario, although safety improvement is achieved, the legal risk remains.

Those participants still in equine practice also expressed concern over the consequences that the loss of skilled equine veterinarians would have on the profession and their practice. One participant said, “... this might introduce problems of gaps in the welfare of animals. Vets will need to refer animals.” The lack of equine specialists would increase demands on the remaining equine veterinarians, who would have to further extend their already overstretched time and resources: they would work longer hours, travel farther to provide services, and be unable to reach sick horses in remote locations or to have them tested in a timely fashion. Participants still in equine practice considered that all these factors made working with horses less safe. Indeed, several studies showed that across a wide range of sectors, working >60 hours/week increased the risks for occupational injury and illness (12–14). Furthermore, several study participants reported that some colleagues now choose to only provide

services to healthy animals and refuse to treat sick horses. A participant described this as choosing the “easy safe money” over the “hard dangerous money.” This choice was creating resentment among members of an otherwise tight-knit veterinary community. Over time, resentment could jeopardize professional networking, which seems to play an essential role in disseminating clinical and safety information among veterinarians.

Although this study did not measure the overall effect of the decreased number of veterinarians who treat equids in Queensland, participants viewed the decrease as a major source of increased occupational risk for the remaining equine practitioners. If this trend is sustained, more private veterinarians may cease equine practice. Other participants no longer regarded themselves as equine practitioners and declared that they had ceased equine practice; however, they later admitted to still regularly treating horses. Their “official” departure from equine practice would increase their safety and legal risks because they might miss program updates on equine health information or infection-control improvement. It is also possible that the perception of increased risk may adversely influence the decision by younger veterinarians to pursue work in equine practice, thereby jeopardizing the normal replacement of the existing pool of aging equine practitioners. One parallel was the effect of severe acute respiratory syndrome. Overall, 35% of severe acute respiratory syndrome–related deaths were in health care workers. Some workers refused to go to work and others adopted a heroic stance and continued to work, resulting in substantial medium-term psychological effects on the healthcare professionals (15).

Conclusions

HeV remains a threat to the veterinary profession and public health in Australia. The experimental success of an HeV vaccine for horses was recently announced; if a vaccine becomes available, it may re-instill confidence in existing and future equine practitioners (9). However, the potential that emerging infectious diseases might dismantle the veterinary workforce should be considered when developing official strategies for the management of

HeV outbreaks. Infection-control management guidelines and workplace health and safety regulations must consider the context in which services are feasibly delivered to the public and should be devised in consultation with the private veterinary professionals on the frontline of outbreaks.

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Dr Mendez is a research officer at James Cook University. Her research interests are emerging infectious diseases, zoonoses, histopathology, amphibian diseases, and strategies to improve infection-control behavior in veterinarians in clinical practice in Queensland, Australia, with the aim of decreasing the risks caused by Hendra virus spillovers.

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Testing for Hendra virus: difficulties experienced by veterinarians in Queensland prior to 2011

D Mendez,^{a*} J Judd^a and R Speare^b

Objective To identify the perceived barriers to Hendra virus (HeV) management by private equine veterinarians in Queensland.

Design An exploratory qualitative study of private equine veterinarians registered and working in coastal Queensland.

Methods A questionnaire that included eight open-ended questions about the management of HeV was used in face-to-face in-depth interviews with 21 veterinary personnel working in equine or mixed private practice between Far North and South-East Queensland in 2009–10. The qualitative data was entered and analysed thematically using QSR's International's Nvivo 9 qualitative data analysis software.

Results This study revealed key issues associated with HeV testing: (1) inadequate knowledge of testing procedures and laboratory diagnostic pathways; (2) difficulty in accessing laboratory services; (3) responsibility for cost of collection and transport of specimen; and (4) the role of government. Participants perceived these issues as reducing potential HeV case management efficiency.

Conclusion Although HeV management plans have been modified in part since 2009–10, this study highlights the importance of considering the perspectives of private veterinary practitioners in any biosecurity protocols.

Keywords biosecurity; Hendra virus; infection control; laboratory diagnosis; qualitative research; veterinarians

Abbreviations HeV, Hendra virus; NSW, New South Wales; QLD, Queensland; VIC, Victoria

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RESEARCH ARTICLE

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Management of the slowly emerging zoonosis, Hendra virus, by private veterinarians in Queensland, Australia: a qualitative study

Diana H Mendez^{1*}, Jenny Kelly^{2,3}, Petra Buttner⁴, Madeleine Nowak² and Rick Speare^{1,4}

Abstract

Background: Veterinary infection control for the management of Hendra virus (HeV), an emerging zoonosis in Australia, remained suboptimal until 2010 despite 71.4% (5/7) of humans infected with HeV being veterinary personnel or assisting a veterinarian, three of whom died before 2009. The aim of this study was to identify the perceived barriers to veterinary infection control and HeV management in private veterinary practice in Queensland, where the majority of HeV outbreaks have occurred in Australia.

Results: Most participants agreed that a number of key factors had contributed to the slow uptake of adequate infection control measures for the management of HeV amongst private veterinarians: a work culture characterised by suboptimal infection control standards and misconceptions about zoonotic risks; a lack of leadership and support from government authorities; the difficulties of managing biosecurity and public health issues from a private workforce perspective; and the slow pattern of emergence of HeV. By 2010, some infection control and HeV management changes had been implemented. Participants interviewed agreed that further improvements remained necessary; but also cautioned that this was a complex process which would require time.

Conclusion: Private veterinarians and government authorities prior to 2009 were unprepared to handle new slowly emerging zoonoses, which may explain their mismanagement of HeV. Slowly emerging zoonoses may be of low public health significance but of high significance for specialised groups such as veterinarians. Private veterinarians, who are expected to fulfil an active biosecurity and public health role in the frontline management of such emerging zoonoses, need government agencies to better recognise their contribution, to consult with the veterinary profession when devising guidelines for the management of zoonoses and to provide them with greater leadership and support. We propose that specific infection control guidelines for the management of slowly emerging zoonoses in private veterinary settings need to be developed.

Keywords: Veterinarians, Emerging infectious disease, Zoonoses, Hendra virus, Infection control, Management, Behavioural change, Queensland

Background

Hendra virus (HeV) is amongst a plethora of zoonoses emerging as new infectious threats to animal as well as human health [1]. HeV first emerged in 1994 in Brisbane, Queensland, Australia [2,3]. HeV is a paramyxovirus carried by pteropid bats with low infectivity to other susceptible species [4,5]. However, the virus can sporadically spillover from its natural reservoir to horses with

secondary spillover to humans in some instances. HeV has high fatality rates in both species, 75% and 57% respectively [6]. Humans can become infected with HeV when exposed to blood and bodily fluids from an infected horse [2,3,7-11]. In 2011, a dog became infected with HeV but did not develop any clinical signs prior to being sacrificed [12]. Since 1994 there have been a relatively low number (49) of self-limiting outbreaks along the eastern coast of Australia between northern New South Wales and Far North Queensland [6]. These outbreaks resulted in the deaths of 90 horses and a total of three non-fatal and four fatal human infections [6]. So

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far, all human HeV cases have occurred between August 1994 and September 2009 in Queensland [6].

HeV infection in humans can be prevented by avoiding contact with infected horses or avoiding exposure to infected substances by implementing infection control (IC) measures such as using personal protective equipment (PPE) [13]. Administration of monoclonal antibodies during the incubation period has been shown to prevent experimentally induced HeV disease in ferrets and non-human primate models and this has also been used in humans exposed to HeV as an experimental prophylaxis [14]. A vaccine for horses became available in late 2012 and was promoted for the protection of horse populations from HeV and humans from secondary spillover [15,16].

Since the emergence of HeV the veterinary profession has paid the highest price with the death of two veterinarians, a veterinary assistant and the non-fatal infection of a veterinarian and a veterinary nurse [2,3,6-11]. As a result of these HeV-related deaths, Federal and State governments and professional agencies initiated an IC and HeV management campaign targeted at equine veterinary practices. Despite the early information campaigns about HeV related risks and risk mitigation strategies targeting private veterinarians, the last two human cases of HeV occurred as late as 2008 and 2009 and proved fatal for two veterinarians, one of whom had recently attended a HeV management workshop [6,9-11]. Additionally, an Australian study conducted in early 2010 by a State government agency showed that IC and HeV management practices in private equine veterinary clinics were still sub-optimal particularly when carrying out high risk procedures (such as dental procedures, endoscopy of the upper respiratory or urinary tracts or endotracheal intubation) with high likelihood of exposure to oral, respiratory and urogenital bodily fluids from a healthy or a sick horse [17]. As a result, government authorities and veterinary professional agencies questioned why private veterinarians were still becoming infected with HeV. In mid to late 2010, in an attempt to promote changes in HeV management and related IC behaviours, the Queensland government sent a new comprehensive HeV management information package to all private veterinarians registered in Queensland (Dr B. Pott, personal communication).

The aim of this paper is to explore the barriers to IC and HeV management in private practices prior to September 2010 as perceived by equine veterinarians and allied staff in Queensland, Australia.

Methods

Research protocol

The purpose of this qualitative study was to identify and understand the factors affecting IC and HeV management in veterinary private practices in Queensland, Australia. This study was conducted as an exploratory, descriptive

design using semi-structured interviews. This method was chosen in order to gain an in-depth understanding of the perceptions and experiences related to the management of HeV and IC implementation in private practices in Queensland [18-20]. No adequate research tool had been previously developed to conduct such a study in the context of HeV emergence. After consultation with major stakeholders involved in the management of HeV (private equine veterinary practitioners, lecturers in equine medicine and representatives from professional and State government agencies) a series of open-ended interview questions were formulated to explore HeV related risk perceptions as well as barriers to IC and HeV management in equine veterinary practices in Queensland. The interview questions were piloted with one equine veterinarian and questions modified accordingly.

Between December 2009 and September 2010 individual, face-to-face interviews were conducted with 21 veterinary personnel from 14 veterinary practices in rural and urban areas along the eastern coast of Queensland, Australia. Interviews were semi-structured to allow the in-depth exploration of issues relating to barriers to IC and HeV management in the context of their veterinary work as perceived by the participating veterinary staff [20]. This project was conducted with the approval of the James Cook University Human Ethics Committee (permit H3513) and complied with qualitative research guidelines on relevance, appropriateness, transparency and soundness of research methodology (RATS) [21,22].

Recruitment and interview protocols

Participation was voluntary and participants could withdraw from the study at any time. Prospective suitable veterinary practices were identified from public phone directories and their associated advertisements and web links. Potential participants were initially contacted by phone, by the lead interviewer (DM), at which time the purpose and protocol of the study were explained to them by the researcher. Prospective participants were subsequently provided via e-mail with a project information sheet and explanations about what would be required of them at the time of the interview. Some declined to participate without further explanation while others were "too busy" or suspicious of the research process. Upon agreement to participate, a suitable interview date, time and location for each participant were organised. At the time of the interviews, the lead interviewer (DM) provided further information about the project and the study protocol when requested by a participant prior to the signing of the consent form. In particular, many participants were concerned about retaining anonymity and wished to ascertain their responses would remain unidentified. This was assured. Prior to commencing each interview, participants were required to provide socio-demographic and

professional profile information such as the type of practice they worked in, their role in the practice, an estimation of percentage of their working time spent providing veterinary services to horses and their experience with HeV outbreaks. Recruitment of new participants ceased when data saturation was reached; i.e., interviews stopped yielding new perspectives. This occurred after interview number 18.

Participants

The target population were veterinary personnel working in private practice in Queensland. The eligibility criteria were: 1) working in private veterinary practice providing veterinary services to either horses exclusively (i.e., equine practice) or to horses as well as to other large and small domestic animals (i.e., mixed practice); 2) working within the known geographic distribution area of HeV in Queensland: the eastern coast between the Far North and the Queensland-New South Wales border [23]. In order to collect a comprehensive range of views within the target population, participants, with different socio-demographic and professional profiles, were purposively selected from regions where HeV outbreaks had occurred (South East; Central; North; and Far North of Queensland). The final study population comprised 21 participants from a total of 14 mixed private veterinary practices. According to the Australia Rural, Remote and Metropolitan Areas (RRMA) classification system nine participants were from areas classified as metropolitan, nine were from rural areas and three were from remote areas [24]. The majority of participants (18) were veterinarians; two were experienced female veterinary nurses and one was a male practice manager who although having no direct involvement with equine patients, worked in a practice with a strong equine component. In most cases, the first point of contact during the recruitment process was the principal veterinarian owner of the practice. More than half the veterinarians interviewed were principal veterinarians (10) of whom only one was female. Interviews with principal veterinarians lasted, on average, longer (75.6 minutes) than interviews with other participants (46 minutes). The remaining eight veterinarians were partners/associates or employees, five of whom were female. Females were on average younger and aged between 31 and 48 years old while males were aged between 28 and 63 years old. This was reflected in the difference of the average number of years since graduation between males (mean = 26.4 yrs, range: 4–40 yrs) and females (mean = 13.1 yrs; range: 4–27 yrs). Excluding the practice manager, on average, females spent proportionally less of their working time than males attending to horse patients (30.4% vs 52.1%). Prior to this study there had only been 13 confirmed outbreaks of HeV with one outbreak occurring during the data collection period [6]. However, more

than half of the participants (60%) had dealt with at least one suspected case of equine HeV and over a third (35%) had dealt with at least one confirmed equine HeV case prior to being interviewed. Further details of this study population have been described elsewhere [25–27].

Data collection

For convenience, the majority of interviewees chose to be interviewed in an office at their place of work or in their own homes. The interviews were conducted by the lead author (DM), a female veterinarian with research skills in qualitative interview techniques, who was well aware of the issues under investigation, with a research assistant participating in some interviews. With written consent from each participant, responses were recorded as digital audio files with complementary hand written notes. Participants were asked to share their experiences when dealing with HeV and what, in their opinion, were the barriers to IC and WHS compliance. At the conclusion of each interview, the notes were read back to each participant to give them the opportunity to clarify or amend their responses. Audio files were later transcribed and entered into qualitative data analysis software (NVivo qualitative data analysis software; QSR International Pty Ltd. Version 9, 2010). After each interview, the interviewer reviewed the notes and recorded a number of reflections capturing the context of each interview. Interviews took between 40 and 160 minutes, with an average time of 64 minutes.

Data analysis

Prior to analysis, each participant was identified using a unique alphanumeric code (V* for veterinarians, VN* for veterinary nurses and PM* for practice manager) and a unique alphanumeric veterinary practice code (P*). Thematic analysis was used to analyse the qualitative data [28]. Interview transcripts were analysed with NVivo (QSR International Pty Ltd. Version 9, 2010) for repeating units of meaning and the main themes and sub-themes were conceptualised using inductive thematic analysis [20,28]. This process was repeated on more than one occasion with identified themes discussed and agreed upon by three of the researchers (DM, RS, JK). Two of the researchers were veterinarians and thus were able to review the themes within the context of private veterinary practice and the emergence of HeV and its management.

Results

Data analysis revealed six main themes expressing the participants' responses about the difficulties associated with the implementation of adequate IC and HeV management in private veterinary practices between the first outbreak in 1994 and the time of the interviews (2009–2010) (Table 1). These themes are: the emerging epidemiology of

Table 1 Main themes surrounding the topics of barriers to infection control and Hendra virus management in private veterinary practices identified in Queensland, Australia, between 2009 and 2010, as illustrated by participants' quotes

Themes	Examples of quotes from participants' responses which best illustrate the themes
The emerging epidemiology of the virus	<p>"When the first case of Hendra came about, it was seen as being rare so we didn't see [it] as a problem." (V3/Pa)</p> <p>"It would have been better to have known more about the virus. Where do you draw the line when you don't know enough about the risks and the non-risks?" (V4/Pc)</p> <p>"The drive [for IC*] needs to be continuous...HeV cases are seldom, so it's easy for people to be slack, to back off from infection control." (V10/Pg)</p> <p>"The biggest challenge is how to manage a hospital facility for horses, because the case definition is not clear...Our biggest concern...a horse that shows up without Hendra on the differential list and it [HeV[#]] shows up on the list later." (V16/Pl)</p> <p>"This is a disease that is here to stay...so we have to learn to live with it." (V15/Pk)</p>
Risk perception determines risk mitigation	<p>"Some think that Hendra is only a North Queensland problem and that it wouldn't happen in South Queensland or northern New South Wales." (V7/Pa)</p> <p>"I didn't think a great deal about it [HeV] because I studied in Victoria and it was presented to us as a disease only found in Queensland." (V14/Pj)</p> <p>"No way in the world would I put a mask or gloves on unless I saw something dramatic." (V13/Pi)</p> <p>"You will not get a primary Hendra case with a horse living in a stable." (V1/Pa)</p> <p>"At the time [before HeV], human safety was not being kicked [by a horse patient], not being trampled on, avoiding any physical injury...Zoonoses were not a big one on my list." (V14/Pj)</p> <p>"Seeing a mate die I think is enough. Obviously you think of self-preservation. I have a life to live...Dying is a pretty big cost." (V5/Pd)</p>
Risk and risk mitigation communication	<p>"There were no guidelines in place in regards to what [protective] equipment should be worn...there was information on what samples were needed but not how to take them." (V14/Pj)</p> <p>"The trouble with AVA[†] is that there is only 50% membership...weekends are when the AVA has the workshops and that is when we have a lot of work on here." (V15/Pk)</p> <p>"Most vets would receive information through email. Some think it's not enough but some of those don't read their emails." (V1/Pa)</p> <p>"They [people at the DPI[‡]] are excellent. The DPI is the most authoritative source of knowledge because they have been dealing with the issues and they are responsible for biosecurity." (V15/Pk)</p> <p>"The local DPI were useless, almost burying their heads in the sand. They didn't have enough knowledge, were unwilling to investigate and had a lack of resources and people." (V9/Pf)</p> <p>"I contacted Biosecurity Queensland on a Saturday afternoon...They transferred me on the phone 19 times to talk to a vet... they have to realise that private vets work 24/7...This disease is too serious to be ignored...they should have been more responsive. It would have been easier to put the horse in a hole and forget about it!" (V5/Pd)</p> <p>"I find great difficulty dealing with owners because it is a power play and ultimately we are responsible for the safety of all involved but some owners don't believe that, which compromises the legal situation. We usually end up with less authority out of concern for the welfare of the animal." (V4/Pc)</p> <p>"By the time you get to the horse you are only the 3rd or 4th opinion...A lot of people around here are gung ho who [think they] know better." (V5/Pd)</p> <p>"Some owners burr at the cost...He [the owner] said 'if you want to test the horse why don't you pay for it'." (V14/Pj)</p> <p>"[The owner said] I don't want them tested for Hendra. If they turn up positive they'll have to be put down. My horses are like my children and I wouldn't euthanase my own children." (V9/Pf)</p>
Education and work culture	<p>"Students are very well aware of the risks to the point of being scared to do things." (V7/Pa)</p> <p>"These days young vets lack confidence around horses because of their lack of experience through their training and personal life." (V1/Pa)</p> <p>"Coming out of Uni the biggest issue was not whether I could follow protocols it was getting the practice of using those protocols." (V17/Pm)</p> <p>"[I] had been inadequately trained [about HeV] when studying in Victoria [another state] ...I didn't realise that interstate [studies] did not offer the same information. Some things should not be disregarded in the curriculum because it doesn't happen in that area." (V14/Pj)</p> <p>"Hopefully they [the students] will go into practice in clinics where they follow best practice." (V7/Pa)</p> <p>"Poor mentorship is a problem. Training is very important. A principal vet can teach a lot to younger vets." (V8/Pe)</p> <p>"I think overall we, as vets, were pretty grubby...to get around with blood on your shirt all day that is just what veterinarians did." (V16/Pl)</p>

Table 1 Main themes surrounding the topics of barriers to infection control and Hendra virus management in private veterinary practices identified in Queensland, Australia, between 2009 and 2010, as illustrated by participants' quotes (Continued)

	<p>"Old school vets always considered getting infected with a zoonosis as a badge of honour." (V8/Pe)</p> <p>"The biggest obstacle is trying to retrain someone who has done something a certain way for 30 odd years." (V13/Pi)</p> <p>"The culture needs to change...[but]...change won't happen overnight. Human medicine was hit in the 1980s [by HIV^{A2}], it sparked infection control improvement but it's still not perfect now. The [veterinary] profession has to change but this will take time." (V8/Pe)</p>
Use of Personal Protective Equipment	<p>"If I am going to be completely honest, a few years ago there would be no way I'd put it [PPE⁵] on." (V13/Pi)</p> <p>"We have always been casual about horses. In cattle you have brucellosis but I have never been worried about catching anything from horses." (3/Pa)</p> <p>"The right PPE ... was not available at the clinic at the time. PPE was still not considered to be an issue at the time." (V10/Pg)</p> <p>"You can read the protocol all you like but until you actually do it and take the gear off under the assumption that you are contaminated it is not an easy thing to do." (V12/Ph)</p> <p>"By following the DPI protocol it took us two hours before the animal was finally sedated." (V4/Pc)</p> <p>"PPE can be cumbersome...smelling the breath of a horse gives you an idea of what's going on. If you are wearing a mask it makes it difficult." (V11/Pg)</p> <p>"The ability to move properly...can be a problem. When you have to deal with horses with fractures you have to move quickly!" (V10/Pg)</p> <p>"The biggest obstacle: heat and humidity...When you are wearing the full PPE it can be very hot." (V6/Pa)</p> <p>"I hate masks, they press on the bottom of my eyes and I can't see...I won't wear goggles it's too difficult with my glasses." (V5/Pd)</p> <p>"Comfort and practicability is an issue for me because one size fits none!!...PPE suits are baggy on me, with a lot of flapping about and this scares horses." (V7/Pa)</p> <p>"During the E⁵ campaign I had to vaccinate between 800 and 1000 horses and at each farm I had to put on a new set of PPE so it's not a big issue for me." (V2/Pb)</p> <p>"Cost is a big one. You have to pass the cost on. The bill can be a lot dearer than before and if the horse turns out negative, the owner will whinge about the money spent." (V5/Pd)</p> <p>"We are lucky in that our clients are used to spending money on their horses." (V12/Ph)</p> <p>"It is potentially dangerous...to have two people walk up [to a horse] looking like spacemen with their clothes rustling and their voices distorted." (V12/Ph)</p> <p>"Vets like me don't want to be seen with over the top PPE...in more rural situations you tend to think you are being a bit of a Wally[silly] dressed up for minor issues." (V10/Pg)</p> <p>"...You felt silly in front of other colleagues to be wearing all the gear." (V3/Pa)</p> <p>"Clients could be a driving force behind it [IC] because they would start questioning why some vets use PPE and others don't." (V1/Pa)</p>
Running a private veterinary practice	<p>"When you have a big backlog of work there is time pressure... your logistics are stretched...many cases end up being emergency cases at the end of the day, which is a recipe for disaster because you start cutting corners and making mistakes." (V4/Pc)</p> <p>"Vets are often busy and to get through a large case load is hard enough, let alone stopping to put protective gear on." (V16/Pl)</p> <p>"Cost is an issue ...Do you then transfer the cost onto the owner? What if the case turns out negative? How do you justify it?" (VN2/Pe)</p> <p>"There would be cases out there that have not been reported because of the cost...I think this puts people at risk. As long as it is hurting the pocket of the clients or the pocket of the vet, cases will go unreported." (V14/Pj)</p> <p>"In the hospital system everything is ...disposable. If we had to treat everything as disposable our cost would increase... The industry would suffer from it." (V3/Pa)</p> <p>"As vets we don't have the luxury of the health system behind us to make [IC] decisions, we don't have a large buying power... for vets the one size fits all approach doesn't work". (V8/Pg)</p> <p>"You look at the paper trail that they [WHS^Y authorities] say you need to have...you would have to employ somebody full time for six months to put it in place." (V12/Ph)</p> <p>"As an employer you can do everything in your power and you can make all the recommendations but it comes down to the individual and if the individual doesn't have Hendra on their mind there is not much you can do." (V14/Pj)</p>

Table 1 Main themes surrounding the topics of barriers to infection control and Hendra virus management in private veterinary practices identified in Queensland, Australia, between 2009 and 2010, as illustrated by participants' quotes (Continued)

"Legally the only way you could send a staff to a property is if on the day the employer went to that property and addressed the risks and said it was safe to work there, because the conditions from yesterday might not apply today." (V9/Pf)

"More positive cases are going to land in our hospitals...Infection control is imperative but what scares me is the unknown [when HeV is not readily suspected]." (V16/Pl)

"The DPI[†] contacted me to do this work and they weren't being flexible about it: they wanted me there and then. This was [8 months ago] ...I am still waiting for my money! Next they'd have to pay me up front." (V5/Pd)

"Everyone's fear is you'll act to the best of your ability and you'll act in the best interest of everyone involved but later your actions will be audited by someone who has never worked in a vet practice and has no idea of the pressures at play and who will apply the letter of the law and potentially cost you your livelihood." (V12/Ph)

"I don't talk to local [WHS] officers anymore because they don't have enough knowledge. This immediately established a low level of credentials with us. Everything after that we see it more as an inconvenience." (V8/Pe)

*IC: Infection control; [†]HeV: Hendra virus; [‡]AVA: Australian Veterinary Association; [†]DPI: Department of Primary Industries; [‡]HIV: Human Immunodeficiency Virus; [°]PPE: Personal protective equipment; [§]EI: Equine influenza; [¶]WHS: Workplace health and safety.

HeV; risk perception determines risk mitigation; risk and risk mitigation communication; education and work culture; personal protective equipment; and running a private veterinary practice.

Each theme included a number of subthemes that are illustrated in Table 1 by selected quotes from participants' responses. The quotes included in Table 1 were selected as best illustrations of the themes and subthemes identified in this study.

The emerging epidemiology of the virus

Many participants were initially not overly concerned about HeV; the sporadic occurrence of equine cases and the rarity of human cases separated by long periods of time belied the seriousness of the epidemic. When HeV first emerged, participants reported that they and others in the profession failed to recognise the significance of this new zoonosis. Most participants felt that in the first few years of HeV emergence, there was insufficient knowledge about the disease and its epidemiology to adequately assess and therefore manage the risks involved. Nevertheless, when HeV began recurring more regularly, participants started implementing HeV management strategies, although these strategies were not always sustained over time. Another major stumbling block identified by many participants was the difficulty associated with the clinical diagnosis of the disease in horses. As some participants pointed out, the case-definition of HeV is non-specific and there can be substantial variations in clinical presentations which rendered the initiation of a HeV management plan difficult. Furthermore, an asymptomatic horse did not always equate to a healthy uninfected horse as it could be in the late incubation period of the disease during which viral shedding is possible. In 2010, however, most participants agreed that HeV was likely to recur in the future and that they needed to adopt a sustainable HeV management plan.

Risk perception determines risk mitigation

Participants who failed to mitigate the HeV-related risks often perceived the risk of being exposed to HeV to be low. Their risk perceptions were initially based on geographic consideration. This viewpoint echoed that of other participants who recalled that prior to 2010 there was an ongoing belief that occurrence of HeV would be restricted to specific geographic areas outside of which the likelihood of HeV spilling over was low as was the risk of exposure. This belief seemed to be perpetuated outside the initial affected state of Queensland. Participants who had studied or started their career in other states were not overly concerned about HeV.

Hendra virus was generally perceived to be a more significant risk by participants if they initially included it in their differential diagnosis, which in turn determined their HeV management attitudes. However, many participants reported that prior to the last fatal human case in 2009, they did not perceive the HeV-related risk to be high unless the symptomatology of a horse was severe and that they would only have considered taking precautions in extreme clinical cases. Some participants were confident they could rule out HeV, and the related risks, on clinical examination alone despite HeV having a non-specific case definition. Another common belief amongst participants was that HeV could only spillover into horses kept in paddocks and therefore, examining a horse kept in a stable represented a low HeV risk.

Participants also prioritised risk management according to risk likelihood. Because of their experience prior to the emergence of HeV, many participants perceived the risk of contracting an infectious disease in equine practice significantly lower than sustaining a serious injury from a horse. Conversely, the HeV-related infectious risk appeared to be of greater relevance for participants who had had direct dealings with early HeV positive cases or personally knew one of the people who had been infected

with HeV. For example, one participant, who had dealings with one of the early outbreaks, became more circumspect when dealing with sick horses; while another participant was reconsidering the viability of managing equine cases after losing a close colleague to HeV.

Risk and risk mitigation communication

At the time this study was conducted, participants were seeking and receiving information about the HeV from government and professional agencies such as the department of primary industries (DPI)/Biosecurity Queensland, the Australian Veterinary Association (AVA) and Equine Veterinarians Australia (EVA). However, not all information was perceived as complete, useful, specific or practical enough in assisting them with HeV management in the field. Additionally, not all information was accessible by all veterinarians. Some modes of information delivery, such as emails, were described as being ineffective in reaching the entirety of its target population; and professional associations could only reach their veterinary membership.

The majority of participants from or around large urban centres were mostly satisfied with the support they received from government agencies in charge of biosecurity. In contrast, participants from rural and remote areas were mostly dissatisfied with the level of support they received from the local representatives of the same government agencies. Government officers from these areas were perceived as lacking capacity, knowledge and experience.

Some participants from rural and remote areas further cautioned that the lack of responsiveness from the government at the local level could lead in some instances to potential cases of HeV going unreported and/or uninvestigated.

Risk and risk mitigation communication also occurred between veterinary staff and horse owners. Some participants found risk communication with horse owners challenging as some clients were not receptive to veterinary directives about HeV-related risks. Many participants thought that the three main reasons for horse owners to refuse veterinary decisions were due to denial of the risk, cost issues and emotional attachment between owners and their animals.

Education and work culture

Australian and overseas educated early career veterinarians who worked in the participating practices were mostly perceived by interviewees as being well informed about IC and HeV related risks. However, a number of participants thought that some undergraduate Australian veterinary students and newly graduated veterinarians lacked experience and confidence in applying IC and animal handling skills. Some participants recalled their own lack of confidence in applying IC principles earlier in their career which they thought was due to insufficient practical

experience and variability in veterinary curricula between universities.

Other participants questioned the role of senior private veterinarians overseeing the practical training of veterinary students on extramural placements and early career veterinarians. Professional mentorship was reported as having a pivotal effect on veterinary IC training. In some instances, poor professional mentorship was deemed responsible for undergraduate students and early career veterinarians failing to adopt and develop adequate IC standards.

Participating senior veterinarians thought that their IC attitudes and beliefs about veterinary occupational risks, which were now considered suboptimal, were the norm at the beginning of their career. This enduring work culture was viewed as a major obstacle to IC improvement in veterinary practice as it required a drastic change in the way veterinarians thought, behaved and made decisions. However, most participants, regardless of how long they had worked in private practice, recognised that veterinary IC required amelioration but warned that it would take some time before this occurred.

Use of personal protective equipment (PPE)

A number of participants, who began their career before the emergence of HeV, pointed out that prior to 1994 the use of PPE in equine practice was not a common occurrence. Some thought the lack of experience with zoonotic risk in equine practice led to the belief that the use of PPE for the management of HeV was not critical. By 2010 all participants were using some form of PPE in combination with other IC strategies to mitigate the risk of exposure to HeV and/or other zoonoses. However, some participants still found it difficult to use PPE routinely in equine practice. Participants gave a range of reasons why they thought the use of PPE presented some drawbacks: it sometimes hindered their ability to work efficiently, competently, safely and comfortably; or was deemed unsuitable for reasons of fit. Interestingly, participants who had repeatedly used PPE during the equine influenza outbreaks and vaccination campaigns did not perceive the use of PPE in equine practice to be an issue.

Some participants also thought that the systematic use of PPE had the disadvantage of increasing the running cost of a consultation which affected the veterinary practice as well as the client, although not all participants viewed the added PPE-related cost as a big issue.

A number of participants were also concerned about the way they were perceived by their patients, clients and colleagues when they wore PPE and the effect this would have on their workplace health and safety (WHS) and their professional credibility. Other participants thought that the clients who perceived the use of PPE as positive work practice could be a driving force behind equine veterinary practices more readily adopting the use PPE.

Running a private veterinary practice

Time management was an issue for most veterinarians interviewed who reported that implementing additional IC measures affected work schedule, quality and safety. The extra time spent implementing additional IC measures was also reported to affect consultation fees. Many participants further explained that any additional cost, such as costs related to the management of HeV, needed to be justifiable to clients as it often affected their level of satisfaction with veterinary services provided. Cost was perceived by many participants as a limiting factor to the management of HeV from a client's and a business perspective.

Some participants highlighted the discrepancies that existed between the business models of veterinary practices and public medical hospitals for people. They pointed out that veterinary practices were small businesses operating solely privately unlike medical hospitals and therefore could not be run as sustainably because of cost and logistical considerations.

Many participants were principal veterinarians who had the added responsibility of ensuring that the running of their practice, including the management of potential HeV cases, complied with the WHS legislation. However, many found that compliance was not easily achieved and in some instances hindered the running of the practice. The need to document WHS policies and procedures, training and incidents, for example, was perceived as unwelcomed extra work. The need to ensure the health and safety of staff who were not always receptive to warnings and instruction was viewed as another major challenge to compliance. Some participants thought that the legislation was open to interpretation; thus making it difficult to always comply. Many participants also felt that because compliance was not legally protective they remained vulnerable to unexpected situations. Although, most participants were aware that they could legally refuse to provide veterinary services if they deemed a situation unsafe, some were not afforded this option when being requested to fulfil HeV management duties on behalf of the government without receiving logistic support or compensation for their skilled services. Additionally, some participants thought that scrutiny of veterinary practices by WHS authorities was often inadequate and arbitrary to the detriment of their businesses.

Discussion

Private veterinarians are likely to be the first frontline clinicians to encounter emerging zoonoses; which puts them at a higher occupational risk of exposure to these diseases [1,29]. Many studies, including Australian studies, have shown veterinarians' attitudes and behaviours towards IC and zoonotic risks to be suboptimal; however, most studies have failed to explain why this was so

[30-34]. The aim of this study was not to evaluate veterinary IC adequacy but to identify and understand the barriers to IC and zoonotic risk mitigation in private veterinary practices within the context of the emergence of HeV in Queensland, Australia. Participants reported experiencing difficulties implementing IC and HeV management for a number of reasons (Table 1). Many of these issues were interconnected and were in actual fact related to four main barriers to IC and HeV management discussed below: veterinary work culture; private workforce managing biosecurity and public health issues; role of government; and uncertainty about the epidemiology of an emerging disease (Table 2).

Strengths and limitations

Between December 2009 and September 2010, the issues surrounding veterinary IC and HeV management were sensitive topics amongst private veterinarians, as two of their colleagues had died of HeV in the previous two years [6,9-11]. Following these events private equine practices came under a high level of government scrutiny. As a result, prospective participants were reluctant to take part in the study. They were concerned their responses would be misunderstood, misrepresented and/or misused. Those who agreed to participate may have had "stronger views on" or "interest in" veterinary IC and HeV management because they had had experience with HeV or biosecurity and WHS government authorities; or because they were principal veterinarians, owners of their practice. Although data were collected over 10 months, the topics brought to the fore during the interviews were very similar and mostly related to veterinary IC and HeV management issues participants had experienced prior to 2010. Many of the views expressed by participants were corroborated by the findings of other reports about HeV management [35-37]. The chief investigator (RS) and the main interviewer (DM) are both veterinarians who were able to communicate with participants as colleagues who understood the context of their workplace. Consequently, participants were more open about their experiences and beliefs, which made for richer data. However, coding and thematic analysis were pursued without any preconceived construct other than the knowledge the researchers had of veterinary workplaces, allowing an in-depth understanding of the issues raised by participants.

Veterinary work culture

Most participants agreed that, as a whole, the veterinary profession had initially been reluctant to adopt new IC strategies for the management of HeV because it required a significant shift in their work culture. Retrospectively, they felt unprepared to deal with an emerging zoonosis. They all agreed that when HeV first emerged veterinary IC was not optimal and needed improvement.

Table 2 Summary of main barriers to infection control and Hendra virus management in private veterinary practices in Queensland, Australia, up until September 2010

Main issues	Related barriers
Work culture	<ul style="list-style-type: none"> • Longstanding observance of suboptimal IC practices; • Veterinarians' perception that zoonotic risks in equine veterinary practice were low; • Veterinarians' perception that they are more likely to be exposed to injury risks than infectious risks in equine practice; • Mitigation of injury risks more readily implemented by veterinarians than mitigation of infectious risks in equine practice; • Inadequate veterinary work habits perpetrated in some instances by poor professional mentorship during extramural undergraduate placement or during early career experiences.
Role of Government	<ul style="list-style-type: none"> • Suboptimal HeV testing pathways • Slow response from government authorities to the emergence of HeV and to HeV outbreaks • Suboptimal and conflicting communication of risk and risk mitigation from government authorities to veterinarians • Inconsistent government support for veterinarians throughout the state, with rural remote areas receiving less skilled technical support • Difficulties in complying and collaborating with WHS legislation and authorities
Managing animal and public health issues and a private business	<ul style="list-style-type: none"> • The logistical, financial and work time costs of implementing infection control changes within the context of running small private businesses • Difficulty in interpreting and enforcing WHS regulation • Mitigation of zoonotic risks interfering with the mitigation of injury risks • Lack of WHS legal protection when a third party breaches the legislation • Veterinarians' lack of experience choosing and using some of the PPE recommended • Inadequate, insufficient and inconsistent training of undergraduate veterinarians about IC and HeV management • Difficulty in implementing IC behavioural changes amongst veterinary staff • Difficulty inefficiently communicating with clients about HeV-related risks and risk mitigation recommendations
Uncertainty about the epidemiology of an emerging disease	<ul style="list-style-type: none"> • Slow emergence and sporadic nature of HeV outbreaks • Slow gathering and dissemination of epidemiological information • Misinterpretation of epidemiological information • Non-specific HeV case definition

In 2010 they were still trying to understand how to best manage HeV. A 2010 government study conducted within the same target population also concluded that IC for the management of HeV still needed amelioration [17]. However, participants cautioned this process would take time. By 2009–2010, all participants had made some improvements to their IC and HeV management strategies; some only recently while others had not been sustained long term. According to the hierarchy of control of health and safety risks which categorises risk mitigation strategies, the changes implemented varied greatly, with some participants implementing only low levels of control (using additional PPE); while others addressed IC issues at a much higher level of control (attending specialised training, developing new standard protocols and policies, seeking new engineered solutions) [38]. A few participants were still sceptical of the appropriateness of the recommended changes.

Successfully changing work culture in human healthcare settings has been described as a lengthy and complex process requiring strong leadership within an organisation [39,40]. The adoption of effective hand hygiene by healthcare workers is a good example. While hand hygiene was recognised in the late 1800s as the simplest and most effective IC measure that could help prevent healthcare associated infections, it remains a practice that is neither consistently nor adequately carried out by healthcare workers despite healthcare systems being strongly supported by government leadership [41]. In comparison, the push for veterinarians to adopt new HeV-related IC measures only dates from the last decade. Veterinarians communicated about HeV risk mitigation within and between practices via an informal professional network; however, most participants felt that government agencies in charge of biosecurity could have provided more leadership and support to the veterinary profession. Instead, the

leadership in veterinary IC for the management of HeV was fragmented and vested in each principal veterinarian, the owner of his/her practice.

Private workforce managing biosecurity and public health issues

Maintaining the financial viability and credentials of the veterinary practice, a small privately owned business, was a concern for all principal veterinarians and some senior veterinary employees interviewed. In their view any change in work habits/protocols could affect the business, presumably because of the perception that in private veterinary practice there is a cost ceiling and any additional cost would decrease profit. Profitability of the business is a common concern of veterinarians running private practices of all types [42,43]. The constraints of running a private business significantly influenced participants' decisions about IC, and some found it difficult to balance their *de facto* public health and biosecurity roles while running a private business and complying with their WHS responsibilities. The WHS legislation, for example, was viewed as open to interpretation and difficult to implement in unpredictable circumstances not easily controlled. The difficulties of using some standard biosecurity measures in the field in equine practice are common to the management of other equine infectious diseases [44]. Some participants were aware that they could legally refuse provision of services if they deemed a situation unsafe [45]. However this option was considered as a last resort as it could jeopardise the welfare of animals, translate into loss of immediate income and future income if unsatisfied clients did not return to the practice. Refusing to provide veterinary services was not an option for participants who reported having been requested to fulfil HeV management duties on behalf of the government. For some, the weight of the legal responsibilities reached breaking point when HeV started to emerge, resulting in them choosing to exit equine veterinary practice [25]. So, although fear of dying acted as a significant motivator for some participants to implement lasting IC changes, the complexity of their responsibilities to their patients, clients, colleagues, business and the community deterred them from doing so.

Role of the government

Many participants perceived government authorities' slow response to the emergence of HeV as a sign of unpreparedness to deal with emerging zoonoses, which contributed to the slow uptake of new IC measures for the management of HeV management by private veterinarians. The subsequent increased scrutiny into veterinary practices by biosecurity and WHS government agencies was perceived by most participants as intrusive and an indication that they were regarded as the sole responsible

for all HeV management shortcomings until 2010. However, most participants thought the government could have better contributed to the management of HeV outbreaks. An Ombudsman's report about government response to HeV outbreaks concurred with this view [37]: prior to 2009 government agencies in charge of biosecurity failed to develop, finalise and implement their policies for the management of HeV and adequately train their staff accordingly. This was reported to have resulted in the communication of incomplete and conflicting information and poor field support of private veterinarians, despite previous independent reports identifying similar issues for the 2008 and 2009 outbreaks [35,36]. Investigation into the handling of equine influenza, an equine specific emerging disease in Australia in 2007, also showed the importance of risk communication from government to private veterinarians when managing emerging infectious diseases [46]. Many of the recommendations from the various reports about the management of HeV have since been adopted by the relevant government agencies [47]. Since 2010 no veterinary personnel have been infected, although equine cases have increased [6]. This may indicate that the provision of early leadership and committed support by government authorities to the veterinary profession may be key to implement more effective management plans of emerging zoonoses from both a biosecurity and a public health perspective.

Uncertainty about the epidemiology of an emerging disease

The lack of preparedness was a major stumbling block in the early management of HeV by veterinarians and government authorities. The slow pattern of HeV emergence appears to have been a contributing factor in delaying the response of both the private and public sectors in charge of HeV management. The practice of IC for HeV management is a matter of biosecurity to protect animal health, of public health and of occupational health and safety. However, deciding to adopt adequate IC strategies and behaviours when managing HeV cases is a matter of personal health choice. Social scientists have developed various cognitive models to help predict health behaviours by examining a number of cognitive skills: *knowledge, motivation, readiness to change behaviour, expected outcomes, risk perception, perception of peer behaviour and beliefs about peer opinion of targeted behaviour* [48]. When HeV first emerged many of these variables would not have scored highly amongst private veterinarians. Veterinarians have been shown to make evidence-based IC decisions [49]. With HeV outbreaks occurring sporadically up until 2010 (13 self-limiting outbreaks with more than four years between the second and third outbreaks and the third and fourth outbreaks) [6], there were few opportunities to gain epidemiological and

clinical knowledge about, or management experience of the disease. The full spectrum of clinical signs in horses, non-specific for the most part, was revealed over decades. As more cases accumulated it became obvious that infected horses could also excrete virus during the incubation period [50]. With such a high clinical variability, equine HeV could only be confirmed by laboratory tests, a process that was not deemed straightforward by all veterinarians [26]. Many participants felt that although they understood the principles of zoonotic risk mitigation, they generally lacked experience dealing with emerging zoonoses in equine practice. Thus, HeV-related risk perception, motivation and readiness for IC behavioural change was low during this time, even though during the first two outbreaks three people became infected, two fatally. Participants' behaviours seemed to have also been influenced by: peer perceptions; beliefs about IC and zoonoses; and a strong professional identity based on the long standing belief that using PPE was a sign of weakness and that acquiring a zoonosis was an achievement not a reflection of malpractice [51]. These beliefs may have been

stronger amongst older participants who had graduated longer ago as they are likely to have received less theoretical and practical biosecurity than those who graduate more recently [44].

Veterinarians and government actions and decisions relating to the management of HeV followed the typical stages of behaviour change: *pre-contemplation* (behavioural change seen as not needed); *contemplation* (behavioural change under consideration); *preparation* (for behavioural change); *action* (behavioural change implementation); *maintenance* (of behavioural change); *transcendence* (behavioural change becomes the new behavioural norm); and sometimes relapse (reverting to old behaviours) [52,53]. The progression through these stages is determined by a number of cognitive variables (Figure 1). In the context of the emergence of HeV, there was at first disbelief that HeV would recur or spread to other areas, and as the government did not recommend any particular changes, veterinary IC behaviours remained unchanged. With recurring HeV outbreaks and additional human infections, there was a slow recognition that changes to

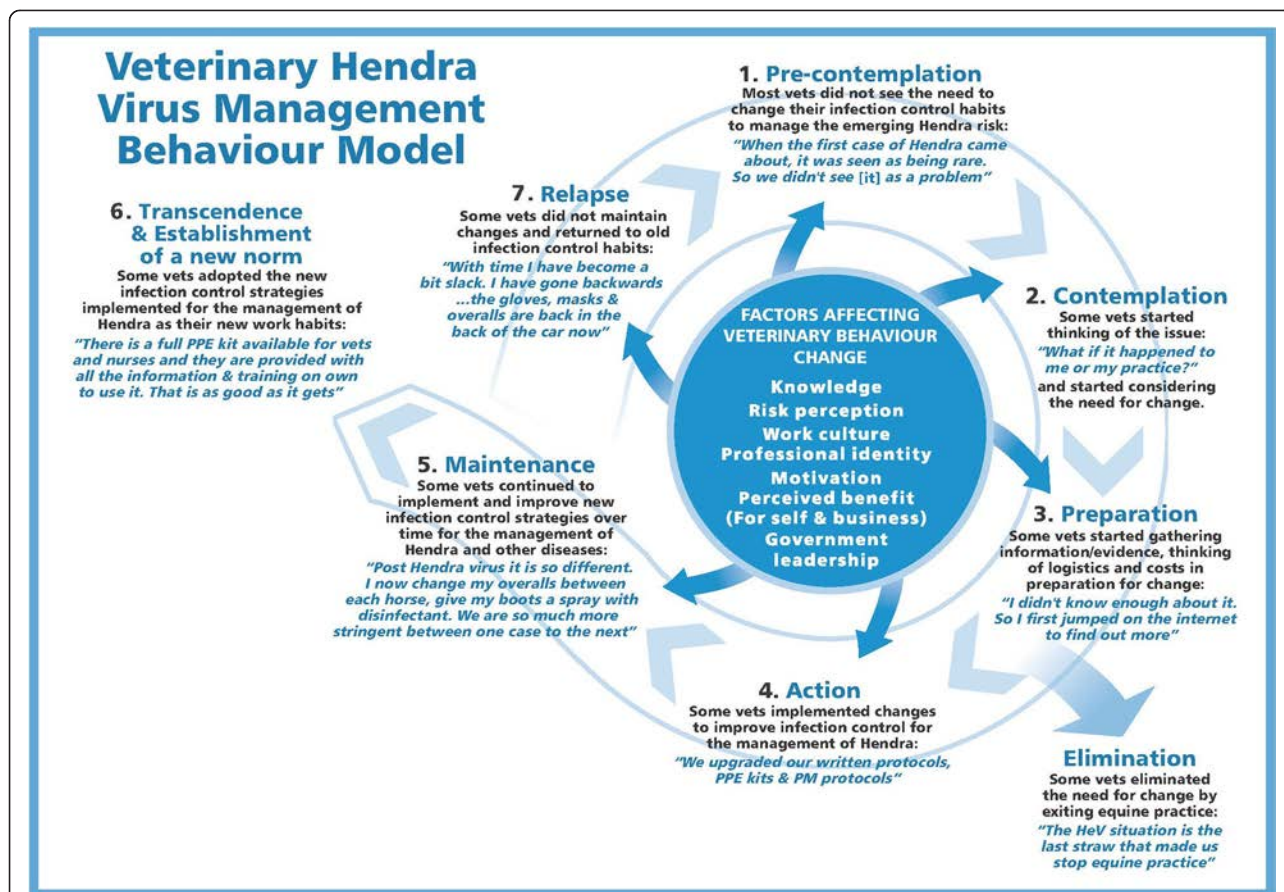


Figure 1 Veterinary Hendra virus management behaviour model, adapted from trans-theoretical model of health behaviour change. Model based on results of a qualitative study investigating barriers to infection control behaviour relevant to Hendra virus management in private veterinary practice in Queensland, Australia, conducted with 21 participants during 2009–2010 [52,53].

veterinary IC were necessary. Some IC changes were made by some veterinarians but these were not always sustained as the required financial and logistic investment could not be justified long-term because of the low frequency of HeV outbreak and the lack of government commitment to a clear HeV management plan. The deaths of two veterinarians in 2008 and 2009 triggered government into finalising their HeV management plan, formulate and widely distribute clear recommendations to private veterinarians and provide more training and field support to equine veterinarians through their emergency response unit. In 2010 all private veterinarians registered in Queensland, received a comprehensive information package from the government. The last three participants to be interviewed for this study had received this package prior to their interview and they were mostly satisfied with this information. Since then there have been no further human infections with HeV even though, in the winter of 2011, there was a marked increase in the number of HeV outbreaks in Queensland and northern New South Wales. Thus, the changes made by the government and the private veterinarians appear to have lowered the risk of human exposure and therefore infection risks for veterinarians and the wider population.

Conclusion

Unlike other zoonoses, which emerged rapidly in human populations causing epidemics (e.g., severe acute respiratory syndrome (SARS), swine influenza (H1N1) in 2009), HeV was slow to emerge, the index cases occurred in horses rather than in humans and HeV did not affect public health on a grand scale. Unlike SARS and swine influenza, HeV is a low-incidence high-consequence pathogen [54]. This type of slow emerging zoonosis, which only affects human health occasionally, comes with its own set of unique challenges. Because they recur infrequently, remain geographically localised or have a limited effect on public health, the health risk they pose to humans may be difficult to assess. However, there is a need to recognise the potential significance of this type of zoonosis earlier and implement risk mitigation measures accordingly. Failing to do so, may put people at risk, in particular professionals such as farmers, zoo and wildlife carers, and veterinarians who may come in contact with an infected animal. However, it would be unrealistic to mobilise the same level of resources used for the management of zoonoses such as SARS or swine influenza. Nevertheless, it may be possible to develop a template framework for the management of slowly emerging zoonoses, which could include: improving veterinary IC and emerging zoonoses management preparedness through education; better communication between government authorities, veterinarians and the public; better recognition of the biosecurity and public health role and services provided

by private veterinarians; consultation with private veterinarians when developing zoonoses management plans compatible with running private practices; a clearer definition of the respective roles of government, professional agencies and private veterinarians using officially ratified agreements; and better and equitable government support for the management of emerging zoonoses to all private veterinarians across all affected geographic areas. A closer collaboration and mutual understanding between private veterinarians and government could be the key to improving adaptability of both parties to slowly emerging or infrequent zoonoses.

Abbreviations

HeV: Hendra virus; IC: Infection control; PPE: Personal protective equipment; AVA: Australian veterinary association; EVA: Equine veterinarians Australia; WHS: Workplace health and safety; SARS: Severe acute respiratory syndrome.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

RS conceived the study and provided support and advice to DM who carried out the study. DM and RS were involved in the drafting and piloting of the research tool. DM recruited participants, conducted interviews, collated and analysed the data. JK assisted in the data analysis as well as the manuscript preparation. DM drafted the initial manuscript which was subsequently reviewed by RS, JK, PB and MN. All authors read and approved the final manuscript.

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Conclusion

The aims of this chapter were met in the following manner:

- Identify the perceived barriers to infection control for the management of Hendra virus in private equine veterinary practices.

⇒ Work culture; cost; risk perception; Hendra virus-related risk communication with staff, clients and government authorities; education; diagnostic pathways; legal responsibilities and running a private business and prior experience managing a Hendra virus outbreak were all factors veterinarians perceived as affecting infection control for the management of HeV.

- Understand the identified perceived barriers to infection control for the management of Hendra virus in private equine veterinary practices.

⇒ The emergence of HeV required the implementation of new management strategies by the veterinary profession and associated relevant government authorities. However, because Hendra virus's pattern of emergence was slow, the need to modify entrenched poor veterinary infection control habits was not recognised immediately.

The emergence of HeV was the trigger that mandated the overhaul of veterinary IC in Australia for the health and safety of private equine veterinarians and those under their responsibility. Private veterinarians interviewed for this study agreed that veterinary IC in Australia needed upgrading. They also warned that the path to IC improvements would take time. Indeed, results of Study 1 indicated that interviewees were all at different stages of the IC behaviour change process and that it would take time before a new IC norm was adopted by the majority. However, some veterinarians never accessed this new norm as they removed themselves from the process by ceasing equine practice altogether.⁸ Participants commented that achieving sustainable IC changes would necessitate consultation with the veterinary profession.

Concurrently to this study, the QLD Workplace Health and Safety authority carried out a series of non-punitive audits of equine veterinary practices in the same QLD region and found that 75% of the audited practices routinely conducted high HeV-exposure risk procedures involving the upper respiratory and uro-genital tracts (dentistry, endoscopy).⁹ However, only 54% of these practices used additional precautions, such as PPE when carrying out these high risk procedures on a healthy horse and only 59% did so when carrying out the same procedures on a sick horse. By the end of 2010, they concluded that equine veterinarians had still not attained the expected IC standards, without exploring possible reasons.⁹

Study 1 distinguished between two types of barriers: some IC issues pre-existed the emergence of HeV, such as those related to work culture, running a small to medium scale private business or a lack of experience managing zoonoses.¹⁰ Other issues were directly related to the emergence of HeV, such as the unpredictability inherent to a new infectious disease, the slow pattern of emergence reflected in the slow formulation of a clear and adequate HeV management plan by governments and veterinarians.¹⁰ Some of the challenges raised in this study echoed those highlighted by two independent reports and an Ombudsman's inquiry into the QLD Government's response to the emergence of HeV, which highlighted the lack of support provided to private veterinarians managing HeV in the field.^{3,7,11} Similar issues were identified during an outbreak of equine influenza in 2007 in QLD.^{12,13}

The barriers to optimal HeV management specifically related to the zoonosis have since been mostly addressed by government measures implemented for the most part concurrently or after the completion of Study 1. However, Study 1 also revealed pre-existing barriers to veterinary IC which seemed to be influenced by factors such as risk perception, IC leadership, risk communication to staff and animal owners and IC education.¹⁰ These factors were further investigated in subsequent quantitative studies which are presented in the following chapters.

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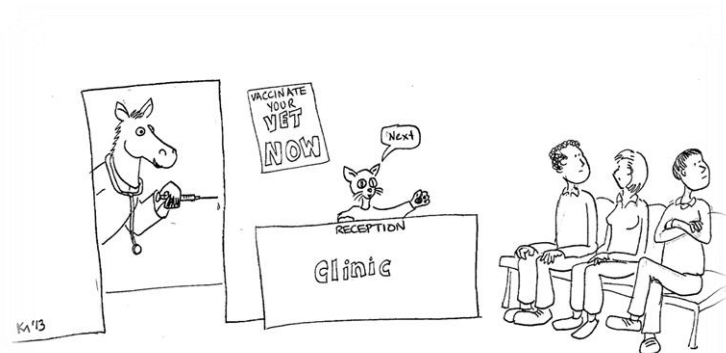
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CHAPTER 4 – Factors affecting veterinary infection control in the management of Hendra virus in Australian equine private veterinary practices.

Aims of this chapter

- Determine how the following factors affect infection control when managing Hendra virus in private equine veterinary practices :
 - Veterinarians' perceptions of risks related to Hendra virus.
 - Veterinarians' prior field experience with management of Hendra virus.
 - Veterinarians' prior training in the management of Hendra virus.
- Determine if and how the introduction of HeV vaccine for horses would affect infection control in the management of this disease.



Art work by Ken Miller

Introduction

Study 1 identified three important factors affecting veterinary infection control (IC) in the management of Hendra virus (HeV): 1) risk perception; 2) prior experience managing HeV; and 3) professional education relating to IC and/or HeV management. The aim of Study 2 was to further investigate in which manner these factors affected IC and HeV management decisions amongst the wider equine veterinary profession across Queensland (QLD), Australia. This investigation was conducted as a cross-sectional survey of all private veterinarians providing services to equine patients (see description in Chapter 2), and occurred after the QLD government had provided a comprehensive information and educational package to all veterinarians working within the state.¹ While this survey was being conducted (June to September 2011) both QLD and New South Wales (NSW) experienced the highest ever number of HeV outbreaks to date (QLD: 10 outbreaks and NSW: 8 outbreaks).² This survey was therefore very topical for equine veterinarians in QLD at the time. Additionally, shortly before the survey was first mailed out, it was announced that a HeV vaccine for horses would soon be available.³ The release of the vaccine was fast-tracked to help curb further outbreaks of HeV and thus minimise future HeV risk to horses and people coming into contact with them.³⁻⁵ As the aim of Study 2 was to investigate the effect of HeV risk perception the survey was revised to include questions that asked veterinarians how the introduction of a HeV vaccine would affect their HeV risk perceptions and their related IC and HeV management plans in the future.

Publications and outputs for Chapter 4

This chapter includes results from Study 2 presented as two peer-reviewed papers. I was the lead author for both these papers and my overall contribution to Study 2 and subsequent outputs was as follows:

- In collaboration with my main supervisor I led the design of Study 2.
- I led the preparation of the ethics application for this study.
- I attended a workshop about how to use SPSS software to analyse quantitative data.

- I updated an existing database containing the contact details of all veterinarians registered in with the Veterinary Surgeons Board of Queensland.
- I designed the survey questionnaire with the guidance of my secondary supervisor.
- I trialled the questionnaire with six veterinarians within the target population.
- I revised the questionnaire in light of the survey trial in consultation with my main supervisor.
- I implemented and managed the postal survey.
- I collated and entered some of the data into Excel and supervised the remaining data entry.
- I cleaned the data in Excel before importing the data into SPSS.
- I used SPSS software package to analyse the data under the guidance of my secondary supervisor.
- I was the lead author of the two manuscripts which I initially drafted. I managed the submission of these manuscripts which were accepted for publication in peer-reviewed journals (see below).

Results for Study 2 are included in the following peer-reviewed publications:

- **Mendez D**, Büttner P, Speare R. Response of Australian veterinarians to the announcement of a Hendra virus vaccine becoming available. *Aust Vet J.* 2013;91(8):328-331.
- **Mendez D**, Büttner P, Speare R. Hendra virus in Queensland, Australia during the winter of 2011: veterinarians on the path to better management strategies. *Prev Vet Med.* 2014;117(1):40-51.



Response of Australian veterinarians to the announcement of a Hendra virus vaccine becoming available

D Mendez,^{a*} P Büttner^{a,b} and R Speare^{a,b}

Design A cross-sectional study of private veterinarians providing equine services in Queensland.

Results The study revealed that a majority of veterinarians would support the introduction of a Hendra virus (HeV) vaccine. Moreover, almost half of the respondents intended to make vaccination a prerequisite to horse patient presentation. However, participants also responded that a vaccine would not reduce the risk sufficiently to cease or downgrade their HeV management plan and infection control measures.

Conclusion When devising promoting and marketing campaigns, government agencies and manufacturers should consider private veterinarians' intentions as a significant driver for the uptake of the HeV vaccine.

Keywords biosecurity; Hendra virus; infection control; vaccines; veterinarians

Abbreviations ARIA, Accessibility/Remoteness Index of Australia; EVA, Equine Veterinarians Association; HeV, Hendra virus; QLD, Queensland

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Hendra virus in Queensland, Australia, during the winter of 2011: Veterinarians on the path to better management strategies



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ABSTRACT

Following the emergence of Hendra virus (HeV), private veterinarians have had to adopt additional infection control strategies to manage this zoonosis. Between 1994 and 2010, seven people became infected with HeV, four fatally. All infected people were at a higher risk of exposure from contact with horses as they were either veterinary personnel, assisting veterinarians, or working in the horse industry. The management of emerging zoonoses is best approached from a One Health perspective as it benefits biosecurity as well as a public health, including the health of those most at risk, in this case private veterinarians. In 2011 we conducted a cross-sectional study of private veterinarians registered in Queensland and providing veterinary services to horses. The aim of this study was to gauge if participants had adopted recommendations for improved infection control, including the use of personal protective equipment (PPE), and the development of HeV specific management strategies during the winter of 2011. A majority of participants worked in practices that had a formal HeV management plan, mostly based on the perusal of official guidelines and an HeV field kit. The use of PPE increased as the health status of an equine patient decreased, demonstrating that many participants evaluated the risk of exposure to HeV appropriately; while others remained at risk of HeV infection by not using the appropriate PPE even when attending a sick horse. This study took place after Biosecurity Queensland had sent a comprehensive package about HeV management to all private veterinarians working in Queensland. However, those who had previous HeV experience through the management of suspected cases or had attended a HeV specific professional education programme in the previous 12 months were more likely to use PPE than those who had not. This may indicate that for private veterinarians in Queensland personal experience and face-to-face professional education sessions may be more effective in the improvement of HeV management than passive education via information packages. The role of different education pathways in the sustainable adoption of veterinary infection control measures should be further investigated.

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Conclusion

The aims of this chapter were met in the following manner:

- How did the following factors affect infection control when managing Hendra virus in private equine veterinary practices?

- Veterinarians' perceptions of risks related to Hendra virus.

⇒ The higher the HeV risk was perceived the more personal protective equipment (PPE) were used by veterinarians.

- Veterinarians' prior field experience with management of Hendra virus.

⇒ Veterinarians with prior field HeV management experience were more likely to use more items of PPE more often.

- Veterinarians' prior training in management of Hendra virus.

⇒ Veterinarians who had attended HeV management training were more likely to use more items of PPE more often.

- Would the introduction of a Hendra vaccine for horses affect infection control when managing this disease in private equine veterinary practices?

⇒ Most veterinarians would still consider that the HeV risk was high and that they

would not relax their infection control measures.

Overall the results from Study 2 showed that by 2011 most private equine veterinarians worked in practices that had adopted IC and HeV management strategies in line with government recommendations.¹ The majority of participants worked in a veterinary practice that based its HeV management action plan on a set of official guidelines provided by government authorities and used a dedicated HeV field kit. This was a further improvement on the results from an audit carried out in 2010 by Workplace Health and Safety Queensland, indicating that veterinarians had been improving their HeV management approaches.⁶ One reason that may have encouraged veterinarians to upgrade their HeV management strategies and behaviours was the marked increase in government support to veterinarians managing HeV in the field.^{7,8} The uncharacteristically high number of HeV outbreaks in 2011 (18) may have also emphasised the relevance of the HeV risk and further motivated veterinarians to use a wider range of IC measures.² Since then the yearly number of HeV outbreaks has greatly decreased and a HeV vaccine for horses was introduced in late 2012.^{2-4,9,10} These factors may have altered the level of HeV related risk perception amongst QLD veterinarians.

Veterinarians' perception of the HeV-related risk depended upon the degree of severity of the clinical signs displayed by a horse on presentation, the frequency of their prior exposure to the HeV risk, and the perceived likelihood of exposure to the HeV depending on the geographic locations of previous outbreaks.¹¹ The frequency, quantity and quality of PPE usage when attending horses varied with the level of HeV risk perception, HeV management professional education, in house HeV management leadership (access to formal HeV management within the practice) and prior experience with potential and/or confirmed HeV outbreaks. These results corroborated the results from Study 1.¹²

However, the implication of these results should be considered cautiously. For example, when attending a suspected HeV case, prior experience with HeV management in the field had a significant positive effect on veterinarians' PPE usage, while prior HeV management training did not. This may be because those with prior HeV management experience recognise the possible risks more readily than those without. In addition, when a horse appeared healthy a large proportion of veterinarians did not use any PPE even though horses have been found to

shed HeV viral particles up to two days before the onset of the first clinical signs of HeV.¹³ Therefore, examining an apparently healthy horse may not be a guarantee of low HeV risk.

Reassuringly, most of the participants declared that the introduction of a HeV vaccine for horses would not modify the way they assessed HeV risks or the way they mitigated these risks.¹⁴ Furthermore, a large proportion of veterinarians anticipated that in the future they would only provide veterinary services to horses that were vaccinated. The introduction of the HeV vaccine was therefore perceived more as an additional IC tool rather than a HeV management panacea. However, since the initial uptake of the vaccine was lower than expected despite a state wide campaign to encourage horse owners to protect their animals from HeV, all other recommended IC measures remain highly relevant today.¹⁵ Uptake of the Hendra vaccine may have been hampered by the high cost (AUD 210 for the first year not including veterinary consultation fees), fear of secondary effects and issues associated with the export of horses that tested positive to HeV following vaccination.¹⁶⁻¹⁸

The impetus to overhaul veterinary IC in Australia is directly linked to the emergence of HeV and its consequences for the veterinary profession. However, HeV is not the only zoonosis with which Australian veterinarians have to contend. The IC strategies used for the management of HeV are also applicable to the management of other zoonoses. The factors affecting IC in the management of HeV, as identified in Studies 1 and 2, need to be further investigated in relation to other zoonoses. This is the aim of Study 3.

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CHAPTER 5 – Risk communication about Hendra virus to horse owners: a veterinary responsibility and an infection control challenge.

Aims of this chapter

- Further investigate communication issues about infection control and Hendra virus related risks between equine veterinarians and horse owners.
- Investigate the ways in which these communication issues affect the management of Hendra virus by equine veterinarians.
- Investigate equine veterinarians' preparedness to provide information about Hendra virus related risks and their management to horse owners.
- Investigate frequency with which equine veterinarians provide information about Hendra virus related risks and their management to horse owners.



Art work by Ken Miller

Introduction

Study 1 revealed that some veterinarians experienced various degrees of difficulty communicating information about Hendra virus-related risk and instructions relating to risk mitigation to staff and clients who played the role of lay assistants when dealing with horses potentially infected with Hendra virus (HeV).^{1,2} One participating principal veterinarian explained, for example, that: *“As an employer...you can make all the recommendations, but it comes down to the individual and if [they, the employees] don’t have Hendra on their mind there is not much you can do.”* (Participant V14/Pj) Another principal veterinarian summarised the issues with HeV risk communication with clients by saying: *“I find great difficulty dealing with [horse] owners because it is a power play and ultimately we are responsible for the safety of all involved but some owners don’t believe that, which compromises the legal situation... We usually end up with less authority out of concern for the welfare of the animal.”* (Participant V4/Pc). This recurrent theme was brought up by participants of Study 1 when asked about the issues they perceived were barriers to infection control (IC) and HeV management in 2009-10. Difficulties with risk communication were viewed as a significant issue, with some participants declaring this was part of the reason some private veterinarians were ceasing equine practice: *“Some clinics have stopped equine work and one of the main factors is health and safety risks with Hendra.”* (Participant V14/Pj).¹

Currently, veterinary practice in Queensland, Australia, is governed by a number of pieces of legislation (Table 5.1).³⁻¹⁷ Thus, private veterinarians have, for example, the responsibility of maintaining the health and safety of all animals and people (staff or clients) under their supervision in their workplace.¹⁶ Animal health and safety is usually achieved by ensuring that animals do not become injured or infected during a consultation or hospital stay, and that they receive adequate and humane veterinary care. The health and safety of staff can be achieved by developing adequate work policies and protocols, and providing supervision, training and safety equipment. In the case of both animal and staff, the veterinarian in charge plays an active role in issuing warnings and implementing health and safety measures.

Table 5.1- Legislation governing private veterinary practice in Queensland, Australia, either directly or indirectly.³⁻¹⁷

Field of Legislation	Legislation
Veterinary practice	<ul style="list-style-type: none"> • Veterinary Surgeons Act 1936 • Veterinary Surgeons Regulation 2002
Animal Welfare	<ul style="list-style-type: none"> • Animal Care and Protection Act 2001 • Animal Management (Cats and Dogs) Act 2008
Agriculture and Livestock industry	<ul style="list-style-type: none"> • Stock Act 1915 • Agricultural Standards Act 1994 • Chemical Usage (Agricultural and Veterinary) Control Act 1988 • Agricultural and Veterinary Chemicals (Queensland) Act 1994
Biosecurity	<ul style="list-style-type: none"> • Exotic Diseases in Animals Act 1981 • Biological Control Act 1987 • Biosecurity Act 2014
Public Health	<ul style="list-style-type: none"> • Public Health Act 2005 • Health (Drugs and Poisons) Regulation 1996
Workplace Health and Safety	<ul style="list-style-type: none"> • Work Health and Safety Act 2011 • Radiation Safety Act 1999

Veterinarians also have an obligation to caution and protect clients against potential exposure to chemical, physical or biological risks within the veterinary workplace. Despite holding these responsibilities, veterinarians do not have the legal authority to enforce client compliance with veterinary health and safety directives. This can leave private veterinarians vulnerable to legal liability. A client suffering a negative health outcome as a result of non-compliance with veterinary instructions could be interpreted as the fault of the attending veterinary; i.e., malpractice or negligence. This is particularly relevant when dealing with zoonoses, which can directly affect humans. Hence, veterinarians' abilities to communicate with clients about the

zoonotic risks and ways to avoid exposure to these risks is essential, not only for the health and safety of all involved but also for the viability of their business.

Following the findings of Study 1 about veterinary HeV risk communication to clients, this aspect of HeV management needed to be further investigated. Consequently the survey questionnaire used for Study 2 included multiple-choice and open-ended questions about HeV related risk and the manner in which risk mitigation was communicated to clients and/or lay assistants.

Publication and outputs for Chapter 5

This chapter examines and compares the results related to risk communication to horse owners in Studies 1 and 2. Results from this analysis are presented as a manuscript submitted to a peer-reviewed journal: BMC Veterinary Research (November 2015). I was the lead author for this manuscript and my overall contribution to this chapter and its outputs was as follows:

- As described in Chapters 3 and 4, I led most aspects of Studies 1 and 2: study design; study implementation; data collection and management; data analysis; publication of results in peer-reviewed journals.
- In Chapter 5, I reanalysed the data related to communication with clients gathered during Studies 1 and 2. I used SPSS to analyse the quantitative results of Study 2, and N-Vivo to analyse thematically and compare the quantitative results of Studies 1 and 2.
- I was the lead author of one manuscript which I drafted and submitted to a peer-review journal (see below).

The combined results regarding HeV-related risk communication between veterinarians and horse owners from Studies 1 and 2 are included in the following manuscript under review with BMC Veterinary Research:

- **Mendez D**, Büttner P, Kelly J, Nowak M, Speare R. Difficulties experienced by veterinarians when communicating Hendra virus risks to horse owners: a mixed methods approach. (submitted to BMC Vet Res. Nov 2015)

The included manuscript was formatted as per BMC Vet Res requirements.

Difficulties experienced by veterinarians when communicating Hendra virus risks to horse owners: a mixed methods approach.

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Abstract

Background

Communication skills are essential for private veterinarians who need to discuss animal health related matters with their clients. When dealing with an emerging zoonosis, such as Hendra virus (HeV), veterinarians also have a legal responsibility to inform their clients about the associated risks to human health. Here we report two consecutive studies that examined the preparedness of and difficulties experienced by veterinarians communicating about HeV-related risks with their clients.

Methods

Study 1 was a qualitative study that consisted of a series of face-to-face semi-structured interviews with veterinary personnel from Queensland Australia (2009-10) to identify the barriers to HeV management in equine practices. Study 2 was a quantitative study that surveyed veterinarians from the same region (2011) and explored the veterinarians' preparedness and willingness to communicate about HeV-related risks, and the reactions of their clients. The second study included both multiple choice and open-ended questions.

Results

Over half the participants (58.6%) from Study 2 had ready-to-use information about HeV available for clients in their practice and a majority (87%) reported to "always or sometimes" inform clients about HeV-related risks when a horse appeared sick. When HeV was suspected, 58.1% of participants reported their clients were receptive to their safety directives and 24.9% of clients were either initially unreceptive, overwhelmed by fear or in denial of the associated risks. The thematic analysis of the qualitative data from Studies 1 and 2 uncovered similar

themes in relation to HeV-related communication issues experienced by veterinarians: *“acceptance and/or compliance”*; *“compliance deemed redundant”*; *“misunderstanding or denial of the risk”*; *“cost”*; *“rural culture”*; *“fear for reputation”*.

Conclusion

Regardless of the circumstances, warning horse owners about the health and safety risks is a legal requirement for private veterinarians. Although communication skills are already part of many undergraduate veterinary curricula, an emerging zoonosis is an unpredictable event that may require a different set of skills and approaches. Future training programs addressing veterinary communication skills should take into account the particular issues inherent to managing an emerging zoonosis and emphasise the importance of maintaining “human-safety”.

Chapter 5 - Risk communication about Hendra virus to horse owners: a veterinary responsibility and an infection control challenge.

Keywords: Veterinarians, Horse owners, Emerging Zoonoses, Hendra virus, Risk communication, Risk management, Health and safety.

Background

Hendra virus (HeV) is a relatively new zoonosis unique to Australia; the etiologic agent is an enveloped negative-sense RNA paramyxovirus.[1-4] It was first recognised in 1994 during a disease outbreak in the suburb of Hendra, Queensland (Qld), Australia.[1,2,5-7] It affected 20 horses (seven confirmed cases and 13 suspected cases) and two humans, one of whom died of a severe pneumonic illness.[1,2,5-8] Earlier the same year another outbreak, which was investigated retrospectively, involved two horses and a lay person assisting a veterinarian during a post-mortem examination.[9,10] This lay veterinary assistant developed aseptic meningitis from which he seemingly recovered before relapsing 13 months later, subsequently dying of severe encephalitis.[7-11] The first two outbreaks occurred more than 900 km apart and were considered unrelated.[12,13] Since then, there have been another 50 outbreaks along the Eastern coast of Australia between Far North Qld and Northern New South Wales (NSW) involving 73 confirmed equine cases, 20 unconfirmed cases and another four humans: a veterinary nurse (survived) and three veterinarians (one survived, two died).[7,14-23] In 2011 a dog found on a Qld property with three confirmed equine HeV cases seroconverted but did not display any clinical signs.[7, 24] In 2013, another dog, from a NSW property where a horse had been diagnosed with HeV, was found infected with HeV.[25, 26]

Pteropid bats, more commonly known as flying foxes, are the animal reservoir from which HeV occasionally spills-over into horses and in some instances from horses to humans.[27-29] The transmission path between bats and horses remains unclear. Hendra virus has been isolated from bats' urine, faeces, birthing fluids and tissue, and blood; and it is believed that the likely route of transmission is via contamination of horse-feed.[7,8,27-29] However, a

recent study found that HeV in the environment was short lived and suggested that transmission between bats and horses was likely occurring via a more direct and immediate path.[30] Infected horses may shed HeV viral particles up to two days prior to the onset of clinical signs.[31] Transmission from horses to humans is via exposure to bodily fluids and/or blood from an infected horse.[7,8] Although infection is rare, the case fatality rate in humans is 57%; hence, its significance for veterinarians who have the responsibility of managing this occupational risk in order to preserve their own health and safety and that of their staff and clients. When managing a suspected equine HeV case, veterinarians are mandated to notify the biosecurity authorities; and while awaiting field support from these authorities, they need to inform horse owners about the risks involved and if necessary instruct them about infection control (IC) strategies to mitigate these risks.[32] Despite holding this responsibility, veterinarians do not have the legal authority to enforce client compliance with veterinary health and safety directives.[33] This can leave private veterinarians vulnerable to legal liability. A client experiencing a negative health outcome as a result of non-compliance with veterinary instructions could be interpreted as veterinary malpractice or negligence.[33] In the case of HeV, some veterinarians found this situation too burdensome and decided to cease equine practice.[34] Hence, veterinarians' abilities to communicate with clients about zoonotic risks and ways to avoid exposure to these risks are essential, not only from a health and safety perspective, but also from a legal and business point of view.

While conducting an exploratory qualitative study investigating the problems experienced by private veterinarians managing potential HeV outbreaks in Qld, between 2009 and 2010; we found that some veterinarians experienced various degrees of difficulty communicating HeV-

related risk information and risk mitigation instructions to clients who, in some instances, were akin to lay assistants.[35] Veterinarians reported that clients' responses to their attempts at communication of risk and risk mitigation varied from acceptance to fear, refusal and denial.[35] Following these findings, we investigated this issue further with a cross-sectional survey of private veterinarians working in Qld that included questions about communicating HeV-related risk information to horse owners or lay assistants when managing a potential HeV outbreak.[36] The work presented here analyses the combined results of these two studies to gain a better understanding of the issues surrounding HeV risk communication between veterinarians and their clients and the possible effect this may have on the management of this disease.

Methods

Research protocol

Research protocols for both the exploratory qualitative and cross-sectional studies have been published elsewhere.[34-36] The qualitative components of the following studies complied with the qualitative research guidelines on relevance, appropriateness, transparency and soundness of research methodology (RATS) [37,38]

Study 1

The first study consisted of a series of 21 face-to-face in-depth interviews with veterinary personnel from 14 private practices along the eastern coast of Qld between December 2009

and September 2010.[34,35] The aim of this study was to identify and understand private veterinarians' perceived barriers to HeV management and related IC practices. During the semi-structured interviews participants explored the issues surrounding IC and HeV management involving horse owning clients and other lay assistants. This study received approval from the James Cook University Human Ethics Committee (approval no.H3513).

Study 2

The second study consisted of a cross-sectional survey of all veterinarians working in private practice in Qld between June 2011 and September 2011.[36] Veterinarians who had provided veterinary services to a horse patient at least once in the 12 months prior to the survey were eligible to participate in the study. Aside from a number of socio-demographic, education and professional questions, participants were asked: 1) if they had access to a formally documented HeV management plan within their practice; 2) if the HeV management plan contained information for horse owners about HeV and flying foxes; and 3) how often they provided HeV information and safety instructions according to the health status of a horse. Participants were also asked open-ended questions about the reactions of lay assistants/horse owners in regards to HeV risk communication and safety instructions when HeV was suspected. This study received approval from the James Cook University Human Ethics Committee (approval no.H3687).

Data analysis

The qualitative data analyses were initially carried out separately for both studies and subsequently compared.[39]

Study 1

Each participant was assigned an individual and a practice alphanumeric identifier (V* for veterinarians, VN* for veterinary nurses, PM* for practice manager, P* for practice). The initial thematic analysis of the qualitative data collected during Study 1 yielded six main themes, one of which was *“risk and risk mitigation communication”*. [35] Here the data coded into this theme was subsequently reanalysed thematically for further units of meaning in order to better conceptualise the communication issues between veterinarians and their clients. This process was repeated on several occasions by author DM and outcomes were reviewed by author RS for agreement and meaningfulness within the context of the management of HeV in private veterinary practices.

Study 2

Questionnaires were attributed a unique identification number and responses were collated into Excel (Microsoft. Released 2010) and later imported into SPSS (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.) for analysis. Open-ended responses about the reaction of horse owners/lay assistants to HeV-related risk warnings and safety instructions were categorised according to the following general themes: *“lay assistant was receptive and complied”*; *“lay assistant was unreceptive but complied”*; *“lay*

assistant was in denial"; *"lay assistant was overcome with fear"*; *"no lay assistant was used"*; and *"lay assistant had another type of reaction not previously described"* (Table 2). Categorical descriptive data were reported using percentages while data from open-ended questions were categorised and reported using percentages.

Study 1 and 2

In order to further identify and understand the barriers to communication of risk and risk mitigation with clients, a content analysis of Study 2 participants' open-ended responses about the reactions of clients/lay assistants to veterinary communications about HeV was conducted. The results from this thematic analysis were subsequently compared to those from Study 1 to determine if issues of risk communication experienced by veterinarians in 2009-2010 (Study 1) were similar to those experienced by veterinarians in 2011 (Study 2).

Results

Study 1 (qualitative)

The reanalysis of the data coded under the *"Risk and risk mitigation communication"* theme yielded a further seven subthemes relating to reactions of horse owners to veterinary advice and instructions about IC and HeV management: 1) *"Acceptance and/or compliance"*; 2) *"Compliance deemed redundant"*; 3) *"Misunderstanding or denial of risk"*; 4) *"Cost"*; 5) *"Rural culture"*; 6) *"Fear for reputation"*; and 7) *"Emotional attachment to animal"*. Each of these subthemes are illustrated by selected quotes from participants' responses during Study 1 (Table 1).

Acceptance and/or compliance

Although, overall HeV-related risk and risk mitigation communication to clients was perceived as a significant issue by participants, some did not find this aspect of HeV management a major challenge. Those who were successful in liaising with clients about HeV issues usually conveyed their expert knowledge about the risks involved confidently and authoritatively. However, for many participants HeV-related risk and risk mitigation communication to horse owners remained difficult. These participants felt that these communication difficulties prevented them from fulfilling their health and safety responsibilities towards the animals, staff and clients under their care, and in some cases themselves as the following subthemes demonstrate.

Compliance deemed redundant

According to participants, some clients appreciated receiving information about the health risks posed by HeV to humans and animals and about ways to manage these risks. However, a number of horse owners did not see the need to use personal protective equipment (PPE) when instructed to do so because they had already been in prolonged close contact with their sick animal and therefore believed they had already been significantly exposed to the potential risks. Veterinarians recognised this was an issue, not only for their clients' health and safety, but also for their own legal liability. Indeed, if a client became infected it would be impossible to determine when the client became infected: before or after the involvement

of the veterinarian. However, the legal ramifications for a veterinarian and their practice could be serious.

Misunderstanding or denial of risk

Some horse owners reportedly disregarded veterinary information about HeV management or did not understand the seriousness of the associated risks. In some cases veterinarians attributed the clients' reluctance to follow their advice to their lack of HeV knowledge. The disconnection between veterinary and lay knowledge about the risks led to mismatched behaviours and a lack of understanding of the significance of the advice veterinarians gave to clients. In some instances not only were the risks poorly understood by clients, but also denied. Denial of the risk resulted in clients either not following veterinary instructions or disagreeing with veterinarians' IC decisions and HeV management strategies. The issues encountered by veterinarians in terms of risk and risk mitigation communication to clients were not exclusive to the HeV management scenario. Some participants reported this also had occurred when they dealt with equine influenza outbreaks. Communication between veterinarians and their clients may therefore be a wider issue that compromises other areas of veterinary practice.

Cost

Unlike the public health care system which is subsidised by various government schemes, every veterinary decision incurs a cost for the private practitioner that needs to be passed on to the client with a profit margin. Veterinarians interviewed for Study 1 reported feeling

pressured to focus on cost minimisation rather than safety. A recurrent example was when a veterinarian suspected a horse of being infected with HeV and wanted to use extra PPE and have the animal tested, but the client disagreed with these decisions and therefore believed the veterinarian, not the client, should bear the financial burden. In other cases veterinarians and their staff were very wary of using extra PPE as the costs might appear unjustified in the eyes of an owner if the horse were later found not to be infected with HeV.

Rural Culture

Some participants reported that clients from rural areas preferred to rely on local traditional knowledge and past personal experiences rather than on the educated professional advice of a veterinarian.[36] For example, in one instance the use of PPE by veterinarians was seen by a farmer as a sign of weakness rather than a sign of professional and responsible competence. A number of veterinarians interviewed also explained that this aspect of rural culture influenced their IC decisions as they sometime felt too self-conscious to use PPE in rural settings, even though this contravened the maintenance of health and safety regulations.

Fear for reputation

Participants described their clients as either owning horses as part of their professional activity or only for recreational purposes. Suspecting a horse of being infected with HeV would therefore hold a different significance depending on the financial or emotional value vested in the animal by its owner. Those working in the horse industry were perceived by participants as having more to lose from an outbreak of HeV than other types of horse owners: loss of

animal assets, loss of access to animals (quarantine), loss of income, and loss of business reputation. Some participants thought that these possible costs represented a threat to this kind of horse owner, some of whom were reluctant to notify authorities about potentially infected animals in order to avoid repercussions to their business. While veterinarians were legally required to notify authorities of any suspected HeV outbreak, horse owners did not seem to be held equally accountable.

Emotional attachment to animals

While professional horse owners were reported as worrying about the consequences for their businesses, many clients who owned horses for recreational purposes were reported as having difficulties accepting veterinary directives because of their emotional attachment to their animals. This led some owners to disregard veterinary safety instructions in order to stay close to their animals, or to refuse testing of their animals for fear of mandatory euthanasia if found infected with HeV. According to some veterinarians and their staff, safety and quarantine instructions were sometimes misconstrued as lack of care. In some cases, participants admitted overlooking some personal safety precautions out of concern for the welfare of the animals. Other participants indicated that following strict HeV management measures had resulted in them to losing business and reputation.

Study 2 (quantitative)

A total of 1604 potentially eligible veterinarians were sent a survey; 200 veterinarians returned their questionnaire.[36] Not all participants answered all questions. A response rate

could not be calculated because the denominator (the number of veterinarians who had treated a horse in the past 12 months) was unknown.[35]

The socio-demographic, professional, educational and practice profile of participants have been presented elsewhere.[35] The majority of participants (83.1%, 162/195) had access to a formalised HeV management plan in their practice. More than half the participants reported their HeV management plan included an information sheet about HeV for horse owners (58.6%, 112/191) (Table 2). Less than half the participants (46.6%, 88/189) “*always or sometimes*” provided HeV-related education to horse owners when a horse appeared healthy while most (87%, 166/191) did so when a horse appeared sick (Table 2). The proportion of participants who reported “*always or sometimes*” instructing lay assistants about the potential risk of exposure to HeV according to apparent health status of horse were similar to those of participants providing HeV education to horse owners (Table 2).

While 41.4% (55/133) of participants reported lay assistants/horse owners usually were receptive to HeV-related information and willing to comply with safety instructions, 19.5% (26/133) reported lay people were often overcome by fear and 11.3% (15/133) considered they were in denial about the information provided (Table 2). The number of participants (58.1%, 72/124) reporting lay assistants being receptive and willing to comply with the safety instructions increased when a horse was suspected of being infected with HeV (Table 2).

Study 1 and 2 (mixed methods)

For ease of understanding this section contains both results and comments. Many of the subthemes extracted from Study 2 coincided with those obtained from Study 1, with some variations within subthemes (Table 1). For example, within the sub-theme “*Misunderstanding or denial of the risk,*” participants of Study 2 had a slightly different insight into why clients did not perceive or understand HeV risks. However, one of the sub-themes identified during Study 1, “*emotional attachment to animal*”, did not recur in Study 2. Below are the sub-themes from the thematic analysis of participants’ open-ended responses from Study 2. Results from Study 2 are also compared to those from Study 1 (Table 1).

Acceptance and/or compliance

A number of participants reported that clients were grateful for the information, safety instructions and equipment provided by veterinarians. However, this still did not guarantee systematic adequate compliance because some clients lacked understanding of the required procedures. In Study 1, some participants noted that sometimes the donning and doffing of PPE in field situations were difficult even for trained professionals. Therefore some clients who were not trained in veterinary IC protocols may have had insufficient experience to readily comply with veterinary safety instructions about using PPE correctly.

Compliance deemed redundant

As in Study 1, exposure of clients prior to veterinary involvement was an issue broached by many Study 2 participants. Some participants reported that a number of clients refused safety equipment because they had already been exposed. However, further exposure to the HeV

risk should still be prevented because a first exposure does not necessarily result in infection. Veterinarians should still meet their health and safety legal duties by offering their clients information, instructions and PPE to avoid further exposure. Veterinarians could also play an important public health role by advising their clients to seek medical attention for assessment of their exposure risk.

Misunderstanding or denial of the risk

Some participants reported that communicating the risk of HeV infection to clients in some geographic areas, such as non-coastal areas of Qld, was difficult because horse owners from these areas thought the risk of exposure to HeV was low as there had not been any HeV cases in inland areas. Participants from Study 1 reported similar beliefs among veterinary professionals prior to 2010, with some believing that HeV could only occur in some areas of Qld. Although most outbreaks have occurred in coastal areas between Far-North Qld and Northern New South Wales, the habitat range of pteropid bats, the animal reservoir of HeV, extends beyond these areas and spill-overs could potentially occur in non-coastal areas. Clients may need to be better informed about the relationship between the presence of flying foxes and the potential for HeV spill-over events. Less than a third of Study 2 participants worked in practices with readily available information about flying foxes in relation to HeV risks. Veterinary practices may require encouragement to include such information in their HeV management plan and HeV field kits.

Participants also explained that non-compliance with HeV management directives among clients was linked to a lack of understanding and/or denial of the risks involved. In some cases denial was due to a lack of recognition of veterinary expertise or not believing the seriousness of the risk. In other cases the risk was not understood because according to some participants, clients lacked the necessary background knowledge to understand the concepts of IC in relation to zoonoses management. In some cases the clients based the likelihood of the risks on the health of the horse. Some participants of Study 1 reported similar misconceptions amongst veterinary personnel. Clients need to be warned about the possibility of HeV viral shedding in bodily fluids excreted up to two days prior to the onset of any clinical signs of illness; this was unknown before 2011.

Cost

Participants from Study 2 also reported that costs incurred by implementing extra IC measures such as the use of PPE, or managing HeV such as diagnostic testing was not well received by some clients especially in rural settings. If clients refuse costs associated with the management of HeV, it leaves veterinarians with the responsibility and liability of health and safety issues as well as the related financial burden.

Rural culture

Participants felt that clients in rural areas were less likely to accept their HeV management decisions. As in Study 1, rural clients seemed focussed on a culture in which safety precautions were seen as a sign of weakness rather than veterinary professionalism. This rural culture

approach to safety was similar to the veterinary work culture described in Study 1, in that it influenced IC behaviours of some experienced veterinarians who wanted to conform to a professional identity characterised by a general disregard for some risks in the workplace.

Fear for reputation

Notifying authorities about a potential HeV outbreak has consequences for horse owners; their property may be subjected to quarantine or scrutinised by the media, thus discrediting their personal and/or professional reputation. In both studies, clients were reported as fearing media attention due to suspected or confirmed HeV outbreaks. The lack of knowledge about HeV epidemiology among the general population, including the media and horse owners, seemed to be the source of this fear. In order to debunk unnecessary fears, education about HeV-related risks may need to target not only those in contact with horses, veterinarians and horse owners, but also those living in communities with horses locally.

Discussion

Results from Study 2 showed that the majority of veterinarians were prepared to provide information about health and safety HeV-related risks to their clients. However, this information was not always passed on to clients. Findings from Study 2 concurred for the most part with those from Study 1. The use of a mixed methods approach to explore the particular issue of communicating HeV-related risks to clients proved valuable in crystallising the main factors affecting this aspect of HeV management. While some horse owners were receptive to information and safety directives regarding HeV-related risks to animal and human health, others were reportedly unreceptive to these recommendations. Reasons for

horse owners' unresponsiveness included: 1) exposure had already occurred; 2) risk not properly understood or denied; 3) cost of IC and/or testing for HeV; 4) rural culture; 5) fear of long-term damage to reputation; and 6) emotional attachment to horse. Participants in both studies reported that the clients' lack of co-operation hampered their efforts to follow official guidelines when managing a potential HeV outbreak.[7] Some participants went further by stating that this communication issue prevented them and/or their practice from fulfilling their workplace health and safety and biosecurity legal responsibilities.

Miscommunication between healthcare providers and their patients also occurs in the medical field. For example, patient compliance with physician's treatment plan is an issue affecting the delivery of health services in a wide variety of medical fields.[40-43] Many studies have shown that patients' adherence to health recommendations and prescriptions improves when the health provider-patient relationship improves through patient-centred communication and shared decision making. In veterinary medicine, communication with patients is limited for obvious reasons and most verbal interactions take place between the veterinarian and the animal's owner; the client. This is a significant difference. Unlike most healthcare professionals whose services are financially supported, at least in part, by the government through a healthcare system,[44] veterinarians officiate as private for-profit service providers. The relationship between veterinarians and their clients is based, therefore, on very different premises than those between medical practitioners and their patients. This distinction is not always understood by animal owners and may be a potential source of conflict between veterinarians and their clients.[45-48]

Veterinarians communicate with their clients not only about zoonotic risks, but about a range of other topics from animal health and lifestyle issues, to animal-human interactions, animal behavioural problems, end of life decisions, and cost for services provided. Exchange of information between veterinarians and their clients has been scrutinised from different perspectives. The following factors have been found to hamper veterinary communication with clients and clients' subsequent compliance with veterinary directives: 1) communication skills of veterinarians; 2) "motivation of veterinarians" vs "expectations of clients"; 3) "routine communication" *versus* "crisis communication"; 4) perceptions of clients about the role of veterinarians; 4) veterinarian's ability to communicate with the whole spectrum of clients; 5) clients' ability to understand the message.[49-68]

Communication skills of veterinarians

Although veterinary training focuses predominantly on biomedical and clinical knowledge, veterinarians and veterinary educators recognise that the acquisition of a number of non-clinical skills such as; business management and acumen, leadership, communication skills, and conflict resolution are essential to be successful in veterinary practice.[49-52] Teaching these non-clinical skills, including communication skills, is now incorporated into many undergraduate veterinary curricula.[49-52] Despite this broadening of veterinary studies, some final year veterinary students still feel unprepared when faced with angry, overpowering, cost reluctant clients or when delivering news about poor prognosis or discussing end-of-life decisions.[49,53]

Participants in Studies 1 and 2 did not question their communication skills and/or training and did not appear to think this was an issue when warning and dealing with clients. A number of participants reported their clients accepted their directives and complied with them. These participants did not appear to have issues conveying their HeV risk and risk management messages authoritatively and efficiently. Their communication skills may have been partly acquired through training and experience, and may partly be an innate quality of some individuals. Another issue may have been accuracy and breadth of knowledge some veterinarians had about HeV. Participants from Study 1 reported not all veterinarians were as well informed about HeV risks; some did not access the information available at the time, while early career veterinarians may have been misinformed about the risks because of discrepancies in undergraduate curricula between universities in Australia.[35] Raising the self-awareness of veterinarians to assess and improve their communications with clients would seem to be an essential step in improving this aspect of work health and safety .

Clients' abilities to understand the message

Clients' expectations may vary with their level of prior knowledge about veterinary topics broached during a consultation. Horse owners do not always recognise the significance of clinical signs in their horses.[54] Clients may also view zoonotic risks to themselves and their animals differently from veterinarians and disagree about the best management strategy. [55] A Swiss study, for example, found that veterinarians, farmers and the wider community all agreed that vaccination was a better way to curb an animal epidemic than mass culling of animals. However, although farmers were expected to have more knowledge about animal health than the rest of the population, their perceptions of the risk associated with animal

epidemics were more similar to those of the lay community than those of veterinarians.[55]

Scheman and colleagues also found that horse owners not directly involved in the horse industry had much lower perception of risk and lower compliance with biosecurity advice during an equine influenza outbreak than horse owners directly involved in the industry.[56]

Clients who do not recognise the significance of infectious diseases or the related risks are unlikely to seek and/or trust veterinary advice. Kung and colleagues reported that horse owners in the HeV geographic distribution range had inconsistent knowledge about the disease and although more than half recognised HeV was likely to occur in their area, only a third would think of HeV if their horse became ill.[57] Furthermore, they also reported inconsistent uptake of the recommendations provided to horse owners in terms of minimising the exposure of horses to HeV.[57]

In some instances clients may also be misinformed by the media. Nicol and colleagues point to the important role the media can play in disseminating information about new diseases to the public and health professionals.[69] However, if little is known about an emerging disease, it is difficult to trust the information source of the media. Some Study 1 participants alluded to the role of the media in misinforming the public about issues surrounding HeV (Mendez et al unpublished data). Degeling and Kerridge examined reports about HeV in the media between 2007 and 2011 and identified conflicting themes in stories relating to HeV outbreaks and their management: 1) an evidence based, health-centred focus aiming to minimise people's exposure to HeV through behavioural changes, *versus*, 2) an unfounded populist focus aiming to eradicate the source of the disease.[70] This is an example of the way the

media may skew information and thus influence public opinion including that of horse owners.

Misinformation, lack of knowledge or erroneous risk perception amongst horse owners was not specifically reported by participants of Study 2, but a number of Study 1 participants reported information about these issues. This led to horse owners' disbelief when their veterinarian suspected HeV.[35] Veterinarians have to consider the beliefs and comprehension capabilities of their clients and adapt the content of their risk communication messages accordingly. Veterinarians may need to develop a pro-forma information package able to be understood by all owners to facilitate communication. Furthermore, with emerging diseases such as HeV, information campaigns led by the relevant government agencies, and targeted at animal owners and the wider population would help the credibility of veterinarians and reduce misinformation. In Qld the Department of Agriculture and Fisheries provides such packages.[7,32]

“Motivation of veterinarians” vs “expectations of clients”

The information provided by veterinarians during a consultation often mismatches their clients' expectations.[58-60] For example, clients tend to focus on the wellbeing of the animal, while veterinarians focus on delivering information about the health status of the animal from a clinical perspective.[58-60] Sayers and colleagues found that although some farmers viewed veterinarians as the experts, their motivations were the health of their animals, while veterinarians were motivated by cost benefits and legal requirements.[61] In some cases, the

communication is hampered by the one-sided, rushed communication style of some veterinarians; the client believes their concerns are not being listened to or they are not being included in the decision making process.[47,62] Furthermore, clients and veterinarians have different views about what constitutes a “good vet”.[63] In a British study, more clients than veterinarians classified veterinary attributes such as confidence, good at explaining technical terms, patience, honesty, and politeness as “very important”.[63] This may contribute to both the differences in expectations between veterinarians and clients, and a difference in satisfaction at the conclusion of a consultation.

Both studies showed that when veterinarians delivered HeV-related information based on their professional knowledge, some clients responded in a highly emotionally charged manner with fear, anger and/or denial. Participants reported that the discordance between the rational perspective of veterinarians and the emotional perspective of the clients hindered their management of HeV and, in some instances, jeopardised their legal workplace health and safety liability.[34] Clients’ attitudes towards veterinary discourse also reportedly varied between rural and urban areas. Study 1, for example, revealed that clients involved in the horse industry as a commercial venture did not relate to veterinarians in the same way as those who owned horses for recreational purposes.[35] This may have reflected a difference amongst owners in financial and emotional interests in the horses. This highlights that veterinarians need to consider tailoring their communication style and content depending on the type of horse owner.

Perceptions of clients about the role of veterinarians

Research suggests that clients perceive veterinarians as the equivalent of their own physician.[45] Furthermore, although veterinarians are recognised by their medical counterparts as experts in the management of zoonoses, this is not always recognised by members of the community, perhaps because they do not understand the nature of zoonoses.[71,72] Animal producers tend to recognise veterinarians as experts in animal biosecurity, yet some domestic animal owners do not value veterinary expertise, only contacting a veterinarian when an animal is seriously ill.[61,64,65] Owners of aged horses from rural areas of Australia reportedly overlook preventive veterinary healthcare more often than horse owners from urban areas.[54]

Study 1 participants reported similar attitudes in clients from rural areas, where local traditional beliefs prevailed over veterinary knowledge. Participants felt this discredited their professional expertise, diminished their authority in regards to veterinary matters, and hampered their efforts to communicate with some horse owners about HeV management. To overcome this communication barrier, veterinarians may need to adapt their approach to how the client relates to veterinarians in general.

“Routine communication” vs “crisis communication”

Some veterinarians have reported feeling uncomfortable when communicating about routine topics such as diagnosis, treatment options (including euthanasia), and costs, a typical example being the conversation about veterinary fees.[46,49,53,66] Some veterinarians

report feeling uncomfortable raising the subject of cost because they are apprehensive about the clients' reactions, which may vary from upfront acceptance; to suspicion; disagreement or lack of compliance with treatment plan; to a client not returning to the practice.[44,45,67]

A number of participants in Studies 1 and 2 found the broaching of seemingly routine topics such as testing for HeV and cost a challenge, particularly when clients did not expect or believe HeV was an issue.[35,67]

Aside from discussing routine animal health issues, veterinarians also sometimes need to address crisis situations with clients; for example, an animal health emergency or an animal disease outbreak. These are unpredictable events and require a different style of communication. Telg differentiates between "risk communication", about the safety of certain known scenarios and "crisis communication", which addresses unpredictable risks.[68] The former type of communication proactively aims to prevent unsafe events, while the latter tends to react to an unforeseen situation. Communicating about HeV-related risk when a horse appears healthy is akin to preventive "risk communication" as its aim is to educate clients about possible risks and ways to prevent exposure to those risks. When a horse appears clinically ill, veterinarians need to switch to "crisis communication" because HeV-related risks are more likely. However, prior to 2011 HeV was still perceived as an emerging zoonosis without a fully elucidated epidemiology, and HeV outbreaks were considered rare events. At that time, the suspicion of HeV would represent an unfamiliar scenario for most horse owners and veterinarians. Some veterinarians may not have had sufficient experience to communicate efficiently or knowledgeably about HeV risk when HeV first emerged. The "crisis situation" may also have altered the usual communication patterns

between veterinarians and their clients. Veterinarians may need better training in “crisis communication” in addition to regular “communication skills”.

Regardless of the risk, training, experience, innate ability to communicate and the audience, it is essential for veterinarians to be able to communicate appropriately and effectively with their clientele. Their communication skills may affect animal health outcomes, the health and safety of their staff and clients, their relationship with their clients, their legal liability, and ultimately the viability of their business. For example, three Australian veterinarians were recently prosecuted for allegedly failing to protect themselves and/or inform and instruct horse owners of the HeV-related risks.[73] One of these prosecutions has since been dismissed on a legal technicality.[74] However, the other two are still proceeding, with serious implications for the veterinary profession if the veterinarians concerned were to be charged in the absence of any adverse effect of the putative exposure to the virus. These prosecutions may also have implications for the medical and nursing professions since, although breaches of IC occur very frequently in hospitals and clinics,[75] they currently do not result in any legal workplace health and safety action, particularly when no harm arises from the lapse. In addition communication over HeV has become more complicated and controversial as Qld veterinarians refuse to examine horses that have not been vaccinated against HeV.[76]

Veterinary communication skills could be improved by targeting the existing veterinary workforce and undergraduate veterinary students by building on health communication skills training models used in medical curricula.[52,77] However, the content of the relevant curriculum would need to be adapted to the specific circumstances of the veterinary

workplace: general communication with clients; communication about specific issues such as IC and public health responsibilities; communication with the aim of selling a service (animal care); and communication about particular emotive issues such as euthanasia.[77] Different authors have championed different teaching approaches. McArthur found that established Australian private veterinarians were in favour of including communication skills in their continuing professional education.[60] However, a one-off training session did not improve their communication skills. To improve the training outcomes, McArthur recommended offering training over a longer period or providing repeated training sessions. Donnelly and colleagues emphasised that communication with clients should be addressed at the practice level.[66] They recommended that all veterinary staff should be trained to deliver a consistent message to clients throughout the practice to avoid confusion or conflicting information. At the undergraduate level, Latham and Morris found that veterinary students who had received communication skills training in the United Kingdom were ranked as “better” by clients.[78] Clients also had improved recall of veterinary information delivered by these students, except for information about medication. In Australia, Mills and colleagues examined a newly introduced curriculum addressing veterinary communication skills at the undergraduate level; it included the use of videos and role play. They found these were valuable and effective tools when teaching communications skills for difficult consultation situations.[50] Since each veterinary-client interaction is likely to be different, practising these skills in a variety of real-life scenarios would benefit future veterinarians.

The results presented here suggest that veterinarians need to be able to communicate effectively with their clients about routine as well as unexpected veterinary topics. This is

particular important when dealing with an emerging zoonosis such as HeV which has a biosecurity and health and safety significance for veterinarians and their practice. Thus future communication training programmes for veterinarians should: provide strategies to tailor the message to the type of client and their circumstances; encourage active listening to and consultation with clients; provide techniques to deal with reluctant and/or difficult clients; and if necessary implement consent forms to avoid legal repercussions.

Since 2009 the workplace health and safety legislation in Australia has changed, but clauses remain allowing veterinarians to refuse their services if they deem a situation is rendered unsafe by the refusal of clients to comply with safety instructions.[79] Very few participants interviewed during Study 1 seemed to be aware of these clauses; thus, some veterinarians may be unaware of this legal option, while others may perceive it as contrary to their responsibilities to animal welfare. Veterinarians may need to be better informed about their rights and responsibilities in order to clarify and reduce their many liabilities in the workplace. Additionally, prioritising physical as well as infectious “human-safety” (for both clients and veterinary staff) during consultations could change the veterinarian-client communication by promoting a “client-centred” approach.

It has been suggested that communication of risk about animal diseases that could affect human health directly (zoonoses) or indirectly (affecting food safety) is not the sole responsibility of veterinarians and should be led by relevant government agencies.[80] Governments should develop policies about ways to communicate such risks to human health through consultation. They should also provide ready to use information targeted at the various potential stakeholders such as veterinarians, farmers, horse owners, animal owners,

and the wider community.[80] Millani suggested private veterinarians should have similar in-house policies, including ready to use informational material about animal diseases for their clients.[81] Two independent reports and an Ombudsman's report about the response of the Qld government to the early HeV outbreaks made similar recommendations; the government responded by sending a comprehensive information package to all private veterinarians registered and working in the State (2010). [17,18, 83,82,83] There have been no further human cases of HeV since that time.[8]

Conclusion

The emergence of a new zoonosis constitutes an unpredictable event that requires a discussion between veterinarians and their clients about the related health and safety risks. However, communicating about an emerging zoonosis may prove difficult because of the lack of availability of evidence-based knowledge. Regardless, veterinarians are expected to act as experts and fulfil their health and safety, biosecurity and public health legal responsibilities. Notwithstanding, the expectations of government authorities and clients often diverge, leaving veterinarians in a professional conundrum; professional liability versus animal welfare versus business sustainability. On the one hand, government recommendations may not sufficiently consider the circumstances of private veterinary practices; on the other hand clients may not always be aware of veterinarians' legal responsibilities. Furthermore, clients may have emotional and/or financial interests vested in their animals and believe that all veterinary decisions associated with their animal are their prerogative. However, with a notifiable disease, such as HeV, there are a number of legally binding rules which must be followed. From a One Health perspective, public health and veterinary-biosecurity authorities

could bridge the gap between veterinarians and their clients by initiating a community based awareness campaign to improve the public's understanding of the relationship between animal and human health and the significance of zoonoses for animal owners. Future communication skills training programs should also take into account unexpected/difficult circumstances such as those that veterinarians faced when dealing with an emerging zoonosis. Programs could focus on promoting "human-safety" for all involved; a desirable outcome for both veterinarians and their clients.

Competing interests

The authors declare that they do not have competing interests.

Authors' contributions

DM and RS conceived the studies and RS provided support and advice to DM who carried out both studies. DM and RS were involved in the drafting of both research tools and the piloting of Study 1. DM recruited participants, conducted interviews, collated and analysed data from Study 1. JK and MN assisted in the qualitative data analysis as well as the manuscript preparation. DM implemented the survey, collated the data and analysed the quantitative and qualitative data from Study 2. BP assisted with qualitative data analysis as well as the manuscript preparation. DM drafted the initial manuscript which was subsequently reviewed by RS, BP, MN and JK. All authors read and approved the final manuscript.

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Table 1- Comparison of the main themes related to communication about Hendra virus risk and risk mitigation between private equine veterinarians and their clients obtained from Study 1 (2009-10) and Study 2 (2011) and illustrated by participants' quotes.

Themes	<i>Examples of quotes from participants' responses which best illustrate the themes</i>	
	STUDY 1	STUDY 2
Acceptance and/or compliance	<p><i>"Acceptance by clients doesn't seem to really be a barrier. If well explained they accept the extra cost and time spent on PPE*." V1/Pa</i></p> <p><i>"I have not had problems with owners complying ... You just need to make them aware of the situation and the risks involved." V17/Pm</i></p>	<p><i>"Usually are very cooperative." (P3553)</i></p> <p><i>"Comply as they have been informed and educated about the risks." (P2378)</i></p>
Compliance deemed redundant	<p><i>"Disease control with the owners is a real problem. They have already been exposed to the disease for a few days." V15/Pk</i></p> <p><i>"The owner had already spent half a day with the sick horse, so he declined the mask because thought exposure had already happened." V7/Pa</i></p>	<p><i>"Most clients refuse PPE* as they have already been handling the horse, so don't feel it necessary to use PPE." (P2444)</i></p> <p><i>"Owners generally very concerned as usually they have been in very close contact with horse...So in theory they have been exposed before vet has examined/tested the horse." (P3221)</i></p>
Misunderstanding or denial of risk	<p><i>"You have to protect yourself first and foremost, but owners don't always see it that way." V8/Pe</i></p>	<p><i>"Most are positive, however usually make mistakes despite explicit instructions." (P4002)</i></p> <p><i>"Lay assistants are often reluctant to consider the disease."</i></p>

	<p>"Sometimes people don't listen...I had one horse who came down with EI** on a property and the next thing the others [horses] did too because the owners did not listen to what you said." V14/Pj</p>	<p>A lot of people don't know anything about it [HeV#]." (P2097)</p> <p>"It is difficult to explain biosecurity to people with no prior [understanding of] concept." (P4002)</p> <p>"Some [lay assistants] have no idea and have poor comprehension skills." (P2658)</p> <p>"They are in denial and think you are overreacting." (P3472)</p>
<p>Cost</p>	<p>"Sometimes owners put too much pressure...not to use sedation or infection control [PPE*] to lower cost but it increases the risks."V1/Pa</p> <p>"Cost is an issue...What if the case turns to be negative? How do you justify it [to the owner]?"V10/Pg</p> <p>"I have had owners burr up at the cost; [some say] "If you want to test the horse why don't you pay for it!" There would be cases out there that have not been reported because of the cost."V14/Pj</p>	<p>"My typical rural horse owner refuses to accept extra cost for exams and treatment of mildly ill horse." (P2227)</p> <p>"Clients will not tolerate extra cost on bill for what they consider to be unnecessary PPE*." (P2925)</p>
<p>Rural culture</p>	<p>"I went to this Hendra case wearing the recommended [PPE*]...the animal took off scared by the PPE*...We eventually, thanks to the owner</p>	<p>"[In rural settings] The cautious vet will often end up looking like it was a stupid fuss about nothing, to the sceptical owner." (P2227)</p>

	<p><i>who wasn't wearing any PPE*, cornered the horse...He said to us when failing to catch the horse: "you are fucking useless"."</i> V4/Pc</p> <p><i>"During EI**...We were following biosecurity measures but at the same time people were driving in and out of properties with the attitude of: "She'll be right, I won't pet the horses"."</i>V7/Pa</p> <p><i>"In more rural situations you tend to think you are being a bit of a Wally [silly] dressed up [in PPE*] for minor issues."</i> V10/Pg</p>	
<p>Fear for reputation</p>	<p><i>"The racehorse trainers don't like to see a vet suit [with PPE*]...they tend to panic. If a horse dies suddenly in a riding school they are obviously very nervous... [They] worry that their horses may be put in quarantine. It is a big threat to them."</i>V18/Pn</p> <p><i>"I am worried owners might not notify of infectious diseases occurrences because don't want to be in the public eye."</i>V1/Pa</p>	<p><i>"Owners generally become nervous. They worry about gossip spreading about potential HeV[#] cases and possible media involvement."</i> (P2717)</p>

Emotional attachment to animals	<p><i>"The owners...refused [HeV#] testing because if...positive for HeV# they would have to euthanase the horse. They considered their horses like their children and said: "I wouldn't euthanase my own child." V9/Pf</i></p> <p><i>"There was a family... all sobbing and cradling the horse's head...no matter what I said they weren't listening...their emotions overrode their ability to follow my instructions." V14/Pj</i></p>
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*PPE: Personal protective equipment; #HeV: Hendra virus.

Table 2 - Access to HeV management plan and HeV-related risk and safety communication to horse owners and/or lay assistants and their reactions according to 200* participants during the winter of 2011. (Study 2)

Characteristics	Frequencies (relative frequencies)
HeV management plan in the practice (n=195)	
Yes	162 (83.1%)
No	27 (13.8%)
Don't know	6 (3.1%)
Are the following information documents available in the practice	
Information sheet about HeV for horse owners (n=191)	112 (58.6%)
Information sheet about flying foxes for horse owners (n=191)	61 (31.9%)
Provision of HeV risk related education to horse owners if horse is healthy (n=189)	
Always or sometimes	88 (46.6%)
Rarely or never	101 (53.5%)
Provision of HeV risk related education to horse owners if horse is sick (n=191)	
Always or sometimes	166 (87%)
Rarely or never	25 (13.1%)
How often did veterinarians instruct lay assistants of potential risk of exposure to HeV if horse was healthy (n=186)	
Always or sometimes	93 (50%)

Rarely or never	93 (50%)
<i>How often did veterinarians instruct lay assistant of potential risk of exposure to HeV if horse was sick (n=189)</i>	
Always or sometimes	172 (91%)
Rarely or never	17 (8.9%)
<i>Lay assistant's reaction to risk communication about HeV (n= 133)</i>	
Receptive comply	55 (41.4%)
Unreceptive but comply	6 (4.5%)
Denial	15 (11.3%)
Fear	26 (19.5%)
No lay assistant used	5(3.8%)
Other	26 (19.5%)
<i>Lay assistant's reaction to safety instructions when HeV suspected (n=124)</i>	
Receptive/comply	72 (58.1%)
Unreceptive but comply	4 (3.2%)
Denial	16 (12%)
Fear	12 (9.7%)
Never had to or help not used	10 (8.1%)
Other	10 (8.1%)

*n= 200 unless otherwise stated

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Conclusion

The aims of this chapter were met in the following manner:

- What were the issues equine veterinarians experienced when communicating about HeV related risks to horse owners?
 - ⇒ Veterinary communication skills, type of clientele, clients' ability to understand veterinary information, clients' misunderstanding or denial of risks, financial considerations, business reputation and client-animal bond.
- How did these communication issues affect equine veterinarians' management of Hendra virus?
 - ⇒ Clients disregarding veterinary safety directives, hampering of outbreak investigation, increase of veterinary liability, decrease of veterinary compliance with official health and safety recommendations.
- Were equine veterinarians prepared to provide information about Hendra virus related risks and their management to horse owners?
 - ⇒ A majority had a HeV management plan but only half had ready-to-use information about HeV and about a third had similar information about flying foxes and their role in HeV spillovers to horses.

- How often did equine veterinarians provide information about Hendra virus related risks and their management to horse owners?

⇒ An increasing number of veterinarians “always or sometimes” provided HeV risk communication information to lay assistants when a horse appeared sick.

Veterinary risk and risk mitigation communication about an emerging zoonosis such as HeV was perceived by many professionals as a somewhat difficult task. The management of HeV and/or future emerging zoonoses, from a veterinary perspective could benefit from:

- Improving training in practical communication skills at the undergraduate and professional levels;
- Providing training in practical crisis communication skills at the undergraduate and professional levels to overcome communication issues during unpredictable events;
- Focusing communication on “human-safety” for all involved and finding a common motivation between veterinarians and their clients;
- Enhanced government support and leadership to the veterinary profession dealing with the emergence of a new zoonosis by provision of evidence-based information to veterinarians and direct communication about the related risk to owners of susceptible animal species and the wider community;
- Better educating veterinarians about their legal responsibilities and discharge of obligation in terms of workplace health and safety;
- Educating animal owners about veterinarians’ legal responsibilities; and
- Educating animal owners about their own legal responsibilities towards their animal.

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CHAPTER 6 – Factors affecting veterinary infection control in Australian private veterinary practices.

Aims of this chapter

- Determine whether and in what way veterinarians' risk perceptions about zoonoses affect their infection control choices.
- Determine whether there is evidence of leadership in infection control at the veterinary practice level.
- Determine how evidence of leadership in infection control at the veterinary practice level influences veterinarians' infection control choices.



Art work by Ken Miller

Introduction

In 2011, implementing veterinary infection control (IC) measures for the management of Hendra virus (HeV) was the recommended strategy for private veterinarians attending equine patients to prevent occupational exposure to virus.^{1,2} Some veterinarians felt that the logistical, financial, and legal implications of following these recommendations were too high a burden and chose to cease equine practice altogether (See Chapter 3).³⁻⁵ Notwithstanding, government and professional agencies along with some private veterinarians agreed that, overall, veterinary IC standards needed to improve across all Australian private practices.^{5,6-8} Studies 1 and 2 revealed that risk perception could be a determining factor of veterinary IC choices and behaviours in private practice (See Chapters 3-5).^{5,9} Additionally, these studies suggested that in house leadership may also play a role in determining individual IC behaviours of existing veterinary staff, early career veterinarians and veterinary students. Leadership in IC has been extensively examined in human healthcare settings, in particular in the field of nursing.¹⁰⁻¹⁴ Since zoonoses represent a health and safety occupational risk for veterinarians,¹⁵⁻²¹ the objectives of Study 3 were: 1) to examine how risk perceptions about zoonoses other than HeV influenced veterinary IC behaviours; and 2) to assess if and how IC leadership indicators within a practice influence individual veterinary IC choices.

Publications and outputs for Chapter 6

This chapter includes results from Study 3 presented as two drafted manuscripts for submission to a peer-reviewed journal: *Preventive Veterinary Medicine* (January 2015). I was the lead author of both these manuscripts and overall contribution to this study and the subsequent outputs was as follows:

- In collaboration with my main supervisor I led the designing of Study 3.
- I led the preparation of the ethics application for this study.
- I attended a workshop about how to use SPSS software to analyse quantitative data.
- I updated an existing database containing the contact details of all veterinarians registered in with the Veterinary Surgeons Board of Queensland.

- I designed the survey questionnaire with the guidance of my secondary supervisor.
- I trialled the questionnaire with six veterinarians within the target population.
- I revised the questionnaire in light of the survey trial in consultation with my main supervisor.
- I implemented and managed the postal survey.
- I collated and entered some of the data into Excel and supervised the remaining data entry.
- I cleaned the data in Excel before importing the data into SPSS.
- I used SPSS software package to analyse the data under the guidance of my secondary supervisor.
- I was the lead author of two companion manuscripts to be submitted to a peer-reviewed journal (see below).

Results from Study 3 are included in the following draft manuscripts:

- **Mendez D**, Büttner P, Speare R. Factors affecting veterinary infection control behaviours: the role of risk perception on mask usage and vaccination.
- **Mendez D**, Büttner P, Speare R. Factors affecting veterinary infection control behaviours: the role of infection control leadership at the practice level.

The included draft manuscripts are formatted as per Preventive Veterinary Medicine requirements.

**Factors affecting veterinary infection control behaviours:
The role of risk perception on mask usage and vaccination.**

Manuscript for submission to peer-reviewed journal, Preventive Veterinary Medicine

Diana Mendez, Petra Büttner, Rick Speare.

Abstract

Private veterinarians have biosecurity, public health and occupational health and safety legal responsibilities to prevent the transmission of zoonoses to animals and humans, including themselves, under their supervision. This requires the implementation of infection control (IC) measures. However, a new emerging zoonosis, Hendra virus (HeV), has highlighted veterinary IC deficiencies in Australian private veterinary practices. Perception of risks has reportedly influenced veterinarians IC choices. This study examined the effect of specific zoonotic risk perceptions among veterinarians on their usage of masks and vaccinations against preventable zoonoses.

All private veterinarians registered in Queensland, Australia were invited to participate in a postal survey between June and September 2011 (n=538; response rate: 35.6%). Participants were asked about: 1) their level of concern about HeV, Australian bat lyssavirus (ABLV), Avian influenza and Q-fever; 2) their vaccination status against preventable zoonoses and other infectious diseases; 3) the frequency with they used masks when examining horses and birds.

The majority of participants were “*extremely to moderately*” concerned about HeV (69.2%) and ABLV (50.1%), and a minority were similarly concerned about Q-fever (22.4%) and Avian influenza (20.4%). Being vaccinated against rabies and Q-fever was not associated with being “*extremely to moderately*” concerned about ABLV or Q-fever. After adjusting for possible

confounders, participants who reported “*always or sometimes*” using a mask when examining a dead horse were more likely to report being “*extremely to moderately*” concerned about HeV ($p=0.004$). Similarly, those who were highly concerned about Avian influenza were more likely to use a mask when examining a live or dead bird ($p=0.008$; $p=0.011$, respectively).

High levels of risk perception about known zoonoses did encourage veterinarians to use masks; however, similar levels of concern about other vaccine preventable zoonoses did not prompt them to seek immuno-prophylaxis. Zoonotic risk perceptions do affect veterinarians’ IC choices. However, the level of risk perception about a zoonosis does not necessarily lead to the implementation of the highest possible IC strategy, in this case seeking vaccination where available. Assessment of a zoonotic risk depends on several components: knowledge about the risk; likely frequency of exposure to the risk; severity of consequences of exposure to the risk. Underestimating any of these components could lead to a lower level of concern or a disregard of the risk leading to misguided veterinary IC decisions. Zoonotic risks in the veterinary workplace need to be reemphasised and relevant IC measures recommended.

Introduction

The majority of emerging infectious diseases are zoonotic in nature, i.e., transmissible from vertebrate animals to humans; and present an increasing threat to biosecurity and public health systems (Taylor et al., 2001; Jones et al., 2008; Cutler et al., 2010; Daszak, 2012; Bordier & Roger, 2013; Kabbatz et al., 2014). Given their host ubiquitousness, zoonoses are better controlled using a transdisciplinary One Health approach (Rabozzi et al., 2012). However, the control systems initiating the management of a zoonosis will vary depending on the pattern of the outbreak. For example, if a zoonotic outbreak is first recognised after establishing in humans, such as in the case of swine influenza or severe acute respiratory syndrome, the management of the zoonosis becomes primarily the responsibility of public health systems (Peiris et al., 2009; Zhong et al., 2003; World Health Organization (WHO), 2004). On the other hand, if a zoonotic outbreak is first identified in animals, such as rabies or psittacosis, the management of the zoonosis will be instigated by private veterinarians who are at the forefront of biosecurity systems (Weese et al., 2002). However, unlike physicians, who do not have any biosecurity responsibilities, veterinarians are expected to prevent the transmission of zoonoses to other animals (same or other susceptible species) and humans (self, other staff and clients) and make recommendations about risk mitigation strategies for people at risk of exposure (Chomel 1998, Lipton et al. 2008). As such, private veterinarians fulfil not only a biosecurity role but also a public health function in the management of zoonoses. Furthermore, the management of these diseases represents a matter of personal health and safety for private veterinarians (Nienhaus et al 2005). Mitigating their personal zoonotic risk involves reducing their potential occupational exposure to zoonoses by either removing the source of the risk (isolation or euthanasia of infected animal); cancelling the risk (vaccination of some or all susceptible species; e.g., Q-fever/humans; Hendra virus/horses; Rabies/humans and susceptible domestic or wildlife mammals); or minimising exposure using personal protective

equipment (PPE) (Chomel, 1998; Weese et al., 2002; Australian Technical Advisory Group on Immunisation of the Australian Government Department of Health, 2013; Australian Veterinary Association (AVA), 2013; Department of Agriculture and Fisheries, Queensland Government (DAF QLD), 2013). However, private veterinarians have a poor track record in relation to the implementation of infection control (IC) measures, including the use of PPE (Wright et al., 2008; Baker et al., 2009; Leggat et al., 2009; Dowd et al., 2013; Mendez et al. 2014 a & b). Additionally, vaccination rates against preventable zoonoses amongst veterinarians are not well documented, even though prophylactic vaccination is considered to be one of the most cost effective preventive measures.

The emergence of a new zoonosis, Hendra virus (HeV), highlighted IC deficiencies amongst private veterinary practices in Australia. The death of two veterinarians, a lay veterinary assistant and the further infection of a veterinarian and a veterinary nurse stimulated a number of initiatives by government and professional agencies to improve veterinary IC standards and management of HeV in Australian private veterinary practices (Anon., 2009; DAF QLD, 2010; DAF QLD, 2012a; AVA, 2012; Animal Health Australia (AHA), 2013; DAF QLD 2015a, Hendra Virus Interagency Technical Working Group, 2014). Prior to the emergence of HeV, veterinary IC received little scrutiny in Australia. Research into veterinary IC mostly focused on describing veterinary IC habits and failures without further investigating the reasons behind these behaviours (Sidjabat et al., 2006 a and b; Shiranghi et al., 2007; Fritschi et al., 2008; Lucas et al., 2009; Leggat et al. 2009). More recent research into the driving forces behind veterinary IC suggests that risk perception is a determinant of veterinary IC behaviours (Dowd et al., 2013; Mendez et al 2014a). In order to understand the effect of zoonotic risk perception on veterinary IC behaviours we conducted a cross-sectional survey of private veterinarians in Queensland (QLD), Australia. This study examined the effect of specific zoonotic risk

perceptions among veterinarians on their usage of masks and vaccinations status against preventable zoonoses.

Methods

Study design

The study design for this investigation has been previously described (Mendez et al., in press). This study, which was approved by the James Cook University Human Ethics Committee (Ethics approval No. H3687), was conducted as a cross-sectional postal survey of all private veterinarians registered with the Veterinary Surgeons Board of Queensland (VSBQ) and working in QLD, Australia, between June and September 2011.

Questionnaire design

The questionnaire was modelled on the one used to investigate zoonotic risk perceptions and related IC practices amongst private veterinarians in QLD in 2006 (Leggat et al. 2009), and the results of another study that examined the HeV-risk related perceptions and barriers to IC and HeV management in QLD equine veterinary practices between 2009 and 2010 (Mendez et al. 2012, 2013a, 2014a). The questionnaire was piloted with six private veterinarians within the target population prior to its distribution.

The survey questionnaire sought information about socio-demographic, education, professional and practice characteristics. Participants' geographic locations were divided into the five Accessibility/Remoteness Index of Australia (ARIA) categories: highly accessible, accessible, moderately accessible, remote, and very remote (Australian Institute of Health and Welfare, 2004). Accessibility and remoteness are defined on the basis of the distance by road between an Australian locality and the closest service centre. The survey questionnaire also

included a number of multiple choice questions about zoonoses-related risk perceptions and risk mitigation. Zoonoses of particular interest were those against which the Australian government recommended veterinarians seek vaccination: rabies (protective against Australian bat Lyssavirus (ABLV)); seasonal influenza; swine influenza (i.e., influenza A H1N1-2009); and Q-fever (Australian Technical Advisory Group on Immunisation of the Australian Government Department of Health, 2013; AVA, 2013). Participants were asked how concerned they were about becoming infected with these zoonoses; their vaccination history against these same zoonoses; and their usage of masks when attending live or dead horses and birds. Participants were also asked if they worked in a practice where there was evidence of IC leadership (IC policies, IC committee and/or a staff in charge of IC implementation).

Survey implementation

Prospective participants were identified from the freely available online VSBQ registry. Survey questionnaires were sent via Australia Post to all 1604 eligible veterinarians in June 2011, followed by three reminders during the months of July, August and September of the same year. All potential participants were provided with an information sheet and a reply paid envelope to return their completed questionnaire. Respondents were informed that their participation was voluntary and that they could withdraw from the study at any time; the return of a completed questionnaire constituted consent. Upon receipt of the completed surveys, responses were de-identified.

Data management and analysis

Each returned questionnaire was assigned a unique identification number and responses were collated in Excel before being imported into SPSS (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.) for analysis. Numerical data

were reported using median and interquartile range (IQR) when skewed, and mean and standard deviations (SD) when symmetrical. Categorical data were reported using percentages. Bivariate analyses using Pearson's Chi-square, Chi-square for trend, and Fisher's exact test were performed to compare: 1) participants who considered themselves currently vaccinated against rabies, seasonal influenza, swine influenza and Q-fever to those who were not vaccinated; and 2) participants who "always or sometimes" used a mask when attending live and dead horses and birds to those who never use a mask in the same circumstances. Bivariate analyses using Pearson's chi-square, Fisher's exact test and Chi-square for trend were conducted in relation to socio-demographic, education, ARIA, professional characteristics and participants' levels of concern for the above mentioned zoonoses. Multiple logistic regression analyses were used to ascertain the observed effect of veterinarians' risk perception on their vaccination status for rabies, seasonal and swine influenza and Q-fever and their usage of masks, adjusting for potential confounders: demographic (gender, age, ARIA), educational (university of graduation, attending an IC workshop in previous 12 months), professional characteristics (type of practice, role in practice, employment status) and presence of in practice IC indicators (IC policies, IC committee, one staff in charge of IC implementation). Any variable that was not in the model was checked for its confounding effect. A Confounder was identified if the final coefficient in the final model with the variable varied by more than 5% compared to the model without the variable. The assumptions for these statistical tests were met. A result was considered significant when the p-value was <0.05 .

Results

Of the 1604 initially eligible veterinarians, 91 were eliminated as they no longer worked at the address listed on the VSBQ web site. Of the 1513 remaining prospective participants 549 returned their questionnaire; an additional 11 participants were eliminated from the survey as

they were retired and therefore no longer worked in private practice (response rate of 35.6%). Of the 538 eligible respondents left, not all participants answered all questions.

Socio-demographic, veterinary education, professional profile and zoonotic infection history (Table 1)

Of the 538 participants, 44.2% (238/538) were male; 51.3% (275/536) were aged 40 years or younger; 77.4% (415/536) had graduated as veterinarians from a university in QLD; and the median number of years since graduation was 16 years (IQR=23, range: 1-50 yrs). The majority worked in practices located in “highly accessible to accessible” ARIA regions (66.9%, 358/535) and more than half of the participants worked in small animal practices (52%, 271/521). Most participants worked full-time (77%, 414/538), as employees (56.1%, 297/529), for a mean of 41.5 hours per week (SD=14.8, range: 1-100 hrs). A third of participants reported having been infected with at least one zoonosis during their career (30%, 161/536), and 4.7% (5/533) reported having been infected with a zoonosis in the 12 months prior to taking the survey. A minority of participants (10.5%, 55/525) had attended an IC workshop in the previous 12 months.

Zoonoses-related risk perception, vaccination history and mask usage with horses and birds (Table 2)

When asked how concerned they were about becoming infected with specific zoonoses, a majority of participants were “*extremely to moderately*” concerned about becoming infected with HeV and ABLV (69.2%, 368/532; 50.1%, 266/531, respectively), and a fifth were similarly concerned about contracting avian influenza or Q-fever (20.4%, 107/525; 22.4%,

117/523, respectively). More than half the participants had been vaccinated at least once in the past against seasonal influenza and Q-fever (51.9%, 242/466; 56.8%, 264/465, respectively); 31.5% (147/466) reported having ever been vaccinated against rabies; and 15.5% (72/466) considered their rabies vaccination current.

More than 80% of participants were prepared to examine live bird patients (or conduct a necropsy on a bird (433/522); while about 40% were prepared to attend live horse patients (244/509) or conduct a necropsy on a horse (213/498). Of those who examined horses, a similarly high number of participants “*always or sometimes*” used a mask whether they were attending a live horse patient (77.9%, 190/244) or carrying out a necropsy on a horse (86.4%, 184/213). A fifth (22.1%, 54/244) of participants who attended horse patients “*never*” used a mask with a live horse, and 13.6% (29/213) had similar habits when conducting a necropsy on a horse.

Of those who were willing to examine birds, more participants were prepared to conduct a necropsy on a bird (35.8%, 155/433) than attend a live bird patient (20.7%, 92/444), and a majority of these participants reported they “*never*” used a mask in either instance (79.3%, 352/444; 64.2%, 278/522, respectively).

Demographic, education, ARIA, professional and zoonotic risk perception characteristics stratified by current vaccination status (Table 3)

Current vaccination status of participants for rabies, seasonal influenza, swine influenza and Q-fever was not associated with being “*extremely to moderately*” concerned about ABLV, avian influenza or Q-fever ($p=0.473$; $p=0.322$; $p=0.080$; $p=0.777$ respectively), and remained so after adjusting for demographic, educational, professional and in practice IC leadership

indicators characteristics using logistic regression ($p=0.083$; $p=0.473$; $p=0.456$; $p=0.207$, respectively).

- Currently vaccinated against rabies

Participants who were vaccinated against rabies (15.5%, 72/466) were more likely to be female (72.2%); graduated from a university outside QLD (21.1%) or from overseas (18.3%); worked in a small animal practice (54.2%) or in a non-traditional veterinary practice (19.4%), than those who were not vaccinated (56.1%; 14.5%, 6.6%; 52.1%; 5.2%, respectively) ($p=0.001$; $p=0.001$; $p=0.001$; $p<0.001$; $p<0.001$, respectively).

- Currently vaccinated against seasonal influenza

Participants who were vaccinated against seasonal influenza (26%, 121/466) were more likely to be male (60.3%); 41 years or older (62.5%); located in a “highly accessible to accessible” ARIA region (72.7%); worked full time (78.5%) in a large animal practice (11.2%) or non-traditional veterinary practice (12.9%) as a principal veterinarian (50.4%); and had attended an IC workshop in the past 12 months (15.1%) compared to those who were not vaccinated (34.8%; 37.1%; 64.6%; 76.2%; 5.6%; 5.6%; 25.4%; 8%, respectively) ($p<0.001$; $p<0.001$; $p=0.012$; $p=0.039$; $p=0.002$; $p=0.002$; $p<0.001$; $p=0.026$, respectively).

- Vaccinated against swine influenza

Participants who were vaccinated against influenza swine influenza (28.5%, 133/466) were more likely to be 41 years or older (57.9%); graduated from a university in QLD (84.7%); were a principal veterinarian (42.7%); and had attended an IC workshop in the past 12 months (16%) compared to those who were not vaccinated (38%; 72.7%; 27.5%; 7.4%, respectively) ($p<0.001$; $p=0.021$; $p=0.001$; $p=0.005$, respectively).

- Vaccinated against Q-Fever

Participants who were vaccinated against Q-fever (56.8%, 264/465) were more likely to: be female (69.7%); be 40 years or younger (83%); have graduated from a university in QLD (81.1%); were located in a “remote to very remote” ARIA region (8%); worked in a mixed practice (40.5%); on a full-time basis (83.7%); as an employee (72%) compared to those who were not vaccinated (43.8%; 21.5%; 69.8%; 2.5%; 23%; 67.2%; 44.2% respectively) ($p < 0.001$; $p < 0.001$; $p = 0.035$; $p = 0.001$; $p < 0.001$; $p < 0.001$, respectively).

***Socio-demographic, education, ARIA, professional and zoonotic risk
perception characteristics stratified by usage of mask with horses and birds
(Table 4)***

- Use of mask with a live horse or when conducting a necropsy on a horse

Participants’ usage of mask when dealing with live horse patients or when carrying out a necropsy on a horse did not vary significantly with socio-demographic, education, ARIA categories, their role and employment status in the practice or attendance at an IC workshop in the previous 12 months. A high proportion of participants “*always or sometimes*” used a mask when dealing with live or dead horses (live horse (LH): 77.9%, 190/244; 86.4%; dead horse (DH): 184/213, respectively). Those who did use a mask were more likely to work in a large animal (LH: 17.3%; DH: 16.7%, respectively) or mixed practice (LH: 74.1%; DH: 73.9%, respectively), and reported being “*extremely to moderately worried*” about HeV (LH: 94.2%; DH: 96.2%, respectively) compared to those who did not use masks (7.5%, 10.7%; 50.9%, 60.7%; 83.3%, 72.4% respectively) ($p < 0.001$; $p < 0.001$; $p = 0.029$; $p = 0.029$; $p = 0.011$, $p < 0.001$, respectively). After adjusting for potential confounders (demographic, educational,

professional and in practice IC indicators characteristics), those who “*always or sometimes*” wore a mask with a dead horse were more likely to be “*extremely to moderately concerned*” about HeV than those who did not use a mask ($p=0.017$). Participants who wore a mask “*always or sometimes*” with a live horse were not significantly different in regards to their level of concern about HeV from those who did not use a mask in the same circumstances ($p=0.317$).

- Use of mask with a live bird

There were no significant differences in university of graduation, type of practice, and employment status characteristics between participants who “*always or sometimes*” used a mask when attending a live bird patient and those who did not. Participants who “*always or sometimes*” used a mask in this scenario (22.5%, 92/448) were, however, more likely to be male (47.8%), 41 years or older (54.3%), lived in a moderately accessible ARIA region (41.8%), were a principal or partner/associate in the practice (39.1%; 12.0%, respectively), had attended an IC workshop in the past 12 months (15.7%), and have reported being “*extremely to moderately worried*” or a “*little worried*” about avian influenza (28.9%; 47.8%, respectively) compared to those who used a mask less frequently (36.4%; 41.4%; 26.5%; 30.2%; 6.6%; 7.3%; 18.2%; 38.9%, respectively) ($p=0.044$; $p=0.026$; $p=0.012$; $p=0.03$; $p=0.03$; $p=0.013$; $p=0.001$; $p=0.001$, respectively). After adjusting for demographic, educational, professional and in practice IC leadership indicators characteristics, those who had high levels of concerns about avian influenza were more likely to wear a mask when examining a live bird ($p=0.003$).

- Use of mask when carrying out a necropsy on a bird

Unlike the results obtained for mask usage with live bird patients, participants who “*always or sometimes*” used a mask when necropsying a bird (35.8%, 155/433) were more likely to have graduated from an Australian university outside of QLD (20.3%), and worked in a non-

traditional veterinary practice such as wildlife sanctuaries and rehabilitation centres or zoos (37.9%) than those who did not use a mask (11.5%; 2.9%, respectively) ($p=0.005$; $p=0.003$, respectively). However, those who “*always or sometimes*” used a mask in this scenario were also more likely to have attended an IC workshop in the past 12 months (14.6%), and to report being “*extremely to moderately worried*” about avian influenza (23.5%) compared to those who used a mask less frequently in the same circumstances (5.9%; 19.3%, respectively) ($p=0.003$; $p=0.006$, respectively). Those who “*always or sometimes*” wore a mask to do a necropsy on a bird were more likely to be “*extremely to moderately worried*” about avian influenza even after adjusting for potential demographic, educational, professional and in practice IC leadership indicators characteristics ($p=0.004$).

Discussion

The major findings of this study were that perceiving a zoonotic risk as possible led private veterinarians to implement risk mitigation strategies such as the use of masks when examining horses and birds. However, the relationship between risk perception and risk mitigation did not appear to be proportional. High levels of concern about a particular zoonotic risk did not always equate to the use of the optimal available risk mitigation strategy. Zoonotic risk mitigation strategies are graded from highest level of control (elimination of the risk) to the lowest level of control (use of PPE) (Safe Work Australia, 2011). When faced with a zoonotic risk, veterinarians, as trained professionals, are expected to choose the highest possible IC strategy to fulfil their occupational health and safety duty of care obligations (to self, staff and clients), public health and biosecurity responsibilities. Vaccination against a known zoonosis, if available, is considered the optimal preventive measure on the scale of IC hierarchy and the use of a mask as one of the lowest preventive measures. Despite this expectation, private veterinarians who reported being “*extremely to moderately*” concerned about HeV and avian

influenza were significantly more likely to use a mask when dealing with horses and birds than those who were less concerned about these zoonoses. Conversely, those who were most concerned about ABLV, avian influenza and Q-fever were no more likely to seek the relevant protective vaccination than those who were less concerned about these zoonoses, suggesting that private veterinarians in QLD are more likely to use PPE than vaccination to mitigate zoonotic risks. So, although the perception of high zoonotic risk motivated veterinarians to take preventive measures, the level of IC chosen did not directly parallel the level of risk perception. Risk perception has been shown to affect risk mitigation behaviours (Dowd 2013, Mendez et al 2014a). However, from these results it seems that the relationship between the level of zoonotic risk perception and the level of risk mitigation in veterinary practice varies and does not influence all areas of IC equally.

Between 19.2% and 43.6% of veterinarians were not overly concerned by any of the zoonoses they were asked to appraise. Amongst those who showed concern about becoming infected with a zoonoses, the majority were more concerned about HeV and ABLV than Q-fever despite HeV and ABLV having a much lower incidence (DAF QLD, 2012b, 2015b and c). Therefore, it is likely that most veterinarians did not base their zoonotic risk assessment solely on the frequency of zoonotic risks. They may have also taken into consideration the severity of the outcome of an exposure to these zoonoses. Hendra virus has a case fatality rate of 57% in humans and ABLV is usually fatal in humans without appropriate post exposure prophylaxis (DAF QLD, 2015b and c). In comparison, none of the 852 cases of Q-fever notified to the Australian National Notifiable Diseases Surveillance System between 2006 and 2007 were fatal (Chui et al., 2010). Thus it is possible that the survey respondents could have in fact assessed the relative severity of each of the zoonotic risks presented to them appropriately.

The disparity in zoonotic risk perceptions may also have been based on the likelihood of coming into contact with a source of zoonotic risk or a misclassification of this risk. Avian and swine influenza (i.e., influenza A H1N1-2009) for example, although initially of animal origin, are zoonoses that can establish in human populations and like seasonal influenza may have been perceived as a threat coming from contact with other humans rather than animals in the workplace (Peiris et al., 2007; Peiris et al., 2009; Chen et al., 2013). Some veterinarians may not have considered themselves at risk of contracting some of these zoonoses due to lack of regular contact with reservoir animal species. Participants exclusively working in small animal practices may have perceived the risk of exposure to HeV, ABLV or Q-fever fairly remote as they did not come into contact with horses, wild bats or livestock in their workplace. However, Q-fever has non-traditional sources of exposure such as environmental dust and foetal materials from small domestic animals (Marrie et al., 1988; Pinsky et al, 1991; Manfredi Selvaggi et al., 1996; Buhariwalla et al., 1996). Furthermore, one dog tested positive for HeV without confirmation of infection (Symons, 2011), another dog was confirmed infected with HeV (Halim et al., 2015; Kirkland et al., 2015), and two horses were infected with ABLV (Annand & Reid, 2014; Shinwari et al., 2014). Consequently working exclusively in an environment usually devoid of traditional reservoir animal species of particular zoonoses may not be protective against these occupational zoonotic risks.

Historical records show that private veterinarians and allied staff in the distribution range of HeV are at the highest risk of contracting HeV (DAF QLD 2015a and b). The veterinary and associated professions have indeed been the most severely affected by this emerging zoonosis with 4 fatalities out of 7 infected humans (DAF QLD 2015b). Human exposure to HeV occurs from contact with infective horse bodily fluids, including blood (Department of Health, 2012); therefore, the use of a mask and eye protection is part of the recommended PPE to prevent such

exposure (DAF QLD, 2013). Currently (2015), there is no vaccine against HeV for humans, hence, the importance of using PPE when examining horse patients or necropsying horses. A high proportion of participants reported “*always or sometimes*” using a mask in those circumstances. The high percentage of mask use with both live and dead horses confirms the results of another survey (Mendez et al 2014b) and suggests that veterinarians in QLD are now protecting themselves against HeV when dealing with horses. In 2010 biosecurity authorities launched a state wide information campaign targeting private veterinarians to help improve their IC strategies for the management of HeV (DAF QLD, 2010). In addition, the timing of the present survey coincided with the highest cluster of HeV outbreaks, making HeV recommendations more relevant (DAF QLD 2015b). The combination of these factors may have worked synergistically to improve veterinary IC in the management of HeV in private practices across QLD. In October 2012 a HeV vaccine for horses was released; it was intended as a biosecurity and public health measure to protect horses and the humans who come into contact with them (Middleton et al., 2014). This measure was well received by the Australian veterinary profession, with some veterinarians reporting that in the future they would only accept vaccinated equine patients (Mendez et al., 2013b). However, to date uptake of the HeV vaccination has been less than expected (Department of Primary Industries, 2013) and the introduction of the vaccine may have modified the HeV risk assessment trends observed in 2011. Nonetheless, the government has maintained its support to private veterinarians in the field, and facilitated access to PPE (DAF QLD, 2012a). There have been no new HeV human infections since 2009 (DAF QLD, 2015b).

Veterinarians, who perceived themselves at lower risk of contracting HeV, may have thought so because they have chosen to only examine apparently healthy horses for routine procedures and refused to attend high risk cases such as a sick horses, or undertake a horse necropsy. Some

veterinarians from the same target population reported that a minority assessed HeV-related risk in this manner and based their mitigation strategies accordingly (Mendez et al., 2012). However, this management approach results from a misguided risk assessment as it has been shown that experimentally infected horses may shed HeV viral particles up to two days prior to developing clinical signs of illness (Marsh et al., 2011).

Although rabies vaccination is cross-protective against ABLV, only 15.5% of participating veterinarians reported being currently vaccinated against rabies in 2011 despite recommendations encouraging veterinarians to be vaccinated (Thompson, 1999; Australian Technical Advisory Group on Immunisation of the Australian Government Department of Health, 2013). The lack of regular contact with bats, the animal reservoir of ABLV, may have led many veterinarians to consider themselves at low risk of contracting ABLV. In 2013 two horses became infected with ABLV confirming that domestic mammals could become infected with this virus and become a secondary source of ABLV for humans (Shinwari et al., 2014; Annand et al., 2014). This event reinforced the need to encourage the immunisation of private veterinarians against rabies to protect themselves against any possible exposure to ABLV (Mendez et al., in press). However, the availability of rabies vaccines in Australia varies and is at times in short supply (Department of Health, 2013). If veterinarians across Australia were to seek rabies vaccination, the Australian Department of Health would need to increase their vaccine procurement to ensure supplies matched the demand.

The main limitation of this study was a low response rate (less than 40%) and therefore these results may lack representativeness of the general veterinary population of QLD. However, the distribution by gender, age and type of practice in this sample is not dissimilar to that of the general veterinary population (Fritschi et al., 2009). Additionally, those who chose to respond

to the survey may have had a higher interest in zoonoses and/or IC in veterinary practice than those who did not; hence, these results may in fact overestimate the zoonotic risk perceptions and underestimate the level of mitigation strategies amongst QLD private veterinarians. Furthermore, HeV risk perception may have been affected by the occurrence of a higher number of HeV outbreaks in 2011 concurrently to the survey. Finally, the survey only captured the possible relationship between the zoonotic risk perception and risk mitigation at a particular point in time. This relationship is not fixed and may be affected by many factors, such as: the introduction of a HeV vaccine for horses; change in the information or recommendation provided to veterinarians about a particular zoonosis; the time between the formulation of a risk perception and receiving and responding to the survey (Weinstein & Mark, 1993). As a consequence, zoonotic risk perception may play an important role in determining veterinary risk mitigation behaviours but further investigation is required to clarify the relationship.

Conclusion

Veterinarians' perceptions of zoonotic risks influence some of their IC behaviours, such as the use of masks, but not others, such as ensuring immunisation against zoonoses for which vaccines are available. Understanding the association between zoonotic risk perception and IC behaviours may be key to improving veterinary IC. Risk perception is the result of a risk assessment which is based on several factors: knowledge about a particular risk (known vs emerging); the likelihood and frequency of exposure to a risk (likely, unlikely; rare, frequent); and consequences of the exposure to a risk (none, mild, moderate, severe). In terms of zoonotic risks, some of these factors cannot be changed but others, such as knowledge, could be increased to encourage better veterinary IC behaviours. In the case of HeV a targeted educational campaign from biosecurity authorities has helped the veterinary profession improve their management of HeV by adopting using more of the recommended IC measures

(DAF QLD, 2010). The same result could be achieved by providing better zoonotic risk and IC education to undergraduate veterinary students and existing private veterinarians.

Table 1 – Demographic, education and professional characteristics of 538* participants.

Characteristics	Descriptive statistics: frequencies (relative frequencies) unless otherwise stated
Demographics	
<i>Sex (n=538)</i>	
Female	300 (55.8%)
Male	238 (44.2%)
<i>Age group (n=536)</i>	
≤40 years	275 (51.3%)
> 40 years	261 (48.7%)
<i>ARIA^a categories (n=535)</i>	
Highly accessible-Accessible	358 (66.9%)
Moderately accessible	145 (27.1%)
Remote-Very remote	32 (6%)
Education	
<i>University attended during veterinary undergraduate studies (n=536)</i>	
University in Queensland (UQ ^b or JCU ^c)	415 (77.4%)
Australian University not in Queensland	76 (14.2%)
Overseas University	45 (8.4%)
<i>Median number of years since graduation (n=538)</i>	16yrs (IQR ^d =23) (range=1-50yrs)
<i>Attended an infection control workshop in previous 12 months (n=525)</i>	
Yes	55 (10.5%)
No	470 (89.5%)
Professional profile	
<i>Type of practice (n=521)</i>	
Small animals	271 (52%)
Large animals	41 (7.9%)
Mixed	172 (33%)
Other	37 (7.1%)
<i>Employment status (n=538)</i>	
Full-time	414 (77%)
Part-time	104 (19.3%)
Other (locum, semi-retired)	20 (3.7%)
<i>Mean of number of hours worked per week (n=515)</i>	41.51 hrs (SD ^e =14.82) (range 1-100 hrs)
<i>Role in practice (n=529)</i>	
Principal	188 (35.5%)
Partner/Associate	44 (8.3%)
Employee	297 (56.1%)
Zoonotic infection history	

<i>Infected with at least one zoonosis over career (n=536)</i>	161 (30%, CI ^h [26.2-34.1])
<i>Infected with at least one zoonosis over past 12 months (n=533)</i>	25 (4.7%, CI ^h [3.1-6.9])

*n=538 unless otherwise stated

^a ARIA: Accessibility/Remoteness Index of Australia (Australian Institute of Health and Welfare, 2004)

^bUQ: University of Queensland; ^cJCU: James Cook University

^dIQR: Interquartile range; ^eSD: Standard deviation

^hCI: 95% Confidence Interval

Table 2 – Zoonoses related risk perception and risk mitigation of 538* private veterinarians registered in Queensland Australia in 2011.

Characteristics	Frequencies (relative frequencies)
Level of concern about becoming infected with a zoonosis while working in veterinary practice	
Australian bat lyssavirus (n=531)	
Extremely to moderately worried	266 (50.1%)
A little worried	162 (30.5%)
Not at all worried	103 (19.4%)
Hendra virus (n=525)	
Extremely to moderately worried	368 (69.2%)
A little worried	62 (11.7%)
Not at all worried	102 (19.2%)
Avian influenza (n=525)	
Extremely to moderately worried	107 (20.4%)
A little worried	211 (40.2%)
Not at all worried	207 (39.4%)
Q-Fever (n=523)	
Extremely to moderately worried	117 (22.4%)
A little worried	178 (34%)
Not at all worried	228 (43.6%)
Other zoonoses not cited above (n=489)	
Yes	254 (51.9%)
No	235 (48.1%)
Immunisation history against zoonoses that are vaccine preventable	
Ever vaccinated against rabies (n=466)	147 (31.5%, CI ^a [27.4-36.0])
Currently vaccinated against rabies (n=466)	72 (15.5%, CI ^a [12.3-19.1])
Ever vaccinated against seasonal influenza (n=466)	242 (51.9%, CI ^a [47.3-56.6])
Currently vaccinated against seasonal influenza (n=466)	121 (26%, CI ^a [22.0-30.2])
Vaccinated against swine influenza (n=466)	133 (28.5%, CI ^a [24.5-32.9])
Vaccinated against Q-fever (n=465)	264 (56.8%, CI ^a [52.1-61.3])
Use of mask when examining horses and birds	
If horse is alive, regardless of health status (n=244=509-265 who never examined horses)	
Always or almost always	16 (6.6%)
Sometimes	174 (71.3%)
Never	54 (22.1%)
When conducting a necropsy on a horse (n=213=498-285 who never conducted necropsies on horses)	
Always or almost always	117 (54.9%)
Sometimes	67 (31.5%)
Never	29 (13.6%)
If bird alive, regardless of health status (n=444=527-83 who never examined birds)	
Always or almost always	11 (2.5%)
Sometimes	81 (18.2%)
Never	352 (79.3%)
When conducting a necropsy on a bird (n=433=522-89 who never conducted necropsies on birds)	
Always or almost always	62 (14.3%)
Sometimes	93 (21.5%)
Never	278 (64.2%)

*n= 538 unless otherwise stated

^aCI: 95% Confidence Interval

Table 3- Association between demographic; Accessibility/Remoteness Index of Australia (ARIA) categories; education; professional characteristics and concern about specific zoonoses reported by 538* participants stratified by current vaccination status for rabies, seasonal influenza, swine influenza and Q-fever.

	Currently vaccinated against rabies			Currently vaccinated against seasonal influenza			Vaccinated against swine influenza			Vaccinated against Q-fever		
	Yes (n=72)	No (n=394)	p-Value†	Yes (n=121)	No (n=345)	p-Value†	Yes (n=133)	No (n=333)	p-Value†	Yes (n=264)	No (n=201)	p-Value†
Demographic characteristics												
Gender												
- Female	52 (72.2%)	221 (56.1%)	0.011†	48 (39.7%)	225 (65.2%)	<0.001†	76 (57.1%)	197 (59.2%)	0.690†	184 (69.7%)	88 (43.8%)	<0.001†
- Male	20 (27.8%)	173 (43.9%)		73 (60.3%)	120 (34.8%)		57 (42.9%)	136 (40.8%)		80 (30.3%)	113 (56.2%)	
Age												
- ≤ 40yrs old	39 (54.2%)	223 (56.7%)	0.685†	45 (37.5%)	217 (62.9%)	<0.001†	56 (42.1)	206 (62%)	<0.001†	219 (83%)	43 (21.5%)	<0.001†
- > 40yrs old	33 (45.8%)	170 (43.3%)		75 (62.5%)	128 (37.1%)		77 (57.9%)	126 (38%)		45 (17%)	157 (78.5%)	
University of graduation												

- Queensland University	43 (60.6%)	310 (78.9%)	0.001[†]	96 (80.7%)	257 (74.5%)	0.362 [†]	111 (84.7%)	242 (72.7%)	0.021[†]	214 (81.1%)	139 (69.8%)	<0.001[†]
- Australian University (excl. Queensland)	15 (21.1%)	57 (14.5%)		14 (11.8%)	58 (16.8%)		14 (10.7%)	58 (17.4%)		43 (16.3%)	29 (14.6%)	
- Overseas University	13 (18.3%)	26 (6.6%)		9 (7.6%)	30 (8.7%)		6 (4.6%)	33 (9.9%)		7 (2.7%)	31 (15.6%)	
ARIA^b Categories												
Highly accessible - Accessible	45 (62.5%)	264 (67.5%)	0.077 [‡]	88 (72.7%)	221 (64.6%)	0.012[^]	87 (65.4%)	222 (67.3%)	0.512 [^]	170 (64.9%)	139 (69.5%)	0.035[^]
Moderately accessible	26 (36.1%)	102 (26.1%)		32 (26.4%)	96 (28.1%)		36 (27.1%)	92 (27.9%)		71 (27.1%)	56 (28%)	
Remote - Very remote	1 (1.4%)	25 (6.4%)		1 (0.8%)	25 (7.3%)		10 (7.5%)	16 (4.8%)		21 (8%)	5 (2.5%)	
Professional characteristics												
Practice type												
- Small animal	39 (54.2%)	199 (52.1%)	<0.001[†]	62 (53.4%)	176 (52.1%)	0.002[†]	71 (55.9%)	167 (51.1%)	0.405 [†]	121 (47.1%)	117 (59.7%)	0.001[†]
- Large animals	2 (2.8%)	30 (7.9%)		13 (11.2%)	19 (5.6%)		9 (7.1%)	23 (7%)		17 (6.6%)	15 (7.7%)	
- Mixed	17 (23.6%)	133 (34.8%)		26 (22.4%)	124 (36.7%)		35 (27.6%)	115 (35.2%)		104 (40.5%)	45 (23%)	

- Other	14 (19.4%)	20 (5.2%)		15 (12.9%)	19 (5.6%)		12 (9.4%)	22 (6.7%)		15 (5.8%)	19 (9.7%)	
Role in practice												
- Principal	20 (28.2%)	127 (32.5%)	0.246 [†]	60 (50.4%)	87 (25.4%)	<0.001 [†]	56 (42.7%)	91 (27.5%)	0.001 [†]	56 (21.2%)	91 (46.2%)	<0.001 [†]
- Partner/Associate	3 (4.2%)	35 (9%)		13 (10.9%)	25 (7.3%)		14 (10.7%)	24 (7.3%)		18 (6.8%)	19 (9.6%)	
- Employee	91 (63.6%)	229 (58.6%)		46 (38.7%)	231 (67.3%)		61 (46.6%)	216 (65.3%)		190 (72%)	87 (44.2%)	
Employment status												
- Full time	54 (75%)	304 (77.2%)	0.219 [†]	95 (78.5%)	263 (76.2%)	0.039 [‡]	96 (72.2%)	262 (78.7%)	0.275 [‡]	221 (83.7%)	135 (67.2%)	<0.001 [†]
- Part time	13 (18.1%)	79 (20.1%)		18 (14.9%)	74 (21.4%)		31 (23.3%)	61 (18.3%)		38 (14.4%)	55 (27.4%)	
- Other	5 (6.9%)	11 (2.8%)		8 (6.6%)	8 (2.3%)		6 (4.5%)	10 (3%)		5 (1.9%)	11 (5.5%)	
Attended IC^c workshop in past 12 months												
- Yes	9 (12.7%)	36 (9.4%)	0.392 [†]	18 (15.1%)	27 (8%)	0.026 [†]	21 (16%)	24 (7.4%)	0.005 [†]	25 (9.6%)	19 (9.8%)	0.949 [†]

- No	62 (87.3%)	348 (90.6%)		101 (84.9%)	309 (92%)		110 (84%)	300 (92.6%)		235 (90.4%)	175 (90.2%)	
Level of concern about specific zoonoses												
Australian bat lyssavirus												
- Extremely -moderately worried	39 (54.2%)	188 (48.2%)	0.473 [^] 0.083 [*]									
- A little worried	18 (25%)	126 (32.3%)										
- Not worried at all	15 (20.8%)	76 (19.5%)										
Avian Influenza												
- Extremely -moderately worried			28 (23.3%)	63 (18.5%)	0.322 [^] 0.473 [*]	34 (25.8%)	57 (17.3%)	0.080 [^] 0.456 [*]				
- A little worried			51 (42.5%)	138 (40.5%)			54 (40.9%)	135 (41%)				
- Not worried at all			41 (34.2%)	140 (41.1%)			44 (33.3%)	137 (41.6%)				
Q-fever												
- Extremely -moderately worried									54 (20.7%)	43 (22.1%)	0.777 [^] 0.207 [*]	

- A little worried		86 (33%)	68 (34.9%)
- Not worried at all		121 (46.4%)	84 (43.1%)

Results are from bivariate analysis.

*Not all participants answered all questions

^a AVA: Australian Veterinary Association

^b EVA: Equine Veterinarians Australia

^c IC: Infection control

[†]p: all p-values relate to Pearson's Chi square unless otherwise indicated

[‡]p: values relate to Fisher's exact test

[^]p: values relate to Chi square for trend

[∗]: p values adjusted for demographic, education and professional characteristics and in practice IC leadership indicators.

Table 4 - Associations between demographic; Accessibility/Remoteness Index of Australia (ARIA) categories; education; professional characteristics and concern about specific zoonoses reported by 538* participants stratified by usage of masks with horses and birds.

	Always or sometimes use of mask with a live horse			Always or sometimes use of mask with a dead horse			Always or sometimes use of mask with a live bird			Always or sometimes use of mask with a dead bird		
	Yes (n=190)	No (n=54)	p-Value†	Yes (n=184)	No (n=29)	p-Value†	Yes (n=92)	No (n=352)	p-Value†	Yes (n=155)	No (n=278)	p-Value†
Demographic characteristics												
Gender												
- Female	100 (52.6%)	25 (46.3%)	0.411†	95 (51.6%)	12 (41.2%)	0.305†	48 (52.2%)	224 (63.6%)	0.044†	86 (55.5%)	179 (64.4%)	0.068†
- Male	90 (47.4%)	29 (53.7%)		89 (48.4%)	17 (58.6%)		44 (47.8%)	128 (36.4%)		69 (44.5%)	99 (35.6%)	
Age												
- ≤ 40yrs old	107 (56.3%)	25 (46.3%)	0.192†	105 (57.1%)	16 (55.2%)	0.848†	42 (45.7%)	205 (58.6%)	0.026†	77 (49.7%)	164 (59.4%)	0.051†
- > 40yrs old	83 (43.7%)	29 (53.7%)		79 (42.9%)	13 (44.8%)		50 (54.3%)	145 (41.4%)		78 (50.3%)	112 (40.6%)	
University of graduation												

- QLD University	150 (79.8%)	38 (70.4%)	0.342 [‡]	145 (79.7%)	20 (69.0%)	0.253 [‡]	67 (73.6%)	275 (78.3%)	0.301 [†]	105 (68.6%)	229 (82.4%)	0.005 [†]
- Australian University (excl. QLD)	24 (12.8%)	10 (29.4%)		22 (12.1%)	7 (24.1%)		13 (14.3%)	51 (14.5%)		31 (20.3%)	32 (11.5%)	
- Overseas University	14 (7.4%)	6 (30.0%)		15 (8.2%)	2 (6.9%)		11 (12.1%)	25 (7.1%)		17 (11.1%)	17 (60.1%)	
ARIA Categories												
Highly accessible - Accessible	100 (52.6%)	31 (58.5%)	0.440 [^]	92 (50.3%)	17 (58.6%)	0.063 [‡]	46 (50.5%)	237 (67.5%)	0.012 [^]	91 (58.7%)	183 (66.3%)	0.161 [^]
Moderately accessible	71 (37.4%)	15 (28.3%)		73 (39.9%)	6 (20.7%)		38 (41.8%)	93 (26.5%)		53 (34.2%)	77 (27.9%)	
Remote - Very remote	19 (10.0%)	7 (13.2%)		18 (9.8%)	6 (20.7%)		7 (7.7%)	21 (6.0%)		11 (7.1%)	16 (5.8%)	
Professional characteristics												
Type of practice												
- Small animal	11 (5.9%)	16 (30.2%)	<0.001 [‡]	10 (5.6%)	6 (21.4%)	0.029 [‡]	45 (50.0%)	206 (59.7%)	0.158 [‡]	79 (51.6%)	165 (60.7%)	0.003 [†]
- Large animals	32 (17.3%)	4 (7.5%)		30 (16.7%)	3 (10.7%)		0	5 (1.4%)		0	4 (1.5%)	
- Mixed	137 (74.1%)	27 (50.9%)		133 (73.9%)	17 (60.7%)		37 (41.1%)	117 (33.9%)		58 (37.9%)	95 (34.9%)	
- Other	5 (2.7%)	6 (11.3%)		7 (3.9%)	2 (7.1%)		8 (8.9%)	17 (4.9%)		58 (37.9%)	8 (2.9%)	

Role in practice												
- Principal	70 (37.4%)	26 (49.1%)	0.226 [†]	68 (37.6%)	14 (50.0%)	0.502 [‡]	36 (39.1%)	105 (30.2%)	0.030[†]	54 (34.8%)	82 (29.9%)	0.346 [†]
- Partner/Associate	21 (11.2%)	3 (5.7%)		22 (12.2%)	2 (7.1%)		11 (12.0%)	23 (6.6%)		14 (9.0%)	19 (6.9%)	
- Employee	96 (51.3%)	24 (45.3%)		91 (50.3%)	12 (42.9%)		45 (48.9%)	220 (63.2%)		87 (56.1%)	173 (63.1%)	
Employment status												
- Full time	166 (87.4%)	43 (79.6%)	0.261 [†]	163 (88.6%)	24 (82.8%)	0.381 [‡]	73 (79.3%)	273 (77.6%)	0.650 [‡]	122 (78.7%)	217 (78.1%)	0.986 [†]
- Part time	18 (9.5%)	9 (16.7%)		15 (8.2%)	3 (10.3%)		15 (16.3%)	68 (19.3%)		28 (18.1%)	52 (18.7%)	
- Other	6 (3.2%)	2 (3.7%)		6 (3.3%)	2 (6.9%)		4 (4.3%)	11 (3.1%)		5 (3.2%)	9 (3.2%)	
Attended IC^c workshop in past 12 months												
- Yes	38 (20.8%)	6 (11.5%)	0.132 [†]	35 (19.6%)	4 (14.3%)	0.507 [†]	14 (15.7%)	25 (7.3%)	0.013[†]	22 (14.6%)	16 (5.9%)	0.003[†]
- No	145 (79.2%)	46 (88.5%)		144 (80.4%)	24 (85.7%)		75 (84.3%)	319 (92.7%)		129 (85.4%)	255 (94.1%)	
Level of concern about specific zoonoses												
Hendra virus												

- Extremely - moderately worried	179 (94.2%)	45 (83.3%)	0.011 [‡] 0.317 [‡]	177 (96.2%)	21 (72.4%)	<0.001 [‡] 0.017 [‡]	
- A little worried	9 (4.7%)	5 (9.3%)		6 (3.3%)	5 (17.2%)		
- Not worried at all	2 (1.1%)	4 (7.4%)		1 (0.5%)	3 (10.3%)		
Avian Influenza							
- Extremely - moderately worried				26 (28.9%)	63 (18.2%)	0.001 [^] 0.003 [‡]	36 (23.5%) 53 (19.3%) 0.006 [^] 0.004 [‡]
- A little worried				43 (47.8%)	135 (38.9%)		74 (48.4%) 98 (35.8%)
- Not worried at all				21 (23.3%)	149 (42.9%)		43 (28.1%) 123 (44.9%)

Results are from bivariate analysis.

*Not all participants answered all questions

^aAVA: Australian Veterinary Association

^bEVA: Equine Veterinarians Australia

^cIC: Infection control

[†]p: all p-values relate to Pearson's Chi square unless otherwise indicated

[‡]p: values relate to Fisher's exact test

[^]p: values relate to Chi square for trend

[‡]p: values related adjusted for demographic, education and professional characteristics and in practice IC leadership indicators.

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**Factors affecting veterinary infection control behaviours:
The role of infection control leadership at the practice level.**

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Abstract

The aim of veterinary infection control (IC) is to prevent the transmission of infectious diseases in the veterinary work environment. When dealing with zoonoses, this aim also has a legal, public health and occupational health and safety significance for veterinarians and veterinary practices. However, veterinary IC has been found to be substandard at the practice and individual level in many countries. Leadership has been shown to successfully improve IC in healthcare settings. This paper examines the effect of veterinary IC leadership displayed at the practice level on veterinarians' individual IC choices.

All private veterinarians registered in Queensland, Australia were invited to participate in a postal survey between June and September 2011 (n=538; response rate: 35.6%). Participants were asked if there was evidence of IC leadership within their practice, such as 1) documented IC policies and/or someone overseeing IC implementation; 2) documented compliance with health and safety regulations; and 3) access to particulate masks (N95/P2). Participants were also asked about their frequency of mask usage and their history of sharps injury.

More than half the participants worked in a practice without a set of IC policies (53.2%) or without a staff member overseeing the implementation of IC (62.7%). Compliance with health and safety regulations was documented in 29.3% of cases and half the participants (50.1%) had

access to particulate masks within their practice. Most participants (83.6%) reported having sustained at least one sharps injury in the previous 12 months. Most common sharps injuries were due to needle stick (68.4%) or suture needles (56.2%). Those who wore a mask at least some of the time when examining birds and horses were more likely to work in a practice where IC leadership was evident, while there was no significant difference in the presence/absence of practice IC leadership between those who had sustained a sharps injury in the previous 12 months and those who had not. Evidence of IC leadership at the practice level was not associated with the vaccination rates of veterinarians.

Commitment to IC leadership within private veterinary practice is not widespread, but when present it appears to motivate staff to use personal protective equipment such as masks. Promoting IC leadership at practice level may improve veterinary IC standards and should be encouraged at the professional and undergraduate levels. Better integration of IC and health and safety regulation knowledge and leadership skills among private veterinary workforces could improve veterinary IC attitudes.

Introduction

Infection control (IC) is, by definition, the combination of policies and procedures used to reduce the risk of transmission of infectious diseases in human healthcare settings or animal healthcare facilities (Mosby, 1998). In veterinary hospitals or practices, the aim of IC is threefold: preventing animal-to-animal; human-to-animal; and animal-to-human transmission of infectious diseases. Infection control in the veterinary setting should also aim to prevent human to human transmission. Animal to human transmission occurs when the infectious disease involved is a zoonosis; i.e., transmissible between vertebrate animals and humans. In such cases IC takes on a public health and occupational health and safety significance and may require: reducing contact opportunities between humans and infected animals; seeking any available pre-exposure prophylaxis; and the use of personal protective equipment (PPE) for those who cannot avoid contact with infected animals, such as veterinarians and their allied staff. Veterinarians are considered the most knowledgeable professionals in regards to zoonoses and are expected to play a key role in implementing the necessary IC measures to prevent their transmission to humans including themselves (Grant & Olsen, 1999; Nowotny & Deutz, 2000; Hill et al., 2012, Speare et al. 2015). Notwithstanding, there have been numerous reports of veterinarians becoming infected with or exposed to zoonotic diseases during the course of their career (Weese et al., 2006; Hannah et al. 2006; Myers et al., 2007; Gait et al al., 2008; Cuny et al., 2009; Baker et al., 2009; Playford et al., 2010) . In most cases infection was attributed to poor IC standards.

Veterinary IC has been deemed suboptimal in Australia (Leggat et al., 2009; Dowd et al., 2013). This issue was highlighted by the recent emergence of a new zoonosis in Australia, Hendra virus (HeV), which has sporadically spilled-over over from bats into horses and from horses to humans since 1994 (Department of Health (DoH), 2012; Department of Agriculture and

Fisheries, Queensland (DAF QLD), 2015) . Although of rare occurrence, HeV has a case fatality rate of 57% in humans and of the seven people infected to date, five were veterinary staff or had assisted in veterinary procedures and three ultimately died as a result of their infection (DoH, 2012; DAF QLD, 2015). All human HeV cases were the result of close contact with infected horses, without the use of adequate PPE (DoH, 2012). Equine veterinarians, allied staff and lay assistants have since been considered at a higher occupational risk of contracting HeV, and government authorities, professional peak bodies and veterinary practitioners have recognised the need to improve veterinary IC standards in Australia (Australian Veterinary Association (AVA), 1999; DAF QLD, 2010; AVA, 2013; Dowd et al., 2013; Mendez et al., 2014).

Documented veterinary IC failures include: lack of in-house IC policies; lack of IC training and professional experience managing zoonoses; lack of hand hygiene; inadequate and insufficient usage of PPE; high rates of needle-stick injuries and inadequate biosafety equipment and protocols for in-house bacteriological cultures (Weese et al., 2006; Myers et al. 2007; Benedict et al. 2008; Lipton et al. 2008; Gait et al. 2008; Wright et al. 2008; Weese & Prescott, 2009; Leggat et al. 2009; Murphy et al. 2010; Dowd et al. 2013). However, few studies have identified or explained the reasons behind substandard veterinary IC practices. Factors affecting veterinary IC that have been identified include: infectious risk perception, lack of health and safety training, lack of government support, logistical and financial cost to private practices, and the veterinary work culture (D'Souza et al., 2009; Dowd et al., 2013; Mendez et al., 2014 a and b).

The implementation of IC in human healthcare settings has also been found to be deficient (Burke, 2003; Pittet et al., 2008). Poor IC is considered costly to public health systems because

it can result in high rates of nosocomial infectious diseases in patients (Burke, 2003; Cole, 2008; Stone, 2009; Lamarsalle et al., 2013). Factors influencing IC in human healthcare settings have been extensively investigated with IC leadership being one of the most determining factors. Improved IC leadership has helped decrease the incidence of health-care associated infections such as Methicillin-Resistant *Staphylococcus aureus* (Snow et al., 2006; Miyachi et al., 2007; Kellie et al., 2012; Lieber et al., 2014).

The role of leadership in the veterinary field has been examined previously but not specifically in relation to the implementation of veterinary IC (Wagner & Brown, 2002; Lloyd et al., 2007; Moore et al., 2007; Fraser et al., 2008). The aims of this study were to explore the role of IC leadership in private veterinary practices in Queensland (QLD), Australia and its effect on IC choices and outcomes at the individual level.

Methods

Study design

The study design for this investigation has been previously described (Mendez et al., in press) and consisted of a cross-sectional postal survey of all private veterinarians registered with the Veterinary Surgeons Board of Queensland (VSBQ) and working in QLD, Australia, between June and September 2011. The study was approved by James Cook University Human Ethics Committee (Ethics Approval No. H3687).

Questionnaire design and implementation

Design and management of the questionnaire have been described previously (Mendez et al. submitted as companion manuscript). The survey questionnaire was mailed via Australia Post to 1604 eligible veterinarians in June 2011, followed by three reminders during the months of

July, August and September. Returning a completed questionnaire in the reply paid envelope provided was considered as informed consent.

The questionnaire used for this survey included questions about socio-demographic, education, professional and practice characteristics. Participants' geographic locations were divided into the five Accessibility/Remoteness Index of Australia (ARIA) categories; highly accessible, accessible, moderately accessible, remote, and very remote (Australian Institute of Health and Welfare, 2004). Accessibility and remoteness are defined here on the basis of the distance by road between an Australian locality and the closest service centres. Participants were asked a number of multiple choice questions about IC leadership within their practice, such as documented IC policies, health and safety compliance and availability of specific personal protective equipment (PPE). The survey questionnaire also included questions about participants' IC practices such as the use of mask and seeking vaccination against certain zoonoses (Australian Bat Lyssavirus (ABLV); swine influenza (i.e., influenza A H1N1-2009); and Q-fever); and their history of sharps injury in the previous 12 months. Participants were also asked about their level of concern about some zoonoses: ABLV, Hendra virus (HeV), avian influenza, and Q fever.

Data management and analysis

Returned questionnaires were de-identified and ascribed a unique identification number. Responses were entered into Excel and subsequently imported into SPSS (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.) for analysis. Numerical data were presented using median and interquartile range (IQR) (skewed distribution) and mean and standard deviation (SD) (symmetrical distribution). Percentages were used to report categorical data. Bivariate analyses using Pearson's Chi-square, Chi-square

for trend, and Fisher's exact test were performed to compare: 1) participants who self-reported to be currently vaccinated against rabies, seasonal influenza, swine influenza or Q-fever to those who were not vaccinated; and 2) participants who "always or sometimes" used a mask when attending live and dead horses and birds to those who never use a mask in the same circumstances. Bivariate analyses using Pearson's chi-square, Fisher's exact test and Chi-square for trend were conducted for socio-demographic, education, ARIA, professional characteristics and presence of IC leadership indicators within participants' practices. Multiple logistic regression analyses were used to confirm the observed effects of IC leadership indicators on veterinarians' vaccination status, their usage of masks, and their sharps injuries adjusting for potential confounders such as demographic (gender, age, ARIA), education (university of graduation, attendance at an IC workshop in the previous 12 months), professional (type of practice, role in practice, employment status) characteristics, and level of concern about ABLV, HeV, avian influenza and Q fever where relevant. During the data analysis, any variable not included in the model was checked for its confounding effect. If the coefficient in the final model with the variable varied by more than 5% compared to the coefficient of the model without the variable then this variable was considered to be a confounder. The assumptions for these statistical tests were met. A result was considered significant when the p-value was <0.05.

Results

After eliminating 91 of 1604 eligible veterinarians who no longer worked at the address listed on the VSBQ website, there were 1513 remaining prospective participants, 549 of whom completed and returned their questionnaire. A further 11 participants were subsequently eliminated from the analysis as they were retired and no longer part of the veterinary workforce (response rate 35.6%). Not all participants answered all questions.

Demographic, veterinary education, professional profile

Demographic characteristics, veterinary education and professional profile have been reported previously (Mendez et al. submitted as a companion manuscript). The majority of respondents were female (55.8%, 300/538); 40 years or younger (51.3%, 275/536); graduates from a QLD university (77.4%, 415/536); and worked full-time (77%, 414/538); as employees (56.1%, 297/529). Most participants worked in a small animal practice (52%, 271/521) located in “*highly accessible to accessible*” ARIA regions (66.9%, 358/535). A tenth of participants (10.5%, 55/525) had attended an IC workshop in the previous 12 months.

Infection control leadership at the practice level (Table 1)

More than half of the participants worked in a practice without IC policies (53.9%, 177/510) or a person overseeing IC implementation within the practice (62.7%, 320/510). Compliance with legal workplace health and safety requirements was documented in fewer than a third of practices (29.3%, 149/508). Particulate masks (N95/P2) were available in half the practices (50.1%, 250/499) (Table 1).

Effect of infection control leadership on participants' vaccination rates

(Table 2)

Participants' vaccination rates have been reported previously (Mendez et al. submitted as a companion manuscript): rabies 15.5% (72/466); seasonal influenza 51.9% (242/466); swine influenza 28.5% (133/466); and Q-fever 56.8% (264/466). After adjusting for demographic, educational and professional characteristics and levels of concern about relevant zoonoses, working in a practice with IC policies, a staff member responsible for overseeing the implementation of IC within the practice, and working in a practice where compliance with

workplace health and safety legislation was documented had no significant effect on levels of vaccination among participants against rabies ($p=0.657$; $p=0.145$; $p=0.843$, respectively), seasonal influenza ($p=0.298$; $p=0.343$; $p=0.069$, respectively), swine influenza ($p=0.543$; $p=0.583$; $p=0.201$, respectively), and Q-fever ($p=0.492$; $p=0.172$; $p=0.533$, respectively).

Effects of infection control leadership on mask usage with horses and birds, and sharps injuries (Tables 3 and 4)

The majority of participants were prepared to examine birds whether alive or dead (82.3%, 444/527; 83%, 433/522 respectively) without a mask (live bird: 79.3%, 352/444; dead bird: 64.2%, 278/522, respectively). Fewer than half the participants were prepared to examine horses whether alive or dead (47.9%, 244/509; 42.8%, 213/498, respectively), but of those who would consider undertaking this task the majority would do so while “*always or sometimes*” using a mask (live horse: 77.9%, 190/244; dead horse: 86.4%, 184/213, respectively). After adjusting for demographic, educational, professional characteristics and level of concern about HeV, those who wore a mask at least some of the time when examining a live horse were more likely to work in a practice with all three IC leadership indicators and particulate masks available within the practice (53.6%; 42.1%; 38.3%; 89%, respectively) than those who never wore a mask in the same circumstances (13.5%; 7.7%; 20%; 55.1%, respectively) ($p<0.001$; $p=0.001$; $p=0.027$; $p=0.002$, respectively) (Table 4). When examining a dead horse there were no significant difference between those who wore a mask at least some of the time and those who didn't in regards to in practice IC leadership even after adjusting for potential confounders (Table 4).

Participants who used a mask at least some of the time when examining a live or a dead bird were also more likely to work in a practice that documented compliance with workplace health

and safety legislations (42.9%; 39.9%, respectively) than those who never used a mask in the same circumstances (23.8%; 21.3%, respectively) ($p=0.020$; $p<0.001$, respectively) after adjusting for demographic, educational professional characteristics and levels of concern about avian influenza (Table 4).

A large proportion of participants reported having sustained at least one sharps injury in the previous 12 months (83.6% [CI 80.0-86.7]; 412/493), most commonly from a syringe (68.4% [CI 64.1-72.4], 337/493) or a suture needle (56.2% [CI 51.7-60.6], 277/493) (Table 3). Those who had sustained at least one sharps injury in the previous 12 months were more likely to be female (60.4%, 249/412) and 40 years or younger (57.9%, 319/412) than those who had not sustained this type of sharps injury during this period (40.7%; 29.6%, respectively) ($p=0.001$; $p<0.001$, respectively). Participants who sustained a sharps injury in the previous 12 months did not significantly differ in regards to any of the IC leadership indicators at the practice level even after adjusting for demographic, educational professional characteristics and levels of concern about all four zoonoses under consideration ($p=0.647$; $p=0.563$; $p=0.674$, respectively) (Table 4).

Discussion

Participants who reported working in a practice where there was evidence of IC leadership were more likely to use masks when examining horses and birds. However, when examining a dead horse, which represents a high risk of becoming infected with HeV (Department of Health, 2012), in practice IC leadership did not make a difference in regards to mask usage indicating the decision of wearing a mask is either the result of personal choice or other unknown factors. Overall IC leadership at the practice level was low and inconsistent throughout practices and many participants reported working in a practice where there was

little tangible evidence of IC leadership. Furthermore, IC leadership did not influence vaccination rates of participants against rabies, Q-fever, swine (i.e., influenza A H1N1-2009) or seasonal influenza; nor did it influence the rate of sharps injuries sustained by participants in the 12 months prior to completing the survey. Sharps injuries were very frequent amongst participants, especially among females and younger participants, supporting findings of an earlier study in the same target population which concluded that IC was poor in Australian veterinary practices (Leggat et al., 2009).

Sharps injuries, in particular needle stick injuries, are very common in veterinary practice (Weese & Jack, 2008; Wright et al., 2008; Weese & Faires, 2009; Leggat et al., 2009), and may be the port of entry for infectious diseases and toxic chemical compounds (Wilkins & Bowman, 1997; Cook et al., 2002; Berkelman, 2003; Oliveira et al. 2010). Despite their occupational health and safety (OHS) importance and recommendations to improve needle handling protocols in veterinary practice, such as not recapping or re-using needles, sharps injuries do not seem to particularly concern veterinarians as little action appears to have been taken at the professional level to reduce this potential route of infection. One reason for the apparent lack of concern about such injuries may be that needle stick injuries in veterinary practice do not hold the same significance as in the medical field (Wright et al. 2008) where healthcare workers are at higher risk of serious blood-borne viruses (e.g., HIV, Hepatitis B virus, Hepatitis C virus, Ebola virus) following needle stick injuries. Despite sharps injuries being very common in veterinary practice, the potential for direct health and safety consequences from biological or chemical materials transmitted via sharps injury are rare (Woodward, 2008). Consequently, veterinary practitioners may be unconcerned by the occupational risk related to sharps injuries; thus rates of sharps injuries may not be a good indicator of veterinary IC standards. In order to

promote improved sharps handling protocols, the real OHS significance of sharps injuries in veterinary practice needs to be further investigated.

Veterinary IC is considered below standard in many countries (Wright et al., 2008; Gait et al. 2008; Benedict et al. 2008; Murphy et al., 2008; Baker et al., 2009; Leggat et al., 2009; Dowd et al., 2013) . For example, lack of in-house IC policies, high rates of sharps injuries and inadequate or insufficient use of PPE (including masks) have been observed previously in a number of countries (Weese & Jack, 2008; Wright et al. 2008; Lipton et al., 2008; Weese & Faires, 2009; Leggat et al., 2009; Dowd et al., 2013). From an OHS and a biosecurity perspective this is an issue not only for animal patients but also for veterinary staff dealing with animals infected with a zoonosis. Since around three quarters of emerging infectious diseases are zoonotic in nature (Taylor et al., 2001; Jones et al., 2008; Cutler et al., 2010), veterinarians are likely to be at an increased risk of acquiring a zoonosis in the future unless veterinary IC standards are improved. The reasons behind poor veterinary IC behaviours have been investigated by the authors in previous studies. Many determinants were found to influence veterinary IC choices: work culture; risk perception; difficulty interpreting work health and safety legislation; and delivery of services by privately owned businesses which puts constraints on the logistical, financial and work time cost of implementing IC (Mendez et al., 2012, 2014a and b). The need for a shift in the attitudes towards IC and zoonoses in the veterinary work culture has been recognised and recommended by the veterinary profession in Australia (Dowd et al., 2013; Mendez et al., 2014a). D'Souza and colleagues examined the health and safety preparedness of small animal veterinary practices in the United Kingdom and found that although many practices had health and safety policies, fewer than a third of veterinary staff had health and safety training. They also found that many veterinarians ranked the use of PPE, as a method of risk mitigation, much higher on the hierarchy of IC, than other

more reliable risk mitigation strategies (D'Souza et al., 2009; Safe Work Australia, 2011). Similarly, Benedict and colleagues found that only 42% (16/38) of veterinary teaching hospitals they surveyed required their staff to receive biosecurity training (Benedict et al., 2008). Veterinarians may therefore need to be better informed/trained about their OHS responsibilities and the related significance of IC; they may also require support to implement the necessary IC measures within the context of their workplace.

The patterns of IC implementation in healthcare settings have been described as a socio-cultural phenomenon rather than a matter of professionalism (Cumbler et al., 2013; Sakamoto et al., 2014). Hence, improving IC has been linked to changing the healthcare work culture. One strategy used to modify the IC work culture in the medical field was to promote “patient safety” (Sakamoto et al., 2014). While another was to rely on strong IC leadership (Rasslan et al., 2011; Lieber et al., 2014). Leadership has been shown to be more effective than additional IC education in improving IC behaviours among healthcare workers and patient safety in healthcare settings (Miyachi et al., 2007; Kellie et al., 2012; Cumbler et al., 2013; Al-Tawfiq et al., 2013; Lieber et al., 2014). Effective IC leadership requires the following key elements: role models who have the knowledge and communication skills to network and inspire other staff to follow best practice and overcome barriers such as the disconnect between perceived IC performance and real IC performance among staff (Saint et al., 2010; Cumbler et al., 2013); implementation of regular IC audits and feedback to staff (Cumbler et al., 2013); the commitment from the entire organisation to implement IC improvement and/ or change IC culture (Rasslan et al., 2011; Cumbler et al., 2013; Al-Tawfiq et al., 2013; Sakamoto et al., 2014); and recognising that IC leadership does not have to be located within higher management (Dawson, 2003; Miyachi et al., 2007; Kellie et al., 2010). It has also been suggested that those acting as IC leaders should be appropriately educated to better fulfil their

function (Dawson, 2003). Saint and colleagues, on the other hand, describe the personal characteristics of a successful IC leader as “*being an inspiring role model to other staff, thriving on a culture of clinical excellence, having good communication skills and being able to provide timely feedback on IC issues, overcoming barriers efficiently, and championing IC initiatives through networking*” (Saint et al., 2010). Some authors have, however, applied caveats to relying on leader figures to improve and sustain high IC standards within the healthcare sector as the size of healthcare facilities and the high turnover of healthcare staff may hamper the outreach of IC leaders in some instances and therefore undermine their role (Dawson, 2003; Cumbler et al., 2013). Veterinary practices with much smaller workforces will not suffer from this problem.

The aim of the present study was to gauge the evidence of IC leadership in veterinary practices and its effect on IC choices and outcomes at the individual level. Infection control policies were not present across participants’ practices as has been observed in previous studies (Wright et al., 2008; Murphy et al., 2008; Lipton et al., 2008). Thus, this is not a uniquely Australian issue, and the need for IC policies in veterinary practices may not been seen as a priority by the veterinary profession. The findings suggest that IC leadership may positively influence some IC behaviours, such as the use of masks with animal species known to be potential sources of zoonoses (horse and birds). This trend was more consistent when participants were asked to consider attending equine patients. This may have been due to the state wide campaign to improve veterinary IC practices for the management of HeV (DAF QLD, 2010). Those who were prepared to examine birds may have also been more aware of the risk than those who seldom examined birds. Vaccination rates against known zoonoses were not influenced by the presence of IC indicators. This study also showed that vaccination rates were not affected by zoonotic risk perception (Mendez et al submitted as companion MS). Thus it is possible that

seeking pre-exposure prophylaxis for zoonotic diseases may be perceived as a matter of personal choice rather than an OHS or IC necessity.

The results of this study suggest that IC leadership may be another avenue to promote IC improvements across the veterinary profession. Leadership in the veterinary field has been investigated previously but not in direct association to IC (Wagner & Brown, 2002; Lloyd et al., 2007; Moore et al., 2007; Fraser et al., 2008). Leadership in veterinary IC provided by professional mentorship of final year veterinary students during placements in private practice and workplace mentorship of early career veterinarians was found to be a key factor in the development of appropriate IC behaviours among new graduates (Mendez et al. 2014, Mendez et al. unpublished data). In the medical field IC leadership is clearly defined within the hierarchy of the public health system which is fully regulated and managed by various levels of government. However, in the veterinary field, apart from specific relevant legislation, an equivalent hierarchical structure does not exist. Relevant government departments, such as Biosecurity Queensland, and professional peak bodies provide veterinarians with IC recommendations and guidelines but do not manage how these are implemented at the level of private practices. Therefore IC leadership in the veterinary field is divided between: government, academia, professional agencies and principal veterinarians running private practices. Academia may influence veterinary IC by providing evidence-based knowledge, while professional agencies may do so by providing guidelines and recommendations, but neither can enforce IC changes. Therefore, since veterinary IC leadership is mostly left to principal veterinarians, it is fragmented within and between private practices. This is reflected in the differences in IC standards between practices (Benedict et al., 2008). Principal veterinarians may establish IC policies but veterinary employees are professional independent workers who may choose to implement IC measures differently. Principal veterinarians from

QLD who participated in an earlier study conducted by the authors reported such experiences in the IC management of HeV and other zoonoses (Mendez et al., 2014a). Furthermore, there is no real coordination of IC leadership between practices, as each veterinary practice is a separate business entity that establishes its own policies and procedures. Australian government and professional peak bodies develop IC guidelines, but these are not mandatory. The only legal requirements in terms of IC are related to biosecurity and OHS. The OHS significance of veterinary IC may need to be emphasised at the undergraduate and professional level to stress its relevance.

This study only sought information about the presence of IC leadership indicators in practices where participants worked and it did not explore the IC leadership characteristics displayed by other members of staff, principal veterinarians or practice managers. Given the low response rate and the limited IC leadership characteristics examined, it is difficult to draw definite conclusions about the effect of IC leadership in veterinary practices or how it should be managed within these practices. In the medical field, key nursing staff play an important role in promoting and maintaining IC standards (Dawson, 2003; Miyachi et al., 2007). Many veterinary nurses have similar rates of exposure to occupational risks, including sharps injuries, as their veterinary counterparts (Van Soest & Fritschi, 2004). However, in Australia many veterinary nurses working in practices are still in training; a course requirement is the completion of many hours of paid employment in a veterinary workplace (Technical and Further Education New South Wales – North Coast Institute, 2015). Trainee veterinary nurses are unlikely to be seen as IC leaders within veterinary practices. Furthermore, veterinary nurses usually do not work outside opening business hours and do not respond to after-hours calls. It is therefore, unlikely that many veterinary nurses would be in a position to fulfil the role of IC leadership within veterinary practices or in the field.

Conclusion

Using leadership to encourage improvements in IC may prove to be an effective way to also shift the paradigm of the veterinary IC work culture. In order to devise a strategy based on the promotion of IC leadership, its potential effect on all aspects of veterinary IC requires further investigation. Although IC principles are the same in the medical and veterinary fields, veterinary IC leadership would need to be context appropriate to suit the framework of private practices. Furthermore, there needs to be cohesion and cooperation between all possible levels of veterinary IC leadership: government; professional peak bodies; academia; and private practices. Cohesion may be achieved by emphasising to the veterinary profession the OHS significance of IC failures at the professional and undergraduate levels. Veterinarians need to be better informed/educated about their OHS responsibilities including IC and provided with support to implement the necessary IC measures within the context of their workplace. Early career veterinarians may also benefit from an integrated approach to learning IC, OHS and leadership skills.

Table 1 – Presence of leadership infection control indicators in the private veterinary practices of 538* participants in Queensland.

Characteristics	Frequencies (relative frequencies)
Infection control at the practice level	
<i>Infection control set of policies in the practice (n= 510)</i>	
Yes	177 (34.7%)
No	275 (53.9%)
Don't know	58 (11.4%)
<i>A staff member overseeing infection control implementation in the practice (n=510)</i>	
Yes	131 (25.7%)
No	320 (62.7%)
Don't know	59 (11.6%)
<i>Compliance with WHS legislation documented within the practice (n= 508)</i>	
Yes	149 (29.3%)
No	174 (34.3%)
Don't know	185 (36.4%)
<i>N95/P2 masks available in the practice (n= 499)</i>	
Yes	250 (50.1%)
No	167 (33.5%)
Don't know	82 (16.4%)

*Not all participants answered all questions.

Table 2 – Association between infection control leadership and commitment indicators at the practice level reported by 538* participants stratified by their current vaccination status for rabies, seasonal influenza, swine influenza and Q-fever.

	Currently vaccinated against rabies			Currently vaccinated against seasonal influenza			Vaccinated against swine influenza			Vaccinated against Q-fever		
	Yes (n=72)	No (n=394)	p-value [†]	Yes (n=121)	No (n=345)	p-value [†]	Yes (n=133)	No (n=333)	p-value [†]	Yes (n=264)	No (n=201)	p-value [†]
IC policies in the practice												
Yes	21 (13.9%)	130 (34.5%)	0.627 0.657 [†]	47 (41.2%)	104 (31.4%)	0.021 0.298 [†]	43 (33.9%)	108 (34%)	0.915 0.543 [†]	85 (33.5%)	64 (33.7%)	0.021 0.492 [†]
No	36 (52.9%)	201 (53.3%)		60 (52.6%)	177 (53.5%)		69 (54.3%)	168 (52.8%)		127 (50%)	111 (58.4%)	
Don't know	11 (16.2%)	46 (12.2%)		7 (6.1%)	50 (15.1%)		15 (11.8%)	42 (13.2%)		42 (16.5%)	15 (7.9%)	
One staff in charge of IC in practice												
Yes	22 (32.4%)	91 (24.1%)	0.176 0.145 [†]	38 (33.3%)	75 (22.7%)	0.009 0.343 [†]	34 (26.8%)	79 (24.8%)	0.845 0.583 [†]	58 (22.8%)	54 (28.4%)	0.015 0.172 [†]
No	35 (51.5%)	239 (63.4%)		69 (60.5%)	205 (61.9%)		78 (61.4%)	196 (61.6%)		153 (60.2%)	121 (63.7%)	
Don't know	11 (16.2%)	47 (12.5%)		7 (6.1%)	51 (15.4%)		15 (11.8%)	43 (13.5%)		43 (16.9%)	15 (7.9%)	
WHS compliance documented in practice												
Yes	19 (27.5%)	112 (29.7%)	0.934 0.843 [†]	43 (37.4%)	88 (26.6%)	0.044 0.069 [†]	42 (32.8%)	89 (28%)	0.441 0.201 [†]	67 (26.3%)	64 (33.7%)	<0.001 0.533 [†]
No	23 (33.3%)	123 (32.6%)		38 (33%)	108 (32.6%)		43 (33.6%)	103 (32.4%)		71 (27.8%)	76 (40%)	

Don't know	27 (39.1%)	142 (37.7%)	34 (29.6%)	135 (40.8%)	43 (33.6%)	126 (39.4%)	117 (45.9%)	50 (26.3%)
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Results are from bivariate analysis. *Not all participants answered all questions; †: all p values relate to Pearson's Chi square; ‡: p values adjusted for demographic, education and professional characteristics and risk perception about Australian bat Lyssavirus virus, Avian influenza and Q fever where relevant.

Table 3 – History of sharps injury reported for the previous 12 months by 493 participants working in private veterinary practices in Queensland.

Sharps injury history for past 12 months	Frequencies (relative frequencies and 95% confidence interval)
<i>Has sustained at least one sharps injury in past 12 months (n= 493)</i>	412 (83.6%, CI ^o [80.0-86.7])
<i>Has sustained at least one sharps injury with following sharps equipment(clean and/or used) in past 12 months (n=493):</i>	
<i>Syringe</i>	337 (68.4%, CI ^o [64.1-72.4])
<i>Clean</i>	133 (27%)
<i>Used</i>	115 (23.3%)
<i>Clean and used</i>	89 (18.1%)
<i>Scalpel</i>	161 (32.7%, CI ^o [28.5-37.0])
<i>Clean</i>	45 (9.1%)
<i>Used</i>	81 (16.4%)
<i>Clean and used</i>	35 (7.1%)
<i>Suture needle</i>	277 (56.2%, CI ^o [51.7-60.6])
<i>Clean</i>	40 (8.1%)
<i>Used</i>	187 (37.9%)
<i>Clean and used</i>	50 (10.1%)
<i>Scissors</i>	17 (3.4%, CI ^o [2.0-5.5])
<i>Clean</i>	3 (0.6%)
<i>Used</i>	10 (2%)
<i>Clean and used</i>	4 (0.8%)
<i>Ampoule/vial</i>	55 (11.2%, CI ^o [8.5-14.3])
<i>Clean</i>	42 (8.5%)
<i>Used</i>	9 (1.8%)
<i>Clean and used</i>	4 (0.8%)

^oCI: 95% Confidence Interval.

Table 4 – Association between infection control leadership indicators at the practice level reported by 538* participants, stratified by their usage of masks with horse and birds and their history of sharps injuries in the previous 12 months.

	Use of mask with Live horse			Use of mask with dead horse			Use of mask with live bird			Use of mask with dead bird			Sustained any sharps injury in past 12 months		
	Yes (n=183)	No (n=52)	p-value	Yes (n=178)	No (n=28)	p-value	Yes (n=85)	No (n=341)	p-value	Yes (n=147)	No (n=270)	p-value	Yes (n=399)	No (n=73)	p-value
IC policies in the practice															
Yes	98 (53.6%)	7 (13.5%)	<0.001 [†] <0.001 [†]	88 (49.4%)	7 (25%)	0.005 [†] 0.059 [†]	36 (42.4%)	102 (29.9%)	0.030 [†] 0.100 [†]	57 (38.8%)	79 (29.3%)	0.043 [†] 0.228 [†]	142 (35.6%)	21 (28.8%)	0.464 [†] 0.647 [†]
No	73 (39.9%)	41 (78.8%)		76 (42.7%)	21 (75%)		44 (51.8%)	192 (56.3%)		79 (53.7%)	153 (56.7%)		210 (52.6%)	44 (60.3%)	
Don't know	12 (6.6%)	4 (7.7%)		14 (7.9%)	0		5 (5.9%)	47 (13.8%)		11 (7.5%)	38 (14.1%)		47 (11.8%)	8 (11.0%)	
One staff in charge of IC in practice															
Yes	77 (42.1%)	4 (7.7%)	<0.001 [†] 0.001 [†]	70 (39.3%)	2 (7.1%)	<0.001 [†] 0.076 [†]	25 (29.4%)	72 (21.1%)	0.057 [†] 0.361 [†]	41 (27.9%)	54 (20.0%)	0.040 [†] 0.310 [†]	102 (25.6%)	16 (21.9%)	0.739 [†] 0.563 [†]
No	94 (51.4%)	44 (84.6%)		94 (52.8%)	26 (92.9%)		55 (64.7%)	221 (64.8%)		95 (64.6%)	177 (65.6%)		249 (62.4%)	49 (67.1%)	
Don't know	12 (6.6%)	4 (7.7%)		14 (7.9%)	0		5 (5.9%)	48 (14.1%)		11 (7.5%)	39 (14.4%)		48 (12.0%)	8 (11.0%)	
WHS compliance documented in practice															
Yes	70 (38.3%)	10 (20.0%)	0.021 [†] 0.027 [†]	69 (39.0%)	4 (14.8%)	0.013 [†] 0.112 [†]	39 (42.9%)	81 (23.8%)	0.002 [†] 0.002 [†]	61 (39.9%)	57 (21.3%)	<0.001 [†] <0.001 [†]	113 (28.3%)	25 (36.2%)	0.192 [†] 0.674 [†]
No	60 (32.8%)	26 (52.0%)		57 (32.2%)	16 (59.3%)		24 (26.4%)	120 (35.3%)		40 (26.1%)	100 (37.3%)		127 (31.8%)	24 (34.8%)	

Don't know	53 (29.0%)	14 (28.0%)		51 (28.8%)	7 (25.9%)		28 (30.8%)	139 (40.9%)		52 (34.0%)	111 (41.4%)		160 (40.0%)	20 (29.0%)	
N95/P2 masks available in practice															
Yes	154 (89.0%)	27 (55.1%)	<0.001 [‡] 0.002 [‡]	148 (88.1%)	18 (66.7%)	0.001 [‡] 0.126 [‡]	50 (60.2%)	149 (44.3%)	0.033 [‡] 0.338 [‡]	79 (54.9%)	118 (44.5%)	0.132 [‡] 0.497 [‡]	201 (51.8%)	27 (37.5%)	0.024 [‡] 0.212 [‡]
No	9 (32.1%)	19 (38.8%)		11 (6.5%)	9 (33.3%)		23 (27.7%)	125 (37.2%)		43 (29.9%)	100 (37.7%)		120 (30.9%)	34 (47.2%)	
Don't know	10 (5.8%)	3 (6.1%)		9 (5.4%)	0		10 (12.0%)	62 (18.5%)		22 (15.3%)	47 (17.7%)		67 (17.3%)	11 (15.3%)	

*Not all participants answered all questions; †p: values relate to Pearson's Chi square; and ‡p: values relate to Fisher's exact test; ¶p: values adjusted for demographic, education, professional characteristics and risk perception about Hendra virus, avian influenza, Australian bat lyssavirus and Q fever where relevant.

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Conclusion

The aims of this chapter were met in the following manner:

- Do private veterinarians' risk perceptions about zoonoses affect their infection control choices?

⇒ Yes, but not consistently.

- How do private veterinarians' risk perceptions about zoonoses affect their infection control choices?

⇒ Private veterinarians who are very concerned about zoonotic risks tend to use masks more often, but they do not tend to seek pre-exposure vaccination against known preventable zoonoses more frequently than those who are less concerned.

- Does infection control at the practice level exist?

⇒ Yes, there is evidence of infection control at the practice level but it is not consistent across all practices.

- Does evidence of infection control leadership at the practice influence private veterinarians' infection control choices?

⇒ Yes, evidence of infection control leadership at the practice level influences some of the veterinarians' infection control choices but not consistently.

- How does evidence of infection control leadership at the practice level influence private veterinarians' infection control choices?

⇒ Evidence of infection control leadership at the practice level tends to encourage veterinarians to use masks, but does not encourage them to seek pre-exposure vaccination against known preventable zoonoses and does not help decrease the rate of sharps injuries.

Veterinary IC choices and behaviours are influenced by a number of factors including the extent of commitment to IC at the practice level and zoonotic risk perceptions at the individual level. Thus, these factors need to be considered when devising programs to improve veterinary IC. High levels of concern for specific zoonoses and the presence of IC leadership indicators within a practice for example prompted the use of personal protective equipment (PPE) by individual veterinarians when dealing with animal species known to be potentially infected with zoonoses. It may therefore be possible to increase the use of PPE by reinforcing the significance of the infectious risks involved in dealing with animals infected with known or unknown zoonoses. This could be achieved by highlighting the risks and occupational health and safety consequences of poorly managed IC measures, at the undergraduate and professional levels. However, it has been shown that additional education is not the most effective way of improving IC standards in the medical and veterinary fields.^{9,22,23} Hence, it is unlikely that an attempt to modify veterinarians' perceptions about zoonotic risks by providing additional training would lead to a significant change in veterinary IC behaviours. Furthermore, improving the use of PPE in veterinary practice, although a step in the right direction, cannot be viewed as the panacea to overhauling the whole of veterinary IC as PPE is the lowest measure in the IC hierarchy of control.²⁴ The aim of IC is to mitigate infectious risks, as such it should encompass all five levels of control included in the occupational health and safety hierarchy of control.²⁴ In this case zoonotic risk perceptions did not have any effect on the use of IC measures that provided more reliable, higher levels of control such as vaccination.

Perhaps veterinarians do not have an appropriate understanding of this hierarchy of control in relation to zoonoses management or are not used to prioritising the IC strategies ranked as most effective.²⁴ Previous studies have shown that measures such as developing IC policies and

providing additional IC training to veterinary staff were not prioritised in veterinary practices.²⁵⁻²⁹ From the literature it is also unclear if this ranking of IC strategies and its relationship to workplace health and safety is being taught in undergraduate studies. The relationship between veterinary IC skills and knowledge and their occupational health and safety significance may be the missing link that could help to reframe veterinary IC standards. The connection between the management of zoonotic risks, their public health and workplace health and safety significance and the hierarchy of IC control measures needs to be emphasised throughout the existing veterinary workforce and undergraduate veterinary curricula.

Whether considered from a medical or a veterinary point of view, it is evident that the work culture and the impetus to adhere to a professional identity as demonstrated by role models in the workplace is at the core of individual healthcare workers' decisions to implement IC strategies.^{5,22,30-32} Consequently, IC is at the cross-roads of knowledge, experience, tradition and professional identity at the individual, practice and professional levels. Instigating any IC improvement will need to address the fundamentals of the veterinary work culture. Strong leadership and the promotion of "patient safety" has successfully prompted a shift in the IC work culture in healthcare settings.^{10-14,22,30,31,33-36} Veterinary IC leadership is, currently, not widely developed nor clearly defined. However, the results from Study 3 indicate that encouraging veterinary IC leadership may be an avenue to improving standards in private practice; it requires further investigation.

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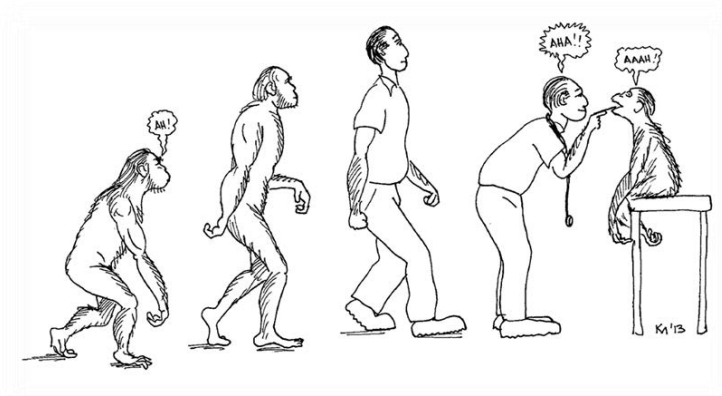
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CHAPTER 7 – Training in veterinary infection control: undergraduate studies *versus* placements in private practices.

Aims of this chapter

- Survey final year veterinary students to determine:
 - Their zoonotic risk perceptions
 - Their level of knowledge and understanding of infection control
- Determine final year veterinary students' perceptions about the degree of concurrence between veterinary infection control standards taught at the undergraduate level and the infection control standards experienced during their extramural placements
- Determine the role of professional mentorship in the development of infection control practices and behaviours by final year veterinary students.



Art work by Ken Miller

Introduction

Work placements are used in a variety of fields of study to enhance theoretical knowledge and acquisition of practical professional skills.¹⁻⁷ Students from different disciplines value this type of educational tool more than formal university courses for acquiring general skills relevant to their respective fields.¹ Extramural placements (EMPs) in private veterinary practices are an integral part of veterinary undergraduate training in Australia and other countries.⁸⁻¹² For example, a Bachelor of Veterinary Science at James Cook University, Australia, requires students to undertake numerous EMPs in veterinary practices, veterinary hospitals, laboratories, government agencies, farm/animal industry settings, and elective EMPs in para-clinical and research settings.^{13,14} The majority of EMPs undertaken during the final year of undergraduate veterinary studies (minimum 12 weeks) occur in private practice and rely on the goodwill of private veterinary practitioners, who accept training responsibilities by becoming mentors to final year veterinary students.^{11,13-15} The aim of these EMPs is to facilitate the transition of veterinary students into professional life by contributing to the integration of theoretical and practical knowledge. EMPs have been found to enhance veterinary students' proficiency across a range of clinical and non-clinical skills.^{8-12,16,17}

Although infection control (IC) is a generic veterinary skill, it is seldom discussed in studies that have examined the effect of EMPs on veterinary students' practice-preparedness. Infection control serves many purposes in veterinary practice including: animal health and biosecurity; public health; and health and safety of veterinarians, their staff and clients. Veterinary IC is a skill particularly relevant to the management of zoonoses, which present a specific risk not only for veterinarians and their staff and clients, but also for veterinary students who come into contact with animals during their various undergraduate studies and EMPs.^{18,19} Despite the importance of IC some veterinary students have contracted a zoonosis during their undergraduate training, indicating IC practices can be below standard at times.¹⁸⁻²⁶ Veterinary students undoubtedly receive theoretical and practical IC training prior to attending EMPs, but it is unclear what role EMPs play in furthering veterinary students' IC skills.

Findings from Study 1 showed that veterinary IC choices and behaviours varied across generations of veterinarians (See Chapter 3).²⁷ Veterinary practitioners who were interviewed in 2009-10 thought that some veterinary students on EMPs and early career veterinarians: 1) lacked confidence when applying IC while handling animals; 2) were too eager to gain clinical experience to even consider IC; and 3) became conflicted when faced with more experienced veterinarians who did not use the full range of recommended IC measures. For example, one participant pointed out:

“Students coming through are very well aware of the risks to the point of being scared to do things right in some cases. Hopefully they will go into practices ... where they follow best practices. But it's not always the case.” (Participant V7/Pa)

In this study some participants acknowledged that not all students and early career veterinarians received the same quality of IC training. Furthermore, many veterinarians agreed that mid and late career veterinarians had been taught and were accustomed to consider zoonotic risks in private practice of minor importance and consequently had shown a casual approach to veterinary IC for the prevention of zoonoses for many years. One participant said:

“Old school vets always considered getting infected with a zoonosis as a badge of honour.” (Participant V8/Pe)

However, few participants believed that professional mentorship of early career veterinarians and veterinary students was a key factor affecting the IC standards ultimately adopted by young veterinarians. In their opinion early career veterinarians were more likely to develop adequate IC habits if they were mentored by senior veterinarians who role modelled these habits during their first working experiences in private practice. For example, one participant from Study 1 remarked:

“Poor mentorship is a problem. Training is very important. A principal vet can teach a lot to younger vets.” (Participant V8/Pe)

The overall aim of Study 4 was to investigate whether there was a disconnection between veterinary IC taught to undergraduate veterinary students and the IC experienced by these students during their EMPs in veterinary practice and how this might influence their future IC behaviours.

7.1- Methods

Study 4, as described previously (See Chapter 2), was an online survey of final year veterinary students from James Cook University in Queensland (QLD), Australia. The survey took place in December 2013, after students had completed all of their EMPs and their final examinations. Students were asked a number of multiple choice questions (Appendix B4) about their: 1) demographic, education and future career plans; 2) zoonotic risk perceptions; 3) IC knowledge and training; 4) history of vaccination against known zoonoses; and 5) EMPs history and experiences in regards to IC. Due to the target population only comprising of 60 prospective participants, categorical and numerical data are reported descriptively with no further statistical analysis. Students were also asked to give further information about some of their responses to multiple choice questions. The corresponding open-ended questions are listed below (in bold italic font):

- Thinking of your latest placement in private veterinary practice, how confident did you feel using personal protective equipment? (“Very confident” to “Did not use any personal protective equipment”) ***Please give further details to explain your response?***
- Thinking of your latest placement in private veterinary practice, did the infection control education you received during your veterinary undergraduate studies match the reality you experienced during this placement? (Yes/ No/ Not sure) ***In what way did the infection control education you received during your veterinary undergraduate studies not match the reality you experienced during this placement?***
- Thinking of your latest placement in private veterinary practice, how easy was it to apply the principles of infection control you learned during your undergraduate studies

to the “real world” of private veterinary practice during this placement? (“Very easy” to “Not easy”) *Please give further details to explain your response?*

- *Would you like to add any comments in relation to zoonotic risks and infection control in veterinary practice?*

A content analysis of the participants’ responses to the above open-ended questions was conducted and thematic units of meaning were identified

7.2- Results

7.2.1 – Veterinary students’ characteristics, their future career plans and EMP history

There were 60 students in the cohort of final veterinary students at James Cook University in 2013. Of those, a third (20/60) completed the online survey; however, not all participants answered all questions (Table 7.1). The median age of participants was 23 (IQR=23-29), with the majority being female (60%; 12/20). About a third of all participants (35%; 7/20) had obtained another tertiary qualification prior to undertaking their veterinary studies; all in the fields of science, health or animal science. All participants had had some experience with animals prior to starting their veterinary studies: domestic pets (95%; 19/20); farm animals, including horses (65%; 13/20); and wildlife (55%; 11/20). The majority intended to work in private practice following graduation (90%; 18/20).

Table 7.1 – Demographic, educational, and future career plan characteristics of 20 participants.

Characteristic	Frequencies <i>(relative frequencies)</i>
Sex	
Female	12 (60%)
Male	8 (40%)
Age	
	Median = 23 yrs IQR* = 23-29yrs [range: 22-41]
Prior education	
Yes (all tertiary)	7 (35%)
Prior animal experience	
Domestic pets	19 (95%)
Farm animals (including horses)	13 (65%)
Wildlife	11 (55%)
No prior animal experience	0 (0%)
Intended future career path	
Private veterinary practice	18 (90%)
Other	1 (5%)
Undecided	1 (5%)

*IQR: Inter-Quartile Range.

Collectively, 20 participants reported attending a total of 144 separate EMPs in the previous 12 months. However, not all participants provided details about all of their placements. The median number of placements attended by each student was 7.2 (IQR[4-10]), and a median of 20 weeks (IQR[8-21.5]) in total was spent on placement per student (Table 7.2). The majority of EMPs took place in mixed or small animal veterinary practices (36.8%, 53/144; 37.5%, 54/144 respectively) (Table 7.2). A large proportion of EMPs were undertaken in QLD (55.9%; 80/143) or Victoria (18.9%; 27/143). Most EMPs lasted two weeks or less (77.8%; 112/144) in practices where participants worked directly with three or more veterinarians (77.1%; 113/144).

Table 7.2 – Characteristic of extramural clinical placement history of 20 participants represented by a combined number of extramural placements of 144* in private practices.

Characteristic	Frequencies <i>(relative frequencies)</i>
Number of placements per student attended in previous 12 months	
	Median = 7.2 [range: 3-10] IQR* [4-10]
Type of placement (n = 144)	
Mixed private veterinary practice	53 (36.8%)
Small animal private veterinary practice	54 (37.5%)
Large animal private veterinary practice	14 (9.7%)
Farm	11 (7.6%)
Zoo/Wildlife Sanctuary	5 (3.5%)
Laboratory	2 (1.4%)
Other	5 (3.5%)
Location of placement (n = 143)	
Queensland	80 (55.9%)
Victoria	27 (18.9%)
New South Wales	17 (11.9%)
Elsewhere in Australia	10 (7%)
Overseas	9 (6.3%)
Total number of weeks spent on placement per student in previous 12 months	
	Median = 20 IQR [8-21.5]
Length of placements (n = 144)	
≤2 weeks	112 (77.8%)
3 weeks	25 (17.3%)
4 weeks or more	7 (4.9%)
Number of veterinarians who worked directly with student on each placement (n = 144)	
1	16 (11.1%)
2	17 (11.8%)
3	35 (24.3%)
4	23 (16.0%)
4 or more	53 (36.8%)

*Respondents did not give all the required information for all placements they included in their responses. *IQR = inter-quartile range.

7.2.2 – Veterinary students’ zoonotic risk perceptions

Participants were asked about their level of concern about various occupational risks including zoonotic risks in the veterinary workplace (Table 7.3). A majority were “*very to moderately*” concerned about suffering from burnout (80%; 16/20); receiving an injury from an animal (75%; 15/20) or being affected by a litigation issue (60%; 12/20). Fewer than half the participants (45%; 9/20) were “*very to moderately*” concerned about acquiring a zoonosis while working in practice; and a fifth (4/20) were as concerned about sustaining a sharps injury.

Table 7.3 – Levels of concerns about occupational risks, including zoonotic risks, of 20* participants.

Risks	Level of concern		
	Very to moderately concerned	A little concerned	Not at all concerned/ Haven't considered it
Occupational concerns (n = 20)			
<i>Burnout</i>	16 (80%)	3 (15%)	1 (5%)
<i>Injury from an animal</i>	15 (75%)	5 (25%)	0
<i>Litigation</i>	12 (60%)	6 (30%)	2 (10%)
<i>Acquiring a zoonosis</i>	9 (45%)	10 (50%)	1 (5%)
<i>Injury from using equipment</i>	7 (35%)	11 (55%)	2 (10%)
<i>Sharps injury</i>	4 (20%)	14 (70%)	2 (10%)
<i>Acquiring an infectious disease from another human</i>	3 (15%)	11 (55%)	6 (30%)
<i>Chemical intoxication</i>	3 (15%)	10 (50%)	7 (35%)
<i>Road accident</i>	3 (15%)	12 (60%)	5 (25%)
Specific zoonotic risk perception to personal health (n = 19)			
<i>Hendra virus</i>	16 (84.2%)	2 (10.5%)	1 (5.3%)
<i>Leptospirosis</i>	13 (68.4)	4 (21.1%)	2 (10.5%)
<i>Australian Bat Lyssavirus</i>	12 (63.2%)	5 (26.3%)	2 (10.5%)
<i>Salmonellosis</i>	12 (63.2%)	4 (21.0 %)	3 (15.8%)
<i>Methicillin-resistant Staphylococcus aureus (MRSA)</i>	9 (47.4%)	9 (47.4%)	1 (5.2%)
<i>Psittacosis</i>	9 (47.4%)	8 (42.1%)	2 (10.5%)
<i>Dermatophytosis (ringworm)</i>	8 (42.1%)	8 (42.1%)	3 (15.8%)
<i>Pasteurellosis</i>	5 (26.4%)	7 (36.8%)	7 (36.8%)
<i>Toxoplasmosis</i>	5 (26.3%)	11 (57.9%)	3 (15.8%)
<i>Brucellosis</i>	5 (26.3%)	9 (47.4%)	5 (26.3%)
<i>Q-Fever</i>	4 (21.1%)	4 (21%)	11 (57.9%)
<i>Avian influenza</i>	3 (15.8%)	8 (42.1%)	8 (42.1%)

*Not all respondents answered all questions

When questioned about their level of concern about specific zoonoses and their animal sources, a majority of participants were “*very to moderately*” concerned about Hendra virus (HeV) (84.2%; 16/19); leptospirosis (68.4%; 13/19); Australian bat lyssavirus (ABLV) (63.2%; 12/19); and salmonellosis (63.2%; 12/19) (Table 7.3). Participants were also most concerned about acquiring a zoonosis from bats, whether the animals appeared healthy or sick (Healthy (H): 80%; Sick (S): 89.5%); horses (H: 65%; S: 89.5%); reptiles (H: 65%; S: 73.7%); and birds (H: 55%; S: 79%) (Table 7.4).

Table 7.4 – Levels of concerns about animal sources of zoonotic risks, depending on the animal health status, of 20* participants.

Animal source of zoonotic risk	Level of concern					
	Very to moderately concerned		A little concerned		Not at all concerned/ Haven't considered it	
	If animal is healthy (n = 20)	If animal is sick (n = 19)	If animal is healthy (n = 20)	If animal is sick (n = 19)	If animal is healthy (n = 20)	If animal is sick (n = 19)
<i>Bat</i>	16 (80%)	17 (89.5%)	2 (10%)	2 (10.5%)	2 (10%)	0
<i>Horse</i>	13 (65%)	17 (89.5%)	6 (30%)	2 (10.5%)	1 (5%)	0
<i>Reptile</i>	13 (65%)	14 (73.7%)	5 (25%)	4 (21%)	2 (10%)	1 (5.3%)
<i>Bird</i>	11 (55%)	15 (79%)	7 (35%)	3 (15.8%)	2 (10%)	1 (5.3%)
<i>Cat</i>	8 (40%)	9 (47.4%)	7 (35%)	6 (31.6%)	5 (25%)	4 (21%)
<i>Rodent</i>	8 (40%)	10 (52.6%)	9 (45%)	6 (31.6%)	3 (15%)	3 (15.8%)
<i>Cow</i>	7 (35%)	9 (47.4%)	8 (40%)	6 (31.6%)	5 (25%)	4 (21%)
<i>Dog</i>	5 (25%)	6 (31.6%)	11 (55%)	10 (52.6%)	4 (20%)	3 (15.8%)
<i>Amphibian</i>	4 (20%)	6 (31.6%)	3 (15%)	4 (21%)	13 (65%)	9 (47.4%)
<i>Sheep</i>	2 (10%)	5 (26.3%)	12 (60%)	9 (47.4%)	6 (30%)	5 (26.3%)
<i>Goat</i>	1 (5%)	5 (26.3%)	10 (50%)	9 (47.4%)	9 (45%)	5 (26.3%)

*Not all respondents answered all questions.

7.2.3 – Veterinary students’ vaccination history and perceptions about the importance of IC

All participants were vaccinated against Q-fever and all but one participant was vaccinated against tetanus at the time of the survey (Table 7.5). However, vaccination rates were much lower for influenza (35%; 7/20) and rabies (20%; 4/20).

Table 7.5 – Influenza, Q-fever, tetanus and rabies vaccination history of 20 participants.

Vaccination history	Frequencies (relative frequencies)
Influenza	
Yes (up to date)	7 (35%)
Yes (but may be out of date)	3 (15%)
No	10 (50%)
Q-Fever	
Yes (up to date)	20 (100%)
Rabies	
Yes (up to date)	4 (20%)
No	16 (80%)
Tetanus	
Yes (up to date)	19 (95%)
Yes (but may be out of date)	1 (5%)

When asked to rate the importance of various IC measures, the majority of students considered all presented measures as “*very important*” (Table 7.6). Notably, three IC measures were rated as “*very important*” by most students: hand washing (89.4%; 17/19); using personal protective equipment (PPE) (89.4%; 17/19); and putting used sharps in appropriate sharp disposal units (84.2%; 16/19). Slightly fewer students rated following IC best practice principles and restraining animals as importantly as the above mentioned measures (73.7%; 14/19, in both cases).

Table 7.6 – Responses of 20* participants to questions about veterinary infection control procedures as taught and applied during their undergraduate veterinary studies.

Veterinary infection control measures (n = 19)	Very important	Important	Moderately important	Not at all important/ Haven't given it any thought
<i>Hand washing</i>	17 (89.4%)	1 (5.3%)	1 (5.3%)	0
<i>Using personal protective equipment</i>	17 (89.5%)	2 (10.5%)	0	0
<i>Putting sharps in appropriate sharps disposal units</i>	16 (84.2%)	3 (15.8%)	0	0
<i>Restraining animals</i>	14 (73.7%)	5 (26.3%)	0	0
<i>Following infection control best practice principles</i>	14 (73.7%)	3 (15.8%)	2 (10.5%)	0
<i>Disinfection of premises and equipment</i>	13 (68.2%)	3 (15.9%)	3 (15.9%)	0
<i>Cleaning equipment after use</i>	13 (68.2%)	3 (15.9%)	3 (15.9%)	0
<i>Observing food and beverage exclusion zones</i>	11 (57.9%)	5 (26.3%)	3 (15.8%)	0

*Not all respondents answered all questions.

7.2.4 – Veterinary students' experiences of IC at university compared to IC experienced during EMPs

Just over half the participants (52.6%; 10/19) thought the IC training they received during their veterinary undergraduate studies matched the reality they experienced during their EMPs. The majority of participants (79%; 15/19) felt the IC principles taught at university were “*moderately easy*” to apply in a “real world situation”. However, during their EMPs 42.1% (8/19) felt “*moderately to not confident*” using PPE. Most participants (89.5%; 17/19) reported that the veterinary practice they had visited during their last EMP had IC protocols in place. However, 70.6% (12/19) of participants thought these IC protocols were “*less stringent*” than those taught at university, and less than half the participants (42.1%; 8/19) found EMPs “*very useful or useful*” in further developing their IC skills.

Table 7.8– Experiences of 20* participants of veterinary IC procedures as taught at university compared to those experienced during their EMPs.

Question	Frequencies (relative frequencies)
<i>Did the IC[#] education received during your undergraduate veterinary studies match the reality experienced during your EMPs[†]? (n = 19)</i>	
Yes	10 (52.6%)
No	7 (36.9%)
Unsure	2 (10.5%)
<i>How easy was it to apply IC[#] principles learnt during undergraduate veterinary studies to the “real world” of private veterinary practice during EMPs[†]? (n = 19)</i>	
Very easy	4 (21%)
Moderately easy	15 (79%)
Not easy	0
<i>Were there IC[#] protocols in place in the last private veterinary practice you visited on EMP[†]? (n = 19)</i>	
Yes	17 (89.5%)
No	0
Unsure	2 (10.5%)
<i>How did the IC[#] protocols in place in your last EMP[†] compared to those in place during your undergraduate veterinary studies? (n = 17)</i>	
More stringent	0
Similar	5 (29.4%)
Less stringent	12 (70.6%)
<i>How confident were you using PPE[‡] during EMPs[†]? (n = 19)</i>	
Very confident	3 (15.8%)
Confident	8 (42.1%)
Moderately confident	5 (26.3%)
Not confident	3 (15.8%)
Did not use any personal protective equipment	0
<i>How useful did you find EMPs[†] in further developing your veterinary IC[#] skills? (n = 19)</i>	
Very useful	3 (15.8%)
Useful	5 (26.3%)
Somewhat useful	11 (57.9%)

*Not all respondents answered all questions. IC[#]: Infection control; EMPs/EMP[†]: Extramural placement(s); PPE[‡]: Personal protective equipment.

Participants were also asked to elaborate on some of their responses about their IC experiences during their EMPs. The content analysis of the responses to these open-ended questions revealed two main themes: 1) Lack of confidence applying IC principles and/or using PPE; 2) Discrepancies between IC education and the way IC was applied in private veterinary practice.

Lack of confidence applying IC principles and/or using PPE

Some students reported that they lacked confidence using PPE or following IC principles during EMPs. Participants explained that this stemmed from a lack of instructions, or from an environment that did not appear to value IC. As a result some students felt embarrassed to follow best IC practices. For example, one student wrote:

“I felt judged by vets for wanting to use PPE, so I didn’t feel confident...The practice did not consistently use PPE... [they said] they were only doing it because I was a student and didn’t want any feedback to the bosses.”

Discrepancies between IC education and the way IC was applied in private veterinary practice

When asked why they found it difficult to apply IC principles or use PPE during their EMPs, many participants reported that the IC standards during their undergraduate studies were very different from those they experienced in real-life situations in veterinary practices.

One student said:

“The gold standard was not met [in practice] ... lack of hand washing and regular cleaning of tables was not consistent ... lack of goggles and masks for horse dentals was shocking!”

Participants further explained that the IC discrepancies they observed were because some veterinarians and animal owners did not value IC or the use of PPE. Some students added that the use of PPE in private practice was driven not by safety concerns but by cost and in some cases PPE was not available in the veterinary practices. Ultimately, some participants found themselves not following what they knew to be best IC practices, because they wanted to conform to the professional identity portrayed by their mentors. A student summarised the issue by saying:

“It feels as though the previous generation of vets look down upon the new generation wanting to wear PPE or have better practices. The general attitude could be described as a “toughen up” mentality. I believe this is one of the key problems with infection

control...The new players want to fit in so although they know the correct way to go about infection control they are willing to cut corners to be approved by the more senior colleagues.”

7.3- Discussion

Overall, final year veterinary students from James Cook University who took part in the 2013 survey were seemingly able to assess zoonotic risks and potential sources of zoonoses reasonably well. However, becoming infected with a zoonosis was not the risk of greatest concern for some participants, who rated the risks of “*burn out*”, “*receiving an injury from an animal*”, and “*litigation*” more highly. The prioritisation of physical injury risks, over zoonotic risk was also evident amongst the veterinarians who took part in Study 1 (see Chapter 3).²⁷ Furthermore, zoonotic risk perceptions reportedly decrease during the transition from veterinary undergraduate studies to working in private practice.²⁸ Notwithstanding, final year veterinary students were more concerned about zoonoses that could be contracted via contact with horses and bats, such as HeV and ABLV than other zoonoses. Emerging zoonoses, such as HeV and ABLV, occur rarely, but are highly significant for human health and the veterinary profession in particular. Five veterinary personnel and lay assistants were infected with HeV between 1994 and 2009, three of whom subsequently died.²⁹ Furthermore, in 2011, while participants were undertaking their veterinary undergraduate studies, there was a marked increase in HeV outbreaks in Queensland and New South Wales, emphasising the relevance of the HeV-related risks to the veterinary profession.

No veterinarians have so far been infected with ABLV. However, in May 2013, two horses were found infected with ABLV.³⁰⁻³³ These horses died after developing a series of neurological signs including ataxia and seizures.^{31,32} Previously ABLV had, on rare occasions, spilt over into humans, not horses. Although ABLV was always thought to be transmissible to all terrestrial mammals, this had not been confirmed until the 2013 equine outbreak. The confirmation of susceptibility to ABLV of mammals other than humans, represented not only a new domestic animal health issue but also increased its public health and veterinary workplace health and safety significance. Despite this, a very few participants were vaccinated

against rabies which confers cross-protective immunity against ABLV.³⁴ Participants from Studies 3 and 4 reported risk perceptions about ABLV that did not match their risk mitigation strategies about this particular zoonosis. A manuscript reporting this issue has been submitted to the Australian Veterinary Journal (accepted for publication Nov 2015, see manuscript included below).

Participating veterinary students provided responses suggesting they had good knowledge and understanding of IC principles. They noted discrepancies between their undergraduate IC training and their IC experiences during EMPs. Some participants acknowledged they sometimes lowered their IC standards in order to match the standards implemented in the practices they visited. They knew they followed substandard IC measures in order to receive approval from their professional mentors and conform to a professional identity. Similar observations were made with new graduates making professional mistakes early in their career when under poor supervision.³⁵ These observations suggest that the transition between veterinary undergraduate studies and professional life may be the pivotal point at which veterinary IC standards taught at university are altered. This process might also be responsible for the maintenance of a veterinary culture which remains mostly unconcerned about zoonoses and puts little value on IC.²⁷

Although, work placements have been found beneficial to the learning outcomes of students from a range of fields, they have also presented several issues.¹⁻⁷ For example, the role and effectiveness of work placements have been extensively evaluated in the field of nursing.^{4,36-39} Practice based learning has been reported to help nursing students transition from theoretical knowledge to clinical practice by enhancing their professional competence and confidence and forging their professional identity.⁴⁰⁻⁴² However, when a disconnection existed between academic educators, who may be out of touch with practice, and professional mentors, who lack time and space to provide quality teaching in the workplace, the benefits from learning outcomes gleaned from practice may be reduced.⁴³ Conflicting information has led to confusion, loss of confidence, lowering of professional standards and ultimately to what Lambert called “*de-professionalization*” of the field of nursing.⁴⁴⁻⁴⁷ Beyond influencing the quality of learning outcomes, professional mentoring can be a determining factor of

professional standards. The results obtained from Study 4 suggest similar issues exist for veterinary IC standards.

Future veterinarians often are expected to be practice-ready and independent from their first day at work.⁴⁸ In the past, the multifaceted and integrative approach used to train veterinarians was deemed insufficient by both by veterinarians and veterinary students.^{49,50} Furthermore, EMPs were previously shown to have some limitations, including: student exposure to low professional standards; reliance on resource and time poor mentors; variation of training quality between EMPs; and lack of quality assurance.⁵¹⁻⁵³

The training of new veterinarians involves five groups of stakeholders: 1) veterinary academics; 2) veterinary professional peak bodies; 3) regulatory government agencies; 4) veterinary private practitioners; and 5) undergraduate veterinary students.^{8-14,51,54} Veterinary academics and professional peak bodies have the inherent responsibility of delivering quality training that fulfils regulatory requirements relevant to the veterinary profession. In contrast, EMPs in veterinary practice depend on the goodwill of practitioners, who are often time poor and whose training input into undergraduate veterinary studies is seldom acknowledged or subjected to quality control.^{51,52,55-59} The quality of training received by veterinary students during their EMPs is an issue with the potential to undermine the training they receive at university, including IC skills.

Many recommendations have been made in the past with the aim of improving the quality of veterinary training during EMPs:

- Better integration of theoretical and practical knowledge through curriculum development;^{51,60}
- Integrate the notion of veterinary professionalism in the undergraduate curriculum;⁶¹
- Greater consultation/communication between academics and private practitioners who take on students for EMPs on curriculum content and student progress;^{51,54}

- Helping students find EMP mentors that are likely to be positive role models/educators;^{62,63}
- Support and prepare private veterinary practitioners to train students during EMPs;^{10,52}
- Provide a framework for “on the job” training for EMP mentors;⁶⁴
- Greater recognition of EMP mentors;^{50,51} and
- Making students responsible for their own learning by setting themselves learning targets prior to EMPs and thus promote independent learning.^{10,51,54}

In order to improve IC behaviours by future veterinary graduates, veterinary educators from James Cook University are promoting the catch-phrase: “Clean to be seen” (Leo Foyle pers. comm.). To improve early career veterinarians’ experiences and skill development Heath recommended that new graduates consider choosing first employers who were supportive, ethical, have good interpersonal skills, and a high degree of professionalism.⁶⁵ Similarly, the Australian Veterinary Association (AVA) provides recommendations about positive professional mentorship to prospective employers, and a “new graduate friendly practice list” to guide newly graduated veterinarians’ choices.^{65,66} None of the above recommendations or interventions specifically address the acquisition of IC skills during EMPs. In order to evaluate the efficacy of these recommendations/interventions for veterinary IC education, further investigations are necessary. The importance of selecting positive professional role models during EMPs and early career may be an issue that needs to be raised during veterinary undergraduate courses; particularly to ensure the further development of a number of valuable attributes and skills including IC.

However, the quality of early career veterinarians’ IC skills does not lie solely with EMP mentors. Veterinary academics also bear some of the responsibility. Beyond teaching veterinary IC gold standards, the curriculum should integrate a more realistic approach to teaching IC. For example, students should be introduced to the possible limitations of the implementation of veterinary IC in real-life practice: time, cost or peer-pressure. They should also be encouraged to reflect on these issues and develop strategies to overcome them.

A major limitation of Study 4 was that it was a small scale study and thus results may not have been representative of veterinary students across QLD and Australia. Study 4 may have been biased towards students who had particular EMP experiences or towards those who had a higher interest in IC. However, some of the trends observed here concurred with those observed in Studies 1, 2 and 3. Furthermore, the open-ended responses provided by participants in Study 4 gave an insight into the experiences of students during their EMPs and posed the questions about quality control of IC training during these placements.

Publications and outputs for Chapter 7

Findings on rabies vaccination status from Study 4 were combined with results from Study 3 and included in a conference presentation and a peer-reviewed paper (accepted for publication Nov 2015, included below). In addition, an abstract has been accepted for presentation at a conference in May 2016 (see below). I was the lead author of the peer-review paper and both conference presentations. Results from Study 4 were also presented at the James Cook University One Health Research Group (see below). My overall contribution to Study 4 was as follows:

- I designed study 4 in collaboration with my primary supervisor.
- I gained approval from the head of the School of Biomedical and Veterinary Sciences to conduct the survey among final year veterinary students at James Cook University.
- I prepared the ethics application for this study.
- I consulted with colleagues from James Cook University and University of Queensland in order to understand the requirements for extramural placements for veterinary students and the delivery of IC training at the undergraduate level.
- I designed the survey questionnaire with the guidance of my two primary supervisors.
- I liaised and collaborated with a colleague at James Cook University who was involved in the management of extramural placements for final year veterinary students. This colleague facilitated the recruitment of participants via an invitational email to students.
- I supervised a research assistant who formatted and uploaded the online survey.
- I managed the online survey.

- I undertook the descriptive analysis of the quantitative data and the thematic analysis of the qualitative data.
- I was the lead author of the manuscript which was accepted for publication in a peer-reviewed journal (see below).
- I was the lead author and presenter of a conference paper (see below).
- I presented a summary of the results from Study 4 to the One Health Research Group, James Cook University.
- I will be the lead author, and presenter at an upcoming conference in 2016 (see below).

Results from Study 4 are included in the following peer-reviewed publication and conference presentations and presentation abstract:

- **Mendez D**, Foyle L, Cobbold R, Speare R. A survey of rabies vaccination of Queensland veterinarians and veterinary students. *Aust Vet J* (Accepted Nov 2015, in press) (Included below)
- **Mendez D**, Speare R. The new face of Australian bat lyssavirus: a new emerging public health threat. Presentation given at the Queensland Tropical Health Alliance/ Australian College of Tropical Medicine “Tropical Health – Local labs: global impact” conference; 2013 September 7-8, Cairns, Australia (Appendix C5).
- **Mendez D**. Is there a disconnection between veterinary undergraduate infection control training and infection control experiences during extramural professional training? Presentation given to the One Health Research Group, School of Public Health and Tropical Medicine – James Cook University; 2014 February 12; Townsville, Australia (Appendix C4).
- **Mendez D**, Foyle L, Cobbold R, Speare R. Veterinary infection control: a mismatch between university and clinical placements. Abstract accepted for presentation at the Annual Australian Veterinary Association Conference that will be held in Adelaide in May 2016 (Appendix C6).

A survey of rabies vaccination of Queensland veterinarians and veterinary students

Rabies vaccination status of Australian veterinarians and veterinary students.

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Keywords: Australian bat lyssavirus, rabies vaccine, veterinarians, veterinary students, zoonoses, emerging infectious disease

Abbreviations: ABLV *Australian Bat Lyssavirus*, ARIA Accessibility/Remoteness Index of Australia, EID emerging infectious disease, HeV *Hendra virus*, PreEP pre-exposure prophylaxis, PostEP post-exposure prophylaxis, RABV classical rabies virus

Abstract

Objectives

To determine the rabies vaccination status of Queensland veterinarians and veterinary students and their perception of zoonotic risk from Australian bat lyssavirus.

Design

Cross-sectional questionnaire surveys.

Methods

Cross-sectional surveys: 1) veterinary surgeons registered in Queensland (postal survey, 2011); 2) final year veterinary students study 1 (James Cook University 2013) and study 2 (James Cook University and University of Queensland 2014) via Survey Monkey.

Results

Response rate for registered veterinarians was 33.5% and for veterinary students 33.3% and 30% in 2013 and 2014 respectively. Rabies vaccination rate for registered veterinary surgeons was 31.5% (147/466) with 15.5% (72/466) currently vaccinated. For veterinary students the rabies vaccination rate was 20.0% (4/20) and 13.0% (6/46) in the 2013 and 2014 surveys, respectively. More than 95% of veterinary students had received the mandatory Q fever vaccine. Both veterinarians and students regarded bats and horses as high risk species for zoonoses.

Conclusions

Queensland veterinarians and veterinary students have low levels of protection against *Australian Bat Lyssavirus* (ABLV). Although incidents of ABLV spilling over from a bat to a domestic mammal are likely to remain rare, they pose a significant human health and occupational risk given the outcome of infection in humans is high consequence. Principals of veterinary practices and veterinary authorities in Australia should implement a policy of rabies vaccination for clinical staff and veterinary students.

Introduction

Rabies is a low incidence – high consequence pathogen with significant cost implications for preventing disease.¹ To manage the cost-benefit aspects, pre-exposure prophylaxis (PreEP) against classical rabies virus (RABV) is only recommended for individuals and groups at higher than average risk of exposure, mainly those handling bats.^{2,3} Currently 14 *Lyssavirus* species, including RABV, are recognised.⁴ For the lyssaviruses other than RABV, guidelines for pre-exposure vaccination are far less clear.⁵

Australia is considered free of RABV, but has *Australian bat lyssavirus* (ABLV) that produces a disease indistinguishable from rabies. ABLV is an emerging infectious disease (EID), discovered in flying foxes in 1996,⁶ with the earliest case detected in 1995.⁷ Veterinarians are at the frontline of zoonotic EID management and as a profession have important roles to play, including protecting animal owners, handlers and themselves from infection. Three people have died from ABLV, none of them veterinarians.⁸⁻¹¹ In addition a bat carer was identified through serological surveillance as having been infected with ABLV, received rabies vaccination and developed no clinical disease.¹² Two genetic strains of ABLV have been identified; the pteropid strain is found in Australian flying foxes (*Pteropus* spp) and the microchiropteran strain has been isolated from the yellow-bellied sheath tailed bat (*Saccolaimus flaviventris*).¹³ In early 2013 the microchiropteran strain killed two horses through natural spillover. Both presented with neurological signs and viral RNA was found in brain and saliva.¹⁴⁻¹⁶ Dogs and cats can also be experimentally infected.¹⁷ Hence, Australian livestock and companion animals potentially could be a source of ABLV. Proof that ABLV can naturally spillover into domestic mammals is an event of great importance for the veterinary profession in Australia.

ABLV can be neutralised by antibodies against classical rabies virus and rabies vaccine produces active immunity although protection after intracranial inoculation, a severe

challenge, in rodent models, is less than 80%.¹⁸ However, there have been no rabies vaccine failures pre-or post-exposure to ABLV in humans. Rabies vaccination is used in Australia post-exposure for people bitten, scratched or licked by bats and pre-exposure for people at high risk.¹⁹ Rabies immunoglobulin is also recommended for recent exposures. Unvaccinated veterinarians in rabies-endemic regions have contracted and died of rabies while treating animals.^{20,21} Veterinarians in developed countries endemic for rabies have a high uptake of rabies vaccination, but in endemic developing countries rates of rabies vaccination in veterinarians is less owing to the cost of vaccination relative to income.²² As a low incidence – high consequence pathogen, rabies PreEP is challenging when costs are a major issue.¹

Although Australian veterinarians were urged in 1999 by a veterinary clinician to widely adopt pre-exposure vaccination,²³ we hypothesised that the current rate of vaccination was low. We conducted three studies with the aim of determining the rate of rabies vaccination in Queensland veterinarians and final year veterinary students. These were a component of a larger study that assessed zoonotic risk perception and infection control in veterinary practices.

Methods

All studies were cross-sectional surveys using self-reported responses with no verification of vaccination status requested. The questionnaires used for these surveys were based on two studies that investigated: 1) zoonotic risk perceptions and related infection control practices amongst private veterinarians in Queensland,²⁴ and 2) infection control measures implemented for the management of Hendra virus in equine veterinary practices in Queensland.²⁵⁻²⁸

The Studies

Registered veterinarians in Queensland

In 2011 we conducted a postal survey of all registered veterinarians working in private practice in Queensland to investigate their approach to infection control. Eligibility criteria were: 1) being registered with the Veterinary Surgeons Board of Queensland; and 2) working in private practice in Queensland. All eligible veterinarians (1604) were invited to take part in the survey on a voluntary basis between June and September 2011. Respondents could opt out of the study at any time. Participants were required to provide socio-demographic, educational and professional background information. They were also asked about their rabies vaccination status and their level of concern about contracting ABLV while working as a private veterinarian.

Participants' post-codes were categorised into highly accessible, accessible, moderately accessible, remote and very remote areas as per defined by the Accessibility/Remoteness Index of Australia (ARIA).²⁹ The ARIA categories are based upon the road distance between any given Australian location to the closest service centres.

Final year veterinary students

Two surveys were conducted using Survey Monkey.³⁰ Participation in these surveys was on a voluntary basis and participants could withdraw at any time.

Study 1: in December 2013, all final year veterinary students (60) from James Cook University, Queensland, Australia, were invited to participate in an online survey with the aim of identifying their perceptions about veterinary zoonoses-related occupational workplace health risks. Participants were asked demographic background information and three questions explored issues around ABLV. The survey took place after the students had completed all their extramural placements and their final exams.

Study 2: in February 2014, the study was repeated with all final year veterinary students from James Cook University (69) and the University of Queensland (101), Queensland, Australia. In this instance the survey took place before students had completed any of their final year extramural placements or final exams. Although both surveys were of fifth year students, individuals approached were different in each survey.

Analysis

Descriptive and bivariate analysis of categorical data from the 2011 postal survey were obtained using SPSS (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). Participants who were “extremely to moderately concerned”, “a little concerned” or “not at all concerned” about contracting ABLV were compared in regards to their rabies vaccination status at the time of the survey using Chi-square for trend (α level = 0.05). The rabies vaccination status of participants who undertook their undergraduate veterinary studies overseas was compared to that of those who had graduated from their veterinary studies in Australia using Pearson’s Chi-square (α level = 0.05). Data from the online student surveys were collated by and descriptive analysis of categorical data was readily available from the web-based survey provider Survey Monkey (SurveyMonkey Inc. Palo Alto, California, USA).³⁰ Fisher's exact test was used to compare the level of concern between the two student studies (α level = 0.05).

Ethics

Ethics approvals were obtained for all studies from James Cook University Human Ethics Committee: private veterinarians H3687; veterinary students H3386.

Results

Not all participants responded to all questions.

Registered private veterinarians

Response rate was 33.5% (538/1604) with males comprising 42.8% (238/538), 48.7% (261/536) being older than 40 years of age, and working in highly accessible-accessible 66.9% (358/535), moderately accessible 27.1% (145/535) and remote-very remote 16% (32/535) ARIA geographic areas. We found that 50.1% of participants (266/531) (95%-CI=46-55%) were extremely to moderately concerned about contracting ABLV while working as private veterinarians. However, only 31.5% (147/466) (95%-CI= 27-36%) had been vaccinated against rabies at least once in the past; and 15.5% (72/466) (95%-CI=12-19%) considered themselves currently vaccinated. Amongst those who considered themselves up to date with their rabies vaccination at the time of the survey (72/466) there was no significant difference between those “extremely to moderately concerned” (39/72), “a little concerned” (18/72) or “not worried” (15/72) about ABLV ($p=0.473$). Overseas graduates (39/464) were significantly more likely to consider themselves currently vaccinated against ABLV (33.3%) (13/39) compared to Australian graduates (13.6%) (58/425) ($p<0.001$).

Veterinary students

Study 1

Response rate was 33.3% (20/60), comprising 40% males, aged between 22-41 years. More than half of the respondents were very to moderately concerned about becoming infected with ABLV during their future veterinary career (63.2%, 12/19). Only 20.0% (4/20) (exact CI=5.7-43.7%) had been vaccinated against rabies. All students (20/20) were vaccinated against Q-fever. Bats and horses were rated as the species of highest risk for zoonotic infections whether the animals appeared healthy, 80% (16/20) and 65% (13/20), respectively; or the animals appeared ill, 89.5% (18/20) for both species.

Study 2

Response rate was 30% (51/170), comprising 21.6% (11/51) males, aged between 21 and 43 years, with 48% (24/50) studying at JCU. Students who participated in this study had similar levels of concern about contracting ABLV during their future veterinary career to those surveyed in 2013, with 73.9% of them being very to moderately concerned (34/46). Students surveyed in 2014 also had a similar vaccination history with only 13% (6/46) (exact CI=4.9-26.3%) vaccinated against rabies and all considered their status as current. Most (95.6%, 44/46) were vaccinated against Q-fever. They rated horses and bats as the highest risk sources of zoonoses: 86.9% (40/46) and 78.3% (26/46), respectively, if animals appeared healthy; and 91.3% (42/46) and 89.1% (31/46), respectively, if animals appeared ill.

When comparing students from both studies in regards to their level of concern about ABLV, among those who were "very to moderately concerned" there was no significant difference between those who took the survey after their final exam and those who took the survey at the start of their final year of undergraduate studies ($p=0.523$).

Discussion

Although more than half of registered veterinarians and final year veterinary students reported to be "extremely/very to moderately concerned" about contracting ABLV, their rabies vaccination rates were low. This is an important finding which documents a mismatch between risk perception and risk mitigation behaviour in a knowledgeable professional group. Participants in all three surveys were located in Queensland and the results may only reflect the situation in this state. Further research is needed to assess if rates of rabies vaccination and risk perceptions about ABLV amongst private veterinarians and veterinary students are similar in other states across Australia. Response rates for all three studies were low which

may indicate that the modes of delivery of the respective surveys were not suited for these target groups or there was a lack of time or interest for the topics broached in the surveys.

Although numbers in the student surveys were low and may have caused bias, the 0.95 CI gave maximum vaccination rates less than 45%.

The surveys have not provided evidence on why the rabies vaccination rate is so low since these aspects were not explored. Reasons could be a perception that the likelihood of exposure is low; avoiding bats will make the risk negligible; the vaccine is too expensive; the requirements for two year boosters/titre testing is too stringent;³ concerns about adverse effects of the vaccine; or a complacency with the status quo caused by no case of ABLV infection having occurred in an Australian veterinarian. The effect of official requirements for vaccination is illustrated by the high rate of Q fever vaccination in veterinary students. In both universities Q fever vaccination is mandatory for veterinary students and the universities subsidise the cost of vaccination.

A number of guidelines from official government and professional sources recommend that people likely to come into close contact with bats be vaccinated with the rabies vaccine as a preventive measure against ABLV.^{3,31,32} However, there is a lack of similar recommendations and guidelines to prevent potential human exposure to ABLV via contact with mammals other than bats. Furthermore, the Australian Immunisation Handbook recommends pre-exposure prophylaxis for persons likely to be bitten or scratched by bats, including bat carers and veterinarians, but not for veterinarians as a profession.³ AUSVETPLAN makes no recommendations for pre-exposure prophylaxis for veterinarians, except to refer to the Communicable Diseases Network of Australia immunization guidelines.³⁴ A decision by a veterinarian to remain unvaccinated and to avoid contact with bats ignores the possibility of ABLV infecting other domestic and wild mammals.

Although the risk is low, it should not be ignored. The challenges of vaccination for ABLV are typical of low incidence – high consequence pathogens.¹ Rabies pre-exposure vaccination comprising an initial course of three 1 ml intramuscular inoculations (days 0, 7, 14) is expensive (\$100-120/inoculation, not including consultation fee).^{32,33} Cost may be a factor in practice principals and professional organisations' reluctance to recommend veterinarians are routinely vaccinated. Intradermal regimes such as the use of 0.1 ml rabies vaccine in two sites on two occasions (days 0, 7) produce comparable immunity and can make simultaneous vaccination of groups much less expensive.^{2,34}

Veterinarians who have been bitten by a mammalian, non-bat patient with neurological signs might consider that timely use of post-exposure prophylaxis (PostEP) would be sufficient. Limitations of relying on PostEP include: the early clinical signs of lyssavirus infection may be non-specific and the diagnosis of ABLV infection in the animal patient may not be considered; PostEP is indicated for a lick on broken skin, a scratch from a rabid animal or saliva contamination of mucous membranes (Category II exposure), not just a bite; and there is evidence of varying incubation periods and tissue susceptibility between lyssavirus strains which could result in less predictable and effective PostEP than seen in cases of RABV exposure.³⁵ The best prophylaxis against rabies is PreEP and it is 100% effective.³⁶

Another misperception surrounding ABLV is that it is localised to the state of Queensland. Although all human cases of ABLV have occurred in this state and the majority of bats confirmed ABLV positive by the Australian Wildlife Health Surveillance system have been detected in Queensland, bats positive for ABLV have been found in all states and territories.³⁷ Government authorities cautiously stipulate in their information to the public and veterinarians about ABLV that all Australian bats are likely to carry ABLV.³¹

Underestimating a veterinary occupational health risk because spillovers are rare events that have been mostly confined to one geographic area has parallels with the approach to *Hendra virus* (HeV) management pre-2009.³⁸ A 2009-2010 exploratory study of equine veterinarians' perceptions about HeV risk and HeV management showed that pre-2009 low frequency of spill-overs into humans confined to the state of Queensland had contributed to the misconception that HeV was rare and an issue specific to Queensland, despite one horse testing positive for HeV in New South Wales in 2006.²⁵⁻²⁸ HeV first emerged in 1994, spilling over from bats to horses to humans in Queensland, Australia. Although HeV initially killed two people, one of whom was assisting at an equine necropsy, and in 2004 a veterinarian became ill but survived, veterinarians did not implement effective infection control strategies until after 2009 when two equine veterinarians died from HeV acquired at work.^{38,39} Even after these events improvements in infection control in equine practices was slower than required.⁴⁰ Since then governments have developed better HeV management strategies that include providing information and technical support to veterinarians dealing with HeV outbreaks.^{38,41} Although the incidence of reported equine HeV cases has increased greatly, veterinarians have now improved their infection control practices with respect to HeV and no further cases have occurred in the veterinary profession.⁴² Rollout of an equine HeV vaccine is unlikely to decrease the level of infection control practised by equine veterinarians.⁴³ Like ABLV, HeV spillover is rare and sporadic and the veterinary profession and government agencies were slow to react appropriately until veterinarian fatalities had occurred. Will this be the case with ABLV?

In addition to the biological risk of infection with ABLV, owners of veterinary practices face a legal risk from ABLV. It would be difficult to prove that they had fulfilled their duty of care if an employee developed rabies from ABLV, particularly since the risk is known and a higher order mitigation strategy (rabies PreEP) is available.

Conclusion

Although the frequency with which ABLV is likely to spillover from a bat to a domestic mammal and then to a human appears very low, the consequence of infection will be high. It is time that Australian veterinary practices considered implementing a policy of rabies vaccination for their clinical staff. Government, professional authorities, and universities training veterinarians should recommend vaccination against ABLV to all clinical staff and students. Intradermal vaccination protocols should also be considered to improve uptake and reduce cost.

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Conclusion

The aims of this chapter were met in the following manner:

- *Were final year veterinary students able to assess zoonotic risks adequately?*

⇒ Yes. However, other occupational risks such as “injury” and “burnout” were rated more highly than zoonotic risks

- Did final year veterinary students have a sound understanding of infection control principles and priorities?

⇒ Yes. However, their level of concern about Australian bat lyssavirus did not prompt them to become vaccinated against rabies.

- Did final year veterinary students perceive that there was a disconnection between the veterinary infection control standards they were taught at the undergraduate level and the infection control standards experienced during their extramural placements?

⇒ Yes. Some thought infection control standards followed in private practices were lower than those taught at university.

- What was the effect of professional mentorship in the development of infection control practices and behaviours among final year veterinary students?

⇒ Caused some students to lower their infection control standards in order to conform to existing work culture and professional identity.

Despite the recognition by the veterinary profession that IC standards need to improve, there remains a strong veterinary culture that continues to undermine IC through poor professional mentorship of final year veterinary students and early career veterinarians. Positive role models in the field of nursing have been shown to be more effective at promoting improved IC behaviours than additional training or IC equipment.⁶⁷⁻⁶⁹ It is therefore unlikely that veterinary IC standards can be improved by simply modifying undergraduate curriculum. Since professional mentorship of undergraduate students relies on the benevolence of private practitioners, it is difficult to see how universities could affect the quality of IC taught to students during EMPs unless there is a bilateral agreement and the will to improve IC training. Improving IC under the financial, logistical, time and legal constraints inherent in running a private business is a major issue for principal veterinarians and any prescriptive action without consultation would most likely remain ineffective.²⁷ Aside from mandating changes, government agencies and professional peak bodies may also have limited leverage on veterinary IC, which is managed at the private practice level. However, if indeed professional mentorship plays a crucial role in the development of IC attitudes amongst early career veterinarians, this may be the pivotal point at which veterinary IC beliefs and behaviours are established and it could be sustainably and positively influenced. Further investigation into possible interventions at this stage of veterinary IC training is necessary.

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CHAPTER 8 – CONCLUSIONS, RECOMMENDATIONS AND FUTURE DIRECTIONS.

The overarching aim of this thesis was to investigate two main research questions which were answered in the following manner:

1- What are the factors affecting veterinary infection control behaviours amongst private veterinarians in Queensland?

⇒ Some of the factors affecting veterinary infection control (IC) were found to be specific to the management of Hendra virus (HeV): unexpected emergence and pattern of emergence; prior experience managing HeV or other infectious diseases; support from professional organisations; and support from government agencies. Other factors related to a work culture that did not traditionally perceive zoonotic risks to be of great significance, nor did it elicit strong IC habits and behaviours. In addition, perceptions about zoonotic risks (likely frequency of exposure and severity of outcome), education/professional mentoring, cost, time, risk communication, running a private business, leadership in IC at the practice level, and risk communication with clients were also found to affect veterinary infection control.

2- How do these factors affect veterinary infection control behaviours amongst private veterinarians in Queensland?

⇒ The factors that were specific to the HeV crisis highlighted the lack of preparedness of veterinarians, professional organisations and government agencies to respond to the

unexpected emergence of a new zoonosis and emphasised veterinary IC deficiencies. The existing work culture hampered veterinarians' ability to adapt to a new situation requiring new IC approaches. Veterinarians' perceptions of zoonotic risks prompted them to mitigate these risks by using IC measures such as personal protective equipment (PPE) but did not encourage them to use more reliable IC methods such as vaccination against zoonoses, where available. According to many veterinarians, factors related to the running of a private business acted as constraints to achieving high IC standards and complying with health and safety legislations. Leadership in IC is not commonly found at the veterinary practice level, but, when present, it encourages veterinarians to not only use PPE but also to seek vaccination. Undergraduate education about zoonotic risks and IC appeared to be appropriate but risked of being undermined by poor IC professional mentorship of veterinary students and early career veterinarians. This appeared to be one pathway by which poor veterinary IC standards were maintained.

Research Methodology

Most previous investigations into veterinary IC quantified IC choices or outcomes, but offered limited insight into the reasons for the IC behaviours of veterinary staff. Social sciences methodologies have been successfully previously used to study IC behaviours amongst healthcare workers.¹⁻³ In order to understand the drivers of veterinary IC among private veterinarians, a mixed method approach was therefore chosen. These doctoral studies comprised a qualitative study (Study 1) followed by three quantitative studies (Studies 2, 3 and 4). This approach proved valuable in understanding veterinary IC and HeV management behaviours by contextualising them within private veterinary practice. The outcomes of the initial qualitative study concurred with previous reports by government authorities and the veterinary profession on the management of HeV and equine influenza.⁴⁻⁹ These outcomes were further corroborated by the three subsequent quantitative studies (Studies 2, 3 and 4). Triangulation between previous, concurrent and subsequent reports strengthened the overall conclusions of this thesis.¹⁰ Mixed research methodologies were valuable tools and as some authors have indicated more recently, should be more readily used to study the management of emerging zoonoses and areas of veterinary science which are difficult to understand.^{11,12} These

combined research tools are regularly used in public health research and should also gain their place in veterinary public health research.

Management of Hendra virus and other zoonoses

The first study conducted for this doctoral thesis was qualitative and explored the perceived barriers to HeV management and IC in equine veterinary practices in Queensland. The results of this study revealed two types of challenges: those specific to the emergence of HeV and those that were not HeV-specific and therefore were pre-existing and possibly common to the mitigation of other zoonotic risks in veterinary practice.¹³⁻¹⁵ One of the main epidemiological features of the emergence of HeV was its slow pattern.¹⁵ The veterinary profession, professional peak bodies and government agencies were unprepared to respond to such zoonosis and the severity of the risks associated with managing an outbreak were not initially adequately assessed.¹⁵ It took several years from the first outbreak in 1994, to firstly recognize the need for and secondly adopt an adequate HeV management plan at both the government and the veterinary practices level.^{7,16} Since that year the QLD government has addressed many of the early HeV management issues by implementing measures concurrently with or after this research was conducted:

- The Department of Agriculture and Water Resources added HeV to the National List of Notifiable Animal Diseases,¹⁷
- Animal Health Australia included HeV in the Australian veterinary Emergency Plan (AUSVET PLAN),¹⁸
- The Australian Veterinary Association in collaboration with Equine Veterinarians Australia, the Department of Primary Industries QLD and Workplace Health and Safety QLD offered HeV management workshop to private veterinarians,¹⁹
- The Department of Agriculture and Fisheries QLD provided a comprehensive HeV management information package including guidelines to all private veterinarians working in QLD and information to horse owners,²⁰⁻²²
- The Department of Agriculture and Fisheries QLD provided training for their staff who might need to manage HeV outbreaks in the field,²³

- The Department of Agriculture and Fisheries provided on the ground technical support to private veterinarians managing suspected outbreaks, and financial support for the purchase of PPE,²⁴
- Substantial state and federal funding was pledged to accelerate research into HeV, resulting in the boosting of the development of a HeV vaccine for horses,²⁵
- Veterinary Surgeons Board of QLD, the Australian Veterinary Association and Equine Veterinarians Australia also amended their IC codes of practice to reflect the need for improvement in IC standards (Dr. B Pott pers. comm.),
- The Australian Veterinary Association and its affiliates updated their professional code of practice in relation to IC and continued to provide information to its members about HeV management,^{26,27}
- Workplace Health and Safety Queensland provided HeV management information for veterinarians and conducted an audit into HeV management in equine private veterinary practices in QLD in 2010.^{6,28}

Most of these measures were implemented after the last recorded human death from HeV (in 2009); this was an equine veterinarian who had attended a HeV management course.³⁴ Since this occurrence, there have no further human HeV infections, which suggests that these measures contributed to improved HeV management and veterinary staff safety.¹⁶ However, since 2012 HeV outbreaks have been sporadic and the incentive for maintaining certain IC measures in relation to HeV may have waned in some practices.¹⁶ Moreover, some issues remain: the veterinary profession, professional agencies and government authorities were unprepared to deal with such an emerging zoonosis. As more emerging zoonoses can be expected, veterinarians are likely to be faced with more of such diseases in the future,²⁹ lessons should be drawn from the HeV experience. Veterinarians are likely to be faced with more new emerging zoonoses in the future.²⁹ However, emerging zoonoses are unpredictable events. Therefore, in order to increase the responsiveness of private veterinarians and the adequacy of their response to emerging zoonoses, investment into building the capacity of private veterinarians to manage emerging zoonoses is necessary. Principles and strategies required to manage emerging zoonoses, including more stringent IC measures, should be offered to private veterinarians through continuing professional education; these should also be included in the undergraduate veterinary studies curricula. Additionally, zoonoses such as HeV, which have a

low-incidence but high-pathogenicity, may require a different managerial approach than that used for zoonoses that establish in human population in epidemic proportions.³⁰ Government agencies responsible for managing emerging zoonoses should also provide timely and context appropriate support to private veterinarians who are often expected to act on behalf of these authorities while expert support is being dispatched in the field. Furthermore, although a HeV vaccine is now available to protect horses and therefore those who come in contact with them, the necessity for high IC standards for the management of HeV is still current.^{31,32} On the one hand, the uptake of the HeV vaccine is reportedly lower than expected with some detractors of the vaccine trying to gain momentum in the media by securing political support.^{33,34} The focus of this negative publicity is that not all horses are protected and adequate IC measures should still apply when examining any horse. On the other hand, many private veterinarians reported they would not examine unvaccinated horses in the future which may cause issues with animal welfare and may place some members of the community at risk of HeV infection.³⁵ Moreover, veterinarians' workplace health and safety liability when managing a potential HeV outbreak remains under high scrutiny and failure to comply with expected standards could lead to prosecution.^{36,37} Ultimately, beyond the specific HeV management issues experienced by private veterinary practices and their staff, it is the whole of veterinary IC that requires an overhaul. Indeed, the results of Study 1 showed that veterinary IC remained a challenge for many private practices. As private businesses, veterinary practices were under several constraints that affected the implementation of IC: time, logistics, and cost.¹⁵ The results of Study 1 also found four main factors affecting veterinary IC: risk perception, risk communication, work culture and IC education. Some of these were examined in subsequent studies.¹⁵

Veterinary infection control

Study 2, further investigated factors influencing veterinary IC measures that QLD equine veterinarians used during potential HeV outbreaks.^{35,38} In this study, veterinarians who: perceived the risk of exposure to HeV as highly likely; had attended professional education about the management of HeV; worked in a practice with evidence of leadership in HeV management; or had prior experience managing potential HeV outbreaks were more likely to

use more PPE more often. Risk perceptions about HeV depended on: the clinical presentation of horses examined; prior exposure to HeV-related risks; or the perceived likelihood of exposure to these risks. When HeV was initially suspected, the amount and frequency of PPE used, significantly increased if participants had prior experience with HeV management. Having attended a HeV management training session did not affect the amount and frequency of PPE usage in the same circumstances. Similar observations have been made in the medical field where IC education has had limited effect on the adoption of better IC habits amongst healthcare workers.^{39,40} By 2011, the veterinary profession in QLD appeared to have understood the necessity for enhanced IC measures in the management of HeV with a number of veterinarians implementing these measures.³⁸ Veterinarians also reported that the introduction of a vaccine would not undermine their HeV management strategies.³⁵

Results from both study 1 and Study 2 identified challenges faced by veterinarians when communicating information about HeV-related risks to horse owners; at times this resulted in veterinarians working in unsafe conditions, bearing the cost of extra IC measures, risking the loss of business and/or professional reputation, or completely ceasing equine practice.^{13,15,41} The teaching in communication skills with clients is a current component of the undergraduate veterinary curricula. However, communicating with clients about issues surrounding an emerging zoonosis is akin to communicating about an unexpected “crisis” situation and may require a set of communication skills which differ from those necessary for everyday veterinary practice. The specific requirements for the management of emerging zoonoses should be considered in future undergraduate curricula and continuing professional education. Practising skills by roleplaying real-life situations may prepare veterinarians to overcome communication difficulties with clients in times of crisis. This approach has been proposed for the training of medical student in emergency medicine.^{42,43} Furthermore, since managing an existing or emerging zoonosis is a significant public health and occupational health and safety occurrence with attendant legal issues, veterinarians should be encouraged to target their messages to clients around the theme of “human-safety” for all in the veterinary working environment.

Study 3 further investigated the effect on individual IC choices of the role of risk perception about known zoonoses, as well as leadership in IC at the practice level. The IC choices assessed were using a mask when examining horses and birds and seeking immunoprophylaxis against

some infectious diseases including zoonoses.⁴⁴ The results of this study showed that although veterinarians had high levels of concerns about specific zoonoses they did not use masks more frequently when examining horses and birds. Similarly those who were concerned about vaccine preventable zoonoses did not seek immunisation. According to the hierarchy of IC seeking vaccination would be ranked as conferring a much higher degree of control than using a mask.⁴⁵ Therefore, the relationship between risk perception and risk mitigation decision was not proportional and is likely to be more complex as other factors may need to be considered. Alternatively, it may be that zoonotic risk perception has a stronger, more immediate, effect on PPE usage because the time between the risk assessment and the possible exposure to the risk is much shorter and the relationship between the two events is more readily understood by veterinarians.

The decision to seek vaccination against a zoonosis requires recognition of the potential risk at a time when a veterinarian is removed from the actual risk and therefore the risk may not be seen as relevant. This is consistent with the veterinary work culture which traditionally prioritises the mitigation of more commonly encountered risks, such as injury, over zoonotic risks. However, veterinarians reported very high rates of sharps injuries, most commonly needlestick and scalpel injuries. Previous studies that found similar rates of sharps injuries concluded that this reflected poor veterinary IC standards.⁴⁶⁻⁴⁸ Although, sharps injuries in veterinary practice are not without infectious and chemical risks, their significance should be interpreted within the veterinary context. In the medical field infectious agents are readily transmissible from patients to healthcare workers as they both pertain to the same species, while in veterinary practice many infectious substances are not transmissible between animal patients and veterinary staff. Therefore, the rate of sharps injuries may not be the best indicator of IC standards in veterinary practice. Furthermore, while commitment to implementing IC in veterinary practices appeared to encourage veterinarians to use PPE, it did not help decrease the rate of sharps injuries or increase the rates of vaccination against preventable zoonoses among the veterinarians surveyed. This may indicate that some IC choices are the result of individual decisions while others may be influenced by the development of IC policies within practices. Some aspects of veterinary IC may be improved by fostering IC leadership at the practice level. Veterinary leadership has been studied in the past in other areas of veterinary practice but not in relation to IC.^{49,50} Leadership has been recognised as an important skill for veterinarians and leadership training is included in some undergraduate veterinary curricula.⁴⁹

Leadership has been found to more effectively improve IC standards in healthcare settings than additional IC education.⁵¹⁻⁵⁵ Veterinary IC education at the undergraduate and professional levels would benefit from emphasising the importance of leadership in this area of veterinary practice, and existing and future veterinarians should be encouraged to develop specific IC leadership skills.

Findings from Study 4 demonstrated that IC leadership through professional mentoring was another crucial factor affecting veterinary IC, particularly acquisition of IC skills in undergraduate veterinary students. Most undergraduate veterinary curricula requires students to engage in a number of extra mural clinical placements (EMPs).^{56,57} These EMPs rely on the goodwill of private veterinary practitioners who host veterinary students and fulfil the role of clinical educators in a real-life situation. In Study 1, participants remarked that some students were likely to be exposed to substandard veterinary IC practices during their EMPs with having potentially long-term effect on their future outlook and decisions about veterinary IC. Results from Study 4 showed that final year veterinary students also prioritized the mitigation of risks of injury over the mitigation of zoonotic risks. However, most students assessed a number of zoonotic risks adequately and they all rated the need for implementing IC in veterinary practice highly. Yet, their high levels of concern about certain zoonoses, preventable by vaccines, did not translate into higher rates of vaccination against these zoonoses.⁶² This may be another indication that vaccination against preventable zoonoses is an individual choice and that undergraduate veterinary education emphasises the risk of injury more than the risk of acquiring a zoonosis. Some students reported that IC was not seen as a priority in some practices they attended, while others reported that the standards of IC they experienced during their EMPs were, in general, lower than those that they were taught at university. These discrepancies between taught and experienced veterinary IC standards led some students to adopt IC practices they considered to be substandard in order to conform to a professional identity. The transition between undergraduate studies and professional life may be the pivotal point at which veterinary IC standards are lowered and the poor attitude of the veterinary work culture towards IC becomes embeded.

The factors found to affect veterinary IC in these studies should be considered in future policies and programs aiming to improve veterinary IC and the management of zoonoses by private

veterinary practitioners. However, interventions to improve veterinary IC standards for the management of zoonoses should be targeted strategically; i.e., before veterinarians become exposed to zoonotic risks. A private veterinarian's career can be divided into three phases: undergraduate training, early career, mid to late career.

Veterinary infection control: future directions

A programme targeting mid to late career veterinarians to improve IC in practice would equate in some cases to retraining professionals and changing career-long habits. Studies of human health behaviours have demonstrated that this can be a protracted process with some individuals never attaining the sought after new behavioural norm.^{58,59} In this case changes to veterinary IC behaviours would require a shift in the current paradigm of the veterinary work culture.⁴⁹ This could be achieved by providing regular theoretical and practical training and information about IC and zoonotic risks in veterinary practice to existing private veterinarians through continuing professional training. However, unlike IC leadership, additional IC education programs have yielded little IC improvement in the healthcare sector.⁶⁵⁻⁶⁹ The solution may therefore lie in an educational program that combines training in leadership with IC training. Using peer teaching by private veterinarians with field and zoonoses management experience would render such training programs more relevant and context appropriate for those without similar experiences. Veterinary IC improvement programs through professional education would also benefit from greater IC leadership from government and professional agencies. Aside from providing operational support to private veterinarians during zoonotic disease outbreaks, government and professional agencies should encourage IC positive role modelling and IC leadership at the practice level. Conversely, when developing IC recommendations and training programmes government and professional agencies would be more effective if they consulted, communicated and collaborated more closely with the private veterinary workforce. Private veterinarians fulfil key roles in the areas of biosecurity, public health and workplace health and safety. Government and professional agencies should also acknowledge that these roles are subjected to the constraints inherent to running a private business and therefore providing support when relying on a private workforce to manage zoonotic outbreaks in the field. In such circumstances, government agencies and the veterinary

profession should work in partnership to better manage zoonoses and promote the “human safety” priority to all involved in such situations.

Another way to improve the veterinary work culture surrounding zoonotic risk and IC would be to enhance the training of upcoming veterinary graduates in these areas. The content of undergraduate veterinary curricula could include specialised theoretical modules on IC and zoonotic risks and more practical classes on IC practices in the veterinary work environment (including the donning and doffing of PPE). Veterinary IC curricula should also be harmonized nationally to ensure consistency of IC standards throughout the country. However, final year veterinary students in this study had a good base-knowledge of IC principles and therefore this approach, which still relies on educational input, may be of limited benefit. Instead, it may be more valuable to ensure future veterinary graduates retain their IC knowledge and habits as they transition into the workforce. Final year veterinary students’ understanding of their future workplace health and safety responsibility in relation to IC should be emphasized. Future graduates should also be better prepared to face the realities and constraints of work in private practice, including peer pressure to downgrade IC standards, and skilled at problem solving in these situations. While training in conflict resolution to address communication issue with clients is a component of existing Australian veterinary curricula (Dr B. Pott pers. comm.), this training should also address the issues associated with communication about IC issues with work colleagues.

Notwithstanding the above recommendations, if veterinary IC and zoonotic risk knowledge acquired at university is being undermined by early career experiences in private practice, it is crucial to target new veterinary graduates entering the workforce so they to retain the IC knowledge and standards acquired during their undergraduate course. Poor veterinary IC habits appear to develop during the early career of veterinarians due to poor veterinary IC mentorship and/or leadership. To prevent this lowering of IC standards, veterinary academics and professional mentors should collaborate more closely to deliver a more realistic IC training program. In other words, achieve a consensus about ways to teach IC skills in a variety of realistic scenarios such as “*how to implement veterinary IC gold standards on a budget, on a rainy Sunday night, in the darkness of a muddy field, under the watchful eye of a reluctant client*”. Applying IC gold standards in an unrealistic environment where monetary, legal, time

and business reputation costs are not taken into account is ultimately counterproductive. Academics developing veterinary curricula should include an array of non-clinical skills to manage the situation beyond the risk of infection, along with the clinical skills required to manage infectious risks. This could be achieved through roleplay and placing students into real-work-life scenarios to learn how to problem solve all the relevant matters and not just the animal health issues which will remain the focus of their chosen careers.

The improvement of veterinary IC standards in Australia and other countries is a process that will take time. In addition, the intricacies of the relationship between veterinarians' beliefs and perceptions about IC and zoonotic risks and veterinary IC standards needs further elucidation. The outcomes of this doctoral thesis have highlighted a number of future areas of investigation:

- Role of zoonotic risk perception among private veterinarians and its effect on veterinary IC;
- Role of IC leadership in private veterinary practice and its effect on veterinary IC;
- Role of the transition of new veterinary graduates into the workforce and its effect on veterinary IC;
- Development, trialing and evaluation of strategies to address the issues above.

In an era where emerging infectious diseases are increasing and are mostly zoonotic in nature, the role of veterinarians in public health is likely to increase. This increasing role will be more likely if biosecurity and health systems adopt a One Health approach to dealing with animal and human diseases. Unlike medical practitioners, veterinarians are used to managing infectious diseases, including zoonoses, that are common to more than one species of animals, including humans, and are therefore key players in One Health. This should be recognised more widely and the veterinary profession should be involved more closely with biosecurity and public health decisions, policies and management. However, as the saying goes: “*with great knowledge comes great responsibility*”. The veterinary private workforce will need to undergo significant changes to fulfil more biosecurity and public health roles in a sustainable manner for the good of the wider community.

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- APPENDICES -

- APPENDIX A -

Ethics Approvals

Appendix A1:

Ethics Approval No H3513 for Study 1.

This administrative form
has been removed

Appendix A2:

Ethics Approval No H3687 for Studies 2 and 3.

This administrative form
has been removed

Appendix A3:

Ethics Approval No H5386 for Study 4.

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has been removed

- APPENDIX B -

Interview Questions

and

Survey Questionnaires

Appendix B1:

Interview questions for Study 1.



JAMES COOK UNIVERSITY
TOWNSVILLE Queensland 4811 Australia Telephone: (07) 4781 4111

INTERVIEW QUESTIONNAIRE

Improving Infection control in Equine Veterinary Practice

Question 1-

When finding out about Hendra virus related deaths of colleagues, what were your immediate thoughts and concerns?

Question 2-

Did it make you modify the way you practice? If yes, in what way?

Question 3-

Who do you contact when seeking professional advice and support on the topic of Hendra virus and infection control in equine vet practice?

- a- People
- b- Organisations

Question 4-

What does the Workplace Health and Safety Act mean to you in relation to your work?

Question 5-

What do you believe are your responsibilities when attending to a horse?

- a- To other staff
- b- To Owners/ Handlers

Question 6-

What are the main obstacles to the use of infection control in equine vet practice?

- a- Cost
- b- Safety
- c- Practicability
- d- Comfort

Question 7-

What do you think will bring change/make a difference to infection control in equine vet practice?

- a- You
- b- Your practice
- c- Vet profession

Question 8-

Is there anything else you would like to add regarding this topic that we might not have addressed through this interview?

Appendix B2:

Survey questionnaire for Study 2.

Infection control and Hendra virus case management in Queensland equine and mixed veterinary practices					
PLEASE ENSURE THAT YOU READ AND ANSWER ALL THE QUESTIONS ON THIS FORM BY TICKING THE APPROPRIATE BOX ✓ (multiple answers are ok for most questions). THANK YOU VERY MUCH FOR YOUR COOPERATION IN THIS IMPORTANT STUDY TO IMPROVE INFECTION CONTROL IN THE PROFESSION. YOUR REPLY IS VERY IMPORTANT TO US					
Gender <input type="checkbox"/> Female <input type="checkbox"/> Male		Age <input type="checkbox"/> <30 <input type="checkbox"/> 31-40 <input type="checkbox"/> 41-50 <input type="checkbox"/> >50		Post Code:.....	
Veterinary Degree Country [if not from an Australian University]:..... University:..... Year of graduation:.....		Other Qualifications	Country	Year Awarded	
Type of Veterinary work <input type="checkbox"/> Clinical practice <input type="checkbox"/> Non-clinical		Practice type <input type="checkbox"/> Large animals <input type="checkbox"/> Mixed <input type="checkbox"/> Specialist, please specify:.....			
Work Status <input type="checkbox"/> Part time <input type="checkbox"/> Full time <input type="checkbox"/> Locum <input type="checkbox"/> Student <input type="checkbox"/> Retired		Average number of hours worked per week			
Role in practice <input type="checkbox"/> Principal <input type="checkbox"/> Partner <input type="checkbox"/> Employee <input type="checkbox"/> Placement		Number of vets currently employed in your practice Full time..... Part time.....			
Are you a member of any of the following? <input type="checkbox"/> AVA <input type="checkbox"/> EVA <input type="checkbox"/> Other:.....					
Frequency with which you provide veterinary services to horses <input type="checkbox"/> Daily <input type="checkbox"/> Weekly <input type="checkbox"/> Monthly <input type="checkbox"/> Yearly <input type="checkbox"/> Only on call/after hours <input type="checkbox"/> Never <input type="checkbox"/> Have ceased to provide Veterinary services to horses, if so when and why?.....					
Type of equine premises you mostly visit <input type="checkbox"/> Hobby farm(paddock) <input type="checkbox"/> Pony Club/Riding School <input type="checkbox"/> Equine Artificial Insemination Centre <input type="checkbox"/> All of the above <input type="checkbox"/> Farm(paddock) <input type="checkbox"/> Performance horse stables <input type="checkbox"/> Stud					
Do you wear Personal Protective Equipment [PPE] when examining a horse? If animal is healthy <input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Rarely <input type="checkbox"/> Never If animal is sick <input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Rarely <input type="checkbox"/> Never If animal is dead <input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Rarely <input type="checkbox"/> Never If carrying out a necropsy <input type="checkbox"/> Always <input type="checkbox"/> Sometimes <input type="checkbox"/> Rarely <input type="checkbox"/> Never					
What kind of PPE do you wear when examining a horse [Tick all that applies]?					
	If horse is healthy	If horse is sick	If horse is dead	If carrying out a necropsy	If HeV is suspected on a live horse
Overalls	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Gown	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Gumboots/Boot covers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Surgical mask	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Surgical mask with fluid barrier	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Surgical mask with eye shield	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Particulate mask (N95/P2)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Face shield	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Powered air respirator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Goggles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hand gloves	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Arm length gloves	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Apron	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Protective dressings on your skin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
abrasions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other:					
.....					
.....					
.....					

Please return this questionnaire to:
Rick Speare or Diana Mendez
SPHTMRS James Cook University Townsville QLD 4811

Or fax to:
Rick Speare or Diana Mendez
47961767

If asked, would you do a necropsy on a horse that died of the following causes?
 Sickness Accident Sudden unexplained death
 If not, why?.....

What are the most common veterinary procedures you conduct on horses?

<input type="checkbox"/> Dentistry procedure	<input type="checkbox"/> Trephination of sinuses	<input type="checkbox"/> Retained foetal membranes
<input type="checkbox"/> Endoscopy of URT	<input type="checkbox"/> Gaseous anaesthesia	<input type="checkbox"/> Abortion/dead foal
<input type="checkbox"/> Endotracheal intubation	<input type="checkbox"/> Endoscopy of urinary tract	<input type="checkbox"/> Necropsy
<input type="checkbox"/> Thermocautery of soft palate	<input type="checkbox"/> Catheterisation of the bladder	<input type="checkbox"/> Wound management
<input type="checkbox"/> Sampling for pharyngeal biopsy	<input type="checkbox"/> Artificial insemination	<input type="checkbox"/> All of the above
<input type="checkbox"/> Injection of ethmoid haematomas	<input type="checkbox"/> Foaling	

Have you ever considered refusing to attend to a horse for any of the following reasons?

Hendra risk to human health	<input type="checkbox"/> Always	<input type="checkbox"/> More than once	<input type="checkbox"/> Once	<input type="checkbox"/> Never
Litigation risk associated with Hendra	<input type="checkbox"/> Always	<input type="checkbox"/> More than once	<input type="checkbox"/> Once	<input type="checkbox"/> Never
Hendra risk related added cost/time	<input type="checkbox"/> Always	<input type="checkbox"/> More than once	<input type="checkbox"/> Once	<input type="checkbox"/> Never

How would you rate the level of Hendra virus [HeV] related risk to human health when performing the following veterinary procedures on a horse?

Clinical examination of a healthy horse	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Clinical examination of a horse displaying respiratory symptoms	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Clinical examination of a febrile horse	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Clinical examination of a horse displaying neurological symptoms	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Clinical examination of a sick horse displaying symptoms other than the ones mentioned above	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Equine dentistry	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Wound management	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Endoscopy	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Foaling	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Artificial insemination	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Necropsy	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil

How would you rate the level of HeV related risk to human health when exposed to the following equine bodily fluids?

Sweat	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Blood	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Nasal secretions	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Sputum	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Saliva	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Foetal material	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Reproductive tract secretions	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Urine	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Manure	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Any of the above in the form of visible droplets	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil
Any of the above in the form of aerosolised droplets	<input type="checkbox"/> Very high	<input type="checkbox"/> High	<input type="checkbox"/> Moderate	<input type="checkbox"/> Low	<input type="checkbox"/> Nil

In your opinion what are the main barriers to the use of PPE in the field when examining a horse?

<input type="checkbox"/> Heat stress	<input type="checkbox"/> Finding the time to source adequate PPE	<input type="checkbox"/> Reaction of horse to altered appearance
<input type="checkbox"/> Facial hair	<input type="checkbox"/> Time & cost to learn to use specialised PPE	<input type="checkbox"/> Negative perception from the owner
<input type="checkbox"/> Practicability	<input type="checkbox"/> Added cost due to infection control [IC]	<input type="checkbox"/> Negative perception from non-PPE user colleagues
<input type="checkbox"/> Comfort	<input type="checkbox"/> Time & cost to maintain specialised PPE	<input type="checkbox"/> Increased time of consultation due to IC
<input type="checkbox"/> Gauging when PPE needed		
<input type="checkbox"/> Other, please specify:.....		

How could some PPE you use be improved?
.....
.....
.....

Does your practice have a HeV management response plan? Yes No Don't know

Does your HeV management response plan include?
 A copy of official set of guidelines for veterinarians handling horses potentially infected with HeV.
If yes, please specify source of guidelines:.....
 Set of specific policies/standard procedures Dedicated field kit (with appropriate PPE)
 Risk assessment management plan Record of field kit maintenance
 Phone triage system Record of specific staff training (IC & PPE)
 Fact sheet about Hendra virus for horse owners Case reporting system
 Fact sheet about flying foxes for horse owners Occupational incident reporting system

Type of HeV field kit used in your practice <input type="checkbox"/> Don't have one <input type="checkbox"/> Kit put together in house <input type="checkbox"/> Commercial kit, please specify brand:	Do you think your HeV kit is complete? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Never used it <input type="checkbox"/> Don't have one If no, how could it be improved?
---	---

What does your HeV field kit include?
 Don't have one Hat Diagnostic sample packaging
 Never looked at it Gumboots/ Boot covers Portable sharps disposable unit
 Surgical masks [SM] Reusable overalls Protective dressing for skin abrasions
 SM with fluid barrier Disposable overalls Biological disposable bags
 SM with eye shield Disposable gloves Hand disinfecting solution
 Face masks Cut resistant glove liners Equipment disinfecting solution
 Powered air respirator Change of clothing Other, please specify:
 Goggles Diagnostic sample equipment

How often do you check the content of your HeV field kit for maintenance?
 Weekly Monthly 6 monthly Yearly Never if not used Don't have one

Does your practice have an isolation stable or yard? Yes No Don't know

How would you rate your experience with diagnostic testing for HeV?
 Excellent Good Difficult Poor

Why?
 Technical sampling difficulties Finding a testing laboratory Getting timely results
 Finding a courier to dispatch samples Acceptance of cost by client Other tests put on hold until HeV is excluded
 Other, please specify:
.....
.....

Do you educate your clients on the risks and management of potential cases of HeV?

If animal is healthy	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Rarely	<input type="checkbox"/> Never
If animal is sick	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Rarely	<input type="checkbox"/> Never
If animal is dead	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Rarely	<input type="checkbox"/> Never
If assisting with a horse necropsy	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Rarely	<input type="checkbox"/> Never

When do you instruct lay assistants on their risk of potential exposure to HeV?

If animal is healthy	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Rarely	<input type="checkbox"/> Never
If animal is sick	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Rarely	<input type="checkbox"/> Never
If animal is dead	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Rarely	<input type="checkbox"/> Never
If assisting with a horse necropsy	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Rarely	<input type="checkbox"/> Never

What is their reaction upon receiving such instructions?
.....
.....
.....

When do you ask lay assistants to use PPE to minimise their risk of potential exposure to HeV?				
If animal is healthy	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Rarely	<input type="checkbox"/> Never
If animal is sick	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Rarely	<input type="checkbox"/> Never
If animal is dead	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Rarely	<input type="checkbox"/> Never
If assisting with a horse necropsy	<input type="checkbox"/> Always	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Rarely	<input type="checkbox"/> Never
What is their reaction upon receiving such instructions?				
.....				
Does your practice have the following facilities in the area where equine patients are examined?				
<input type="checkbox"/> Hand washing dedicated station	<input type="checkbox"/> Quarantine isolation stable			
<input type="checkbox"/> Equipment washing dedicated station	<input type="checkbox"/> Biological waste disposal unit(s)			
<input type="checkbox"/> A food & beverage exclusion zone	<input type="checkbox"/> Sharps disposal unit(s)			
<input type="checkbox"/> Separate fridges for food & drugs/diagnostic specimen	<input type="checkbox"/> Sterilisation station [Autoclave]			
Have you attended any training session about the risks and management of HeV in the past 12 months? <input type="checkbox"/> Yes <input type="checkbox"/> No				
If yes, please specify training provider and numbers of training hours:.....				
Have you ever had to deal with a potential case of HeV? <input type="checkbox"/> Yes <input type="checkbox"/> No				
If yes how would you rate the following aspects of this experience				
Client response	<input type="checkbox"/> Excellent	<input type="checkbox"/> Good	<input type="checkbox"/> Difficult	<input type="checkbox"/> Poor
Financial aspect	<input type="checkbox"/> Excellent	<input type="checkbox"/> Good	<input type="checkbox"/> Difficult	<input type="checkbox"/> Poor
Support from relevant authorities	<input type="checkbox"/> Excellent	<input type="checkbox"/> Good	<input type="checkbox"/> Difficult	<input type="checkbox"/> Poor
Interfacing with testing laboratories	<input type="checkbox"/> Excellent	<input type="checkbox"/> Good	<input type="checkbox"/> Difficult	<input type="checkbox"/> Poor
Staff response	<input type="checkbox"/> Excellent	<input type="checkbox"/> Good	<input type="checkbox"/> Difficult	<input type="checkbox"/> Poor
Media response	<input type="checkbox"/> Excellent	<input type="checkbox"/> Good	<input type="checkbox"/> Difficult	<input type="checkbox"/> Poor <input type="checkbox"/> Not involved
Additional comment:				
.....				
If a HeV vaccine for horses were available, would you?				
<input type="checkbox"/> Still consider HeV a high risk for equine practice	<input type="checkbox"/> No longer consider HeV a high risk for equine practice			
<input type="checkbox"/> Require all horses you examine to be vaccinated	<input type="checkbox"/> Terminate your HeV risk management plan & procedures			
<input type="checkbox"/> Return to equine practice if you had stopped because of HeV	<input type="checkbox"/> Be less concerned about implementing IC			
In your opinion, how can infection control in equine veterinary practice be improved?				
In the short term:				
.....				
.....				
.....				
In the long term:				
.....				
.....				
.....				
Are there any other comments you wish to add on the subject of infection control in equine veterinary practice?				
.....				
.....				
.....				

Thanks for your time!

Appendix B3:

Survey questionnaire for Study 3.

Managing infection control in Queensland veterinary practices			
PLEASE ENSURE THAT YOU READ AND ANSWER ALL THE QUESTIONS ON THIS FORM BY TICKING THE APPROPRIATE BOX ✓ (multiple answers are ok for most questions). THANK YOU VERY MUCH FOR YOUR COOPERATION IN THIS IMPORTANT STUDY TO IMPROVE INFECTION CONTROL IN THE PROFESSION.			
YOUR REPLY IS VERY IMPORTANT TO US			
Gender <input type="checkbox"/> Female <input type="checkbox"/> Male		Age <input type="checkbox"/> <30 <input type="checkbox"/> 31-40 <input type="checkbox"/> 41-50 <input type="checkbox"/> >50	
Veterinary Degree Country [if not from an Australian University]:..... University:..... Year of graduation:.....		Other Qualifications	Country
Type of Veterinary work <input type="checkbox"/> Clinical practice <input type="checkbox"/> Non-clinical		Practice type <input type="checkbox"/> Small animals <input type="checkbox"/> Large animals <input type="checkbox"/> Mixed <input type="checkbox"/> Zoo/Wildlife rehabilitation centre <input type="checkbox"/> Specialist, please specify:.....	
Work Status <input type="checkbox"/> Part time <input type="checkbox"/> Full time <input type="checkbox"/> Locum <input type="checkbox"/> Student <input type="checkbox"/> Retired		Average number of hours worked per week	
Role in practice <input type="checkbox"/> Principal <input type="checkbox"/> Partner <input type="checkbox"/> Employee <input type="checkbox"/> Placement		Number of vets currently employed in your practice Full time..... Part time.....	
Are you a member of any of the following? <input type="checkbox"/> AVA <input type="checkbox"/> EVA <input type="checkbox"/> Other:.....		Have you attended an AVA/EVA infection control workshop in the past 12 months? <input type="checkbox"/> Yes <input type="checkbox"/> No	
Does your veterinary practice have? <input type="checkbox"/> An infection control committee <input type="checkbox"/> Infection control precautionary standards <input type="checkbox"/> None of the above <input type="checkbox"/> Infection control set of policies <input type="checkbox"/> A staff member overseeing infection control within the practice <input type="checkbox"/> Don't know			
Have you sustained a needlestick or sharps injury(s) in the past 12 months? <input type="checkbox"/> Not Applicable			
Syringe <input type="checkbox"/> Clean <input type="checkbox"/> Used		Scissors <input type="checkbox"/> Clean <input type="checkbox"/> Used	
Scalpel <input type="checkbox"/> Clean <input type="checkbox"/> Used		Ampoule/vial <input type="checkbox"/> Clean <input type="checkbox"/> Used	
Suture needle <input type="checkbox"/> Clean <input type="checkbox"/> Used		Other: <input type="checkbox"/> Clean <input type="checkbox"/> Used	
Have you contracted any zoonotic disease in your career? <input type="checkbox"/> No <input type="checkbox"/> Yes, please specify disease(s) & from which type of animal		Have you contracted any zoonotic disease in the past 12 months? <input type="checkbox"/> No <input type="checkbox"/> Yes, please specify disease(s) & from which type of animal	
How often do you wear a mask and/or goggles when examining horses of any kind (dead or alive)?			
If horse is alive <input type="checkbox"/> Never <input type="checkbox"/> Sometimes <input type="checkbox"/> Almost always/Always <input type="checkbox"/> I never examine horses		If horse is dead <input type="checkbox"/> Never <input type="checkbox"/> Sometimes <input type="checkbox"/> Almost always/Always <input type="checkbox"/> I never examine horses	
How often do you wear a mask and/or goggles when examining birds of any kind (dead or alive)?			
If bird is alive <input type="checkbox"/> Never <input type="checkbox"/> Sometimes <input type="checkbox"/> Almost always/Always <input type="checkbox"/> I never examine birds		If bird is dead <input type="checkbox"/> Never <input type="checkbox"/> Sometimes <input type="checkbox"/> Almost always/Always <input type="checkbox"/> I never examine birds	
Have you been vaccinated against the following diseases?			
<input type="checkbox"/> Rabies (ever) <input type="checkbox"/> Rabies (currently up to date)		<input type="checkbox"/> Influenza (ever) <input type="checkbox"/> Influenza (Currently up to date)	
		<input type="checkbox"/> Swine flu <input type="checkbox"/> Q-fever (ever)	
How concerned are you about the following diseases in veterinary practice?			
Bat lyssavirus	<input type="checkbox"/> Not at all	<input type="checkbox"/> A little	<input type="checkbox"/> Moderately <input type="checkbox"/> Extremely worried
Hendra virus	<input type="checkbox"/> Not at all	<input type="checkbox"/> A little	<input type="checkbox"/> Moderately <input type="checkbox"/> Extremely worried
Avian influenza	<input type="checkbox"/> Not at all	<input type="checkbox"/> A little	<input type="checkbox"/> Moderately <input type="checkbox"/> Extremely worried
Q-fever	<input type="checkbox"/> Not at all	<input type="checkbox"/> A little	<input type="checkbox"/> Moderately <input type="checkbox"/> Extremely worried
Are you concerned by other zoonotic diseases in the veterinary environment? <input type="checkbox"/> Yes <input type="checkbox"/> No			
If yes, please specify zoonose(s) and from which type of animal			
.....			
.....			

Please return this questionnaire to:
Rick Speare or Diana Mendez
SPHTMRS James Cook University Townsville QLD 4811

Or fax to:
Rick Speare or Diana Mendez
47961767

Does your practice have particulate masks (N95/P2) readily available for use? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Don't know	
Are you aware of the obligations of the principal veterinarian/owner of your practice towards staff, trainees & clients under the Queensland Workplace Health and Safety [QWHS] Act1995? <input type="checkbox"/> Yes <input type="checkbox"/> No	
What is the level of compliance of your practice with the QWHS Act 1995? <input type="checkbox"/> Excellent <input type="checkbox"/> Good <input type="checkbox"/> Could be improved <input type="checkbox"/> Poor <input type="checkbox"/> Non-existent <input type="checkbox"/> Don't know	
Are you aware that under section 29 of the QWHS Act 1995 there is a term of reference called "Discharge of obligation"? <input type="checkbox"/> Yes <input type="checkbox"/> No	
The above mentioned "Discharge of obligations" refers to the provision by the principal veterinarian/owner of the practice of the following items (see list below). With which of these items does your practice comply? <input type="checkbox"/> Information to ensure occupational health & safety <input type="checkbox"/> Training to ensure occupational health & safety <input type="checkbox"/> Don't know <input type="checkbox"/> Instruction to ensure occupational health & safety <input type="checkbox"/> Supervision to ensure occupational health & safety	
Is compliance with the above mentioned items documented within your veterinary practice? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Don't know If yes, how so?..... if no, would you like to receive more information on WHS requirements in Veterinary practice? <input type="checkbox"/> Yes <input type="checkbox"/> No	
In your opinion what are the main barriers to compliance with the QWHS Act 1995? <input type="checkbox"/> Logistics of implementation <input type="checkbox"/> Lack of control over clients actions <input type="checkbox"/> Financial cost of implementation <input type="checkbox"/> Applying the QWHS Act 1995 to the veterinary environment <input type="checkbox"/> Time cost of implementation <input type="checkbox"/> Full compliance does not guarantee protection from litigation <input type="checkbox"/> Lack of control over staff actions <input type="checkbox"/> Other, please specify:.....	
Have you been audited by QWHS in the past 12 months? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Don't know	
How would you rate this auditing experience? <input type="checkbox"/> Excellent <input type="checkbox"/> Good <input type="checkbox"/> Difficult <input type="checkbox"/> Poor <input type="checkbox"/> N/A	How helpful was the audit process to your practice? <input type="checkbox"/> Very helpful <input type="checkbox"/> Moderately helpful <input type="checkbox"/> A little helpful <input type="checkbox"/> Not helpful <input type="checkbox"/> N/A
After the QWHS audit, did you make any changes to the following? <input type="checkbox"/> Use of PPE <input type="checkbox"/> Policies/Processes <input type="checkbox"/> No changes <input type="checkbox"/> Premises <input type="checkbox"/> Record keeping <input type="checkbox"/> N/A <input type="checkbox"/> Equipment <input type="checkbox"/> Infection control standards <input type="checkbox"/> Other, please specify:.....	
How would you rate the understanding of the veterinary work environment by QWHS officers? <input type="checkbox"/> Excellent <input type="checkbox"/> Good <input type="checkbox"/> Could be improved <input type="checkbox"/> Poor <input type="checkbox"/> Non-existent <input type="checkbox"/> Don't know	
Are you aware of the range of penalties you or your veterinary practice would incur for non-compliance with the QWHS Act 1995? <input type="checkbox"/> Yes <input type="checkbox"/> No	
Would you or your practice like to receive support from a QWHS small business adviser in order to improve your level of infection control? <input type="checkbox"/> Yes <input type="checkbox"/> No If not why?	
Would you or your practice like to receive support from a QWHS small business adviser in order to improve your level of compliance with the QWHS Act 1995? <input type="checkbox"/> Yes <input type="checkbox"/> No If not why?	
Would you or your practice prefer to receive support from another advisory source? <input type="checkbox"/> Yes <input type="checkbox"/> No If yes, please specify:.....	
Do you have any other comments about infection control and workplace health and safety in the veterinary practice?	

Thanks for your time!

Appendix B4:

Survey questionnaire for Study 4.

Final year veterinary students' perceptions of zoonotic risks and their infection control training.

- *Online Survey Questionnaire* -

You are about to take part in an online survey as part of a research project conducted by a collaborating team of researchers from James Cook University and the University of Queensland.

Project title: "Exploring final year veterinary students' perceptions of zoonotic risks and their infection control training"

This survey should only take 15 minutes to complete.

By ticking the box below, you acknowledge that you have read the information provided about this study and agree to participate in the said study.

(You will not be able to proceed to the survey if this box is not ticked.) (1)

Thank you for your participation!

Q1 Gender:

- Male (1)
- Female (2)

Q2 Age:

- 17 (1)
- 18 (2)
- 19 (3)
- 20 (4)
- 21 (5)
- 22 (6)
- 23 (7)
- 24 (8)
- 25 (9)
- 26 (10)
- 27 (11)
- 28 (12)
- 29 (13)
- 30+ (14)

Q3 I am a 5th year veterinary student at:

- James Cook University (1)

Q4 Before starting your veterinary degree at University did you have any experience with the following animals? (Please tick as many as applicable.)

- Domestic pets (1)
 Wildlife animals (2)
 Farm animals (including horses) (3)

Q5 Prior to commencing your veterinary degree, did you have any other tertiary qualifications? (Please tick where applies.)

- Yes (1)
 No (2)

Q6 If yes, please give the name of your qualification(s)

Q7 Please indicate in the table below your placement history during the last year of your veterinary degree: (Use one line for each placement.)

	What type of placement did you do? (e.g. farm; large animal, mixed or small animal private veterinary clinic; zoo/wildlife sanctuaries; laboratory) (1)	Where did you do your placement? (Please indicate State or OS if placement was done overseas.) (2)	How long was your placement? (Please indicate in days or weeks, e.g. 4 weeks) (3)	How many veterinarians did you work directly with during your placement? (e.g. 2) (4)
Placement 1 (1)				
Placement 2 (2)				
Placement 3 (3)				
Placement 4 (4)				
Placement 5 (5)				
Placement 6 (6)				
Placement 7 (7)				
Placement 8 (8)				
Placement 9 (9)				
Placement 10 (10)				

Q8 Do you intend to work in private veterinary practice when you graduate?(Please tick where applies.)

- Yes (1)
- No (2)
- Undecided (3)

Q9 Have you been vaccinated against any of the following diseases?(Please tick as many as applicable.)

	Yes (I have been vaccinated, but it may be out of date) (1)	Yes (my vaccination status is up to date) (2)	Unsure (3)	No (4)
Influenza (recommended yearly vaccine) (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Q -Fever (recommended only once) (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rabies (recommended 2nd yearly/protective titre) (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tetanus (recommended every 10 years) (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify): (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q10 Thinking of your future career as a private veterinarian, how concerned are you about being affected by the following occupational risks?(Please tick where applies.)

	Very (1)	Moderately (2)	A little (3)	Not at all/Haven't given it any thought (4)
Burnout (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Chemical intoxication (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Infection from exposure to an animal (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Infection from exposure to another human (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Injury caused by animal (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Injury caused by using equipment (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Litigation (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Road accident (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sharps injury (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify): (10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q11 Thinking of your future career as a private veterinarian, how concerned are you about contracting an infectious disease from the following animals *in general*? (Please tick where applies.)

	Very (1)	Moderately (2)	A little (3)	Not at all/Haven't given it any thought (4)
Amphibian (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bat (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bird (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cat (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cow (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Dog (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Goat (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Horse (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reptile (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rodent (10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sheep (11)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q12 Thinking of your future career as a private veterinarian, how concerned are you about contracting an infectious disease from the following animals *if the animal appears ill*? (Please tick where applies.)

	Very (1)	Moderately (2)	A little (3)	Not at all/Haven't given it any thought (4)
Amphibian (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bat (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bird (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cat (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cow (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Dog (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Goat (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Horse (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reptile (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Rodent (10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sheep (11)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q13 Thinking of your future career as a private veterinarian, how concerned are you about contracting any of the infectious disease listed below?(Please tick where applies.)

	Very (1)	Moderately (2)	A little (3)	Not at all/Haven't given it any thought (4)
Avian influenza (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bat Lyssavirus (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Brucellosis (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Dermatophytosis (ringworm) (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hendra virus (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Leptospirosis (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Methicillin-resistant Staphylococcus aureus (MRSA) (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Pasteurellosis (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Psittacosis (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Q Fever (10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Salmonellosis (11)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Toxoplasmosis (12)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify): (13)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q14 How would you rate the following veterinary standard procedures?(Please tick where applies.)

	Very important (1)	Important (2)	Moderately important (3)	Not at all important/ Haven't given it any thought (4)
Cleaning equipment after use (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Disinfection of premises and equipment (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Following infection control best practice principles (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hand washing (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Observing food and beverage exclusion zones (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Putting sharps in appropriate sharp disposal units (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Restraining animals (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Using personal protective equipment (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify): (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q15 Thinking of your last placement in private veterinary practice, how confident did you feel using personal protective equipment?(Please tick where applies.)

- Very confident (1)
- Confident (2)
- Moderately confident (3)
- Not confident (4)
- Did not use any personal protective equipment (5)

Q16 Please give further details to explain your response:

Q17 Thinking of your last placement in private veterinary practice, did the infection control education you received during your veterinary undergraduate studies match the reality you experienced during this placement?(Please tick where applies.)

- Yes (1)
- No (2)
- Not sure (3)

Q18 Please give further details to explain your response:

Q19 Thinking of your latest placement in private veterinary practice, how easy was it to apply the principles of infection control you learned during your undergraduate veterinary studies to the “real world” of private veterinary practice during this placement?(Please tick where applies.)

- Very easy (1)
- Moderately easy (2)
- Not easy (3)

Q20 Please give further details to explain your response:

Q20 Thinking of your latest placement in private veterinary practice, were there infection control protocols in place in the practice you visited?(Please tick where applies.)

- Yes (1)
- No (2)

Q21 If yes, how did these infection control protocols compare to those you experienced during your undergraduate studies at University?(Please tick where applies.)

- More stringent (1)
- Similar (2)
- Less stringent (3)

Q22 Thinking of all the placements you did in private veterinary practice, how useful did you find these experiences in developing the following veterinary skills?(Please tick where applies.)

	Very useful (1)	Useful (2)	Somewhat Useful (3)	Useless (4)
Animal handling (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Communication with clients (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Communication with colleagues (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Compliance with workplace health and safety (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Following infection control procedures (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Personal infectious disease prevention (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Personal injury prevention (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Use of personal protective equipment (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other (please specify): (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q23 Would you like to add any comments in relation to your placements in private veterinary practices?

Thank you for taking part in this survey.

- APPENDIX C -
Non-Peer Reviewed
Additional Outputs
of
Doctoral Studies

Appendix C1:

Draft of research methodology case study published in **Büttner P, Muller R. *Epidemiology*. 2nd ed. Melbourne: Oxford Press; 2015.**

CASE STUDY: Identifying and understanding the factors affecting infection control and Hendra virus management in private veterinary practices in Queensland, Australia.

Diana Mendez, PhD candidate, Public Health, James Cook University.

I hold a BVSc equivalent (Ecole Nationale Vétérinaire de Nantes, France), a MPH (JCU), and am currently undertaking doctoral studies in veterinary infection control (IC). The first outbreak of Hendra virus (HeV), a zoonosis transmitted from bats to horses (mortality rate 75%) and in some cases from horses to humans (mortality rate 57%), occurred in Australia in 1994. Since then, seven people have been infected with HeV and only three have survived. All infected people were involved with either the horse or veterinary industries (a horse trainer, a stable hand, a lay person assisting a veterinarian during a necropsy, three veterinarians and a veterinary nurse). The emergence of HeV has highlighted deficiencies in IC standards amongst the Australian private veterinary workforce despite being at higher occupational risk of exposure to zoonoses, infectious diseases transmissible between vertebrate animals and humans. Previous studies have shown that veterinary IC is less than optimal in Australia but did not explain IC behaviours amongst veterinarians. Quantifying behaviours gives little insight into the motivations behind these behaviours and one can only speculate on what these may be. Social and health behaviours have long been studied qualitatively; a methodology well established and accepted in these fields but seldom used in veterinary sciences. Between 2009 and 2010 my colleagues and I took the novel approach of conducting an exploratory qualitative study to identify and understand the factors influencing IC behaviours and HeV management in private veterinary practices in Queensland, Australia.

This study consisted of a series of face-to-face in depth interviews with 18 private equine veterinarians and 3 allied staff (two veterinary nurses and one practice manager). Participants were recruited from 14 different private practices located in urban, rural and remote areas in the known distribution range of HeV between Far North and South East Queensland (2009-10). The majority of participants had dealt with at least one potential HeV outbreak. Participants were asked a number of open ended questions on the topics of HeV and its management, IC and workplace health and safety. The thematic analysis of the data revealed that participants agreed with the need for veterinary IC and HeV management improvements. However, they also agreed that bringing these changes had been and remained challenging for a range of reasons: low HeV-related risk perception when disease first emerged prompted little action from the profession and government authorities; insufficient and uneven government support to private veterinarians across the affected region; recurrent underestimation of the occupational importance of zoonoses within the veterinary work culture; time and financial cost of implementing new IC measures as well as fulfilling biosecurity and public health roles while running a private business; and risk and safety communication challenges between government authorities, veterinary staff and clients. Behaviour changes were more likely to occur when HeV-risk was adequately perceived; participants had a personal interest in IC and zoonoses; participants had previously dealt with confirmed cases of HeV or other zoonoses (such as equine influenza (EI)).

Qualitative research proved to be a valuable approach to understanding veterinary IC control and HeV management behaviours by putting them into the context of private equine veterinary practice. The outcomes of this qualitative exploratory study concurred with other reports on the management of HeV and EI by government authorities and the veterinary profession; and the results from three

quantitative follow up studies. Triangulation between previous, concurrent and subsequent reports strengthened the overall conclusion: slow emerging zoonoses may need a different management approach than rapidly emerging ones and the private veterinary workforce needs to be better prepared, supported and consulted with if expected to fulfil a public health and biosecurity role when new zoonoses emerge.

Interestingly enough, publishing these qualitative results proved to be a challenge because: 1) most target veterinary journals were unfamiliar with the methodology used and reviewers criticised manuscripts on quantitative basis only; and 2) public health journals which publish qualitative research more readily saw the issues presented as only relevant to the veterinary field despite the public health role of private veterinarians dealing with a HeV outbreak. Nevertheless, patience, persistence and the provision of informative responses to reviewers eventually yielded 3 publications in traditionally quantitatively oriented journals and a poster presentation at an Australian conference on Zoonoses. Christley et al. have since highlighted that qualitative research could be a valuable tool in hard to understand areas of Veterinary sciences. It is a tool regularly used in public health research and should also gain its place in veterinary public health research.

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Mendez D, Miller K, Judd J, Speare R. Risk communication between veterinarians and horse owners: a key factor in the management of Hendra virus. In *Online Proceedings of Australian Society for Infectious Diseases, Zoonoses Conference.* Sydney: 2012. www.asid.net.au/documents/item/202

Christley R, Perkins E. Researching hard to reach areas of knowledge: qualitative research in veterinary science. *Equine Vet J.* 2010, 42(4):285-286.

Appendix C2:

Speare R, Mendez D, Judd J, Cox J. **Challenges to infection control implementation in equine practices in Queensland: preliminary results from consultation with coastal veterinarians in Queensland.** In: Department of Employment, Economic Development and Innovation, Queensland Government. Addressing barriers to veterinary infection control – workshop. Report. Brisbane: Department of Employment, Economic Development and Innovation; 2010. (Study 1).

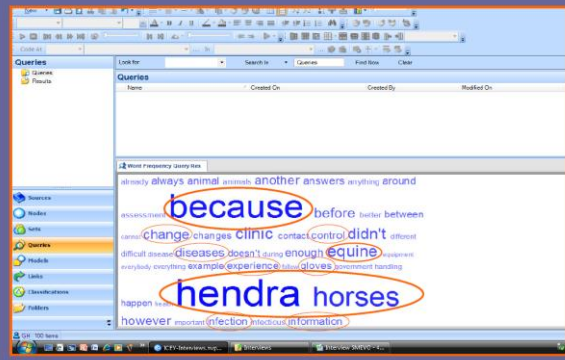
Challenges to infection control implementation in equine veterinary practices in Queensland

Preliminary results from consultation with coastal veterinarians in Queensland
Richard Speare, Diana Mendez, Jenni Judd & Jen Cox

Anton Breinl Centre for Public Health and Tropical Medicine



Townsville
25th August 2010



Background

- Vets are largely evidence based
- Use risk assessment
- Why were markers of infection control practice so poor?
 - Sharps injuries (75%/yr – Leggat et al 2008)
 - Mask use in high risk situations (2%)
- Why were equine vets being infected with HeV?

HeV is to the vet profession as SARS was to human health care



30% were Healthcare workers!

Muller et al 2004

Wake-up call!
Driver for change!

Alignment of Infection Control and WHS requirements

- Practical strategies to prevent nosocomial disease transmission in veterinary practice
- WHS requirements to reduce risks
- Do they align?
- Are some WHS requirements providing no advantage to reduce IC risks and adding unnecessary burdens to practitioners?

Main Strategies

- In-depth interviews with Queensland veterinarians and allied veterinary staff [Dec 2009- Sept 2010: 18/20]*
- Survey of all registered veterinary surgeons in Queensland [Sept 2010]
- Focus groups with final year veterinary students from JCU and UQ, and veterinary nurse students from Ithaca (QLD) TAFE [Oct 2010]

Results from the first 18 in-depth interviews

- **Methodology:**
 - Interview questions
 - Recruitment
 - Interview procedures

Demographics:

- **Participants: N= 18** (F 44.4% (8) , M 55.6% (10))
- **Practices: N=11***
- **Distribution/job:**
PV=38.9%*, PM= 5.6%, N= 11.1%, VA= 44.4%
- **Average age: 40.8 [31-63]** (F 35.8 [31-48], M 49.3 [31-63])
- **Average number of years since graduation:**
20.2 [4-40] (F 13.1 [4-27], M 26.4 [4-40])
- **Average number of staff/practice: 16.7 [6-27]**

- **Average equine work proportion /participant:**
41.1% [1-100%]* (F 39% [1-95%]* , M 42.8% [2-100])
- **Average time of interview (min):**
66.8 [40-160] (F 52.6 [40-75], M 78.1 [45-160])
- **% of participants with direct contact with + HeV cases: 35.2%***
- **% of participants with direct contact with susHeV cases: 53%**
- **% of participants with no direct contact with HeV cases: 11.8%**

Results from the first 18 in-depth interviews

- **Results:**
 - What do veterinarians know?
 - Current reported barriers to IC
 - Enablers of IC currently in use
 - Further related concerns voiced
 - What do veterinarians want?

What do veterinarians know?

- They understand the HeV related risks
- They know how to inform themselves
- They understand their legal and ethical responsibilities
- They agree that improvement of IC is needed beyond HeV outbreaks and EVP
- They admit the veterinary culture needs to change

Current reported barriers to IC

- The Disease
- The Definition of IC
- The Vet
- The Business
- The Cost
- The Logistics

Current reported barriers to IC (cont)

- The Patient
- The Client
- The Lab
- The Law
- The Lack of Support
- The Media

Current reported barriers to IC (cont)

- The Patient
- The Client
- The Lab
- The Law
- The Lack of Support
- The Media

Enablers of IC currently in use

- Fear
- Experience with outbreaks
- Self-education
- Management action in vet clinics
- Professional networking
- IC already implemented in vet practices

Further related concerns voiced

- Animal welfare
- Loss of equine professionals
- Dangers of under-reporting and under-investigating cases
- Vaccination

What do veterinarians want?

They want:

- Changes to be relevant to the profession
- To contribute to knowledge & changes
- More access to relevant information/training
- To work safely within their business context
- To be supported by government and professional bodies

They don't want:

- To be scapegoats

POSSIBLE SOLUTIONS?

“Usually if people talk about a problem they already have thought about it and they already have a solution”^[P6]

Listening to the practitioners...

HeV incidents

- Better support from DEEDI for HeV incidents
- Responsive, competent incident team to work with private vet
- Clearly negotiated roles for private vet
- Financial support for time spent and material expended in assisting in incident management

Getting a diagnosis

- Clarification with labs about requirements for diagnostic specimens
 - Packaging
 - Couriering
 - Responsibilities to test for other than HeV
- Training for vets in specimen handling
 - Collecting samples
 - Packaging

Training

- Accredited short-course in equine infection control
- Ensure infection control is well taught in all Australian veterinary schools
- Educate horse owners that if they are assisting in procedures, they must comply with veterinary instructions owing to WHS legislation

WHS: a difficult model

- The academic and professional model is assessment by peers or by experts
- The QWHS model turns this on its head – assessment by individuals with minimal veterinary expertise and credibility
- Results in an immense amount of frustration, even anger
- Vets accept the importance of WHS in infection control
- What can be done?

WHS: a way forward

- Better communication and mutual respect is needed between vets and QWHS
- Consensus meeting – equal footing
- Discuss details of checklist
- Discuss how veterinary credibility of QWHS can be improved
- Discuss issues of fair play and credit for partial compliance

Professional Assistance

- AVA – develop a standard template for discharge of obligations for infection control
- AVA - Develop a method to assist practices to assess their infection control status

Financial Assistance

- Govt – provide financial assistance for small practices to meet IC requirements

THANK YOU FOR LISTENING



Public Health and Tropical Medicine
Anton Breinl Centre

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Appendix C3:

Mendez D, Miller K, Judd J, Speare R. Risk communication between veterinarians and horse owners: a key factor in the management of Hendra virus. Poster presented at the Australasian Society for Infectious Diseases Zoonoses conference; 2012 July 27-28; Sydney, Australia. (Study 1)

Risk Communication Between Veterinarians & Horse Owners: A Key Factor in the Management of Hendra Virus

Diana Mendez^{1*}, Ken Miller², Jenni Judd¹ & Rick Speare¹

Background

Hendra virus (HeV): high occupational risk

- A rare zoonosis
- BUT**
- High mortality rate in Humans (57%) & Horses (75%)
- Spills over:

7 infected
4 died
5 associated with veterinary activity

36 outbreaks

Better infection control (IC):
key to good veterinary occupational health & safety (OHS) risk management

Workplace health & safety legislation:

- Private vets responsible for the health and safety of all people present at the time of the consultation

Assess risks & decide on risk management strategy

Communicate risk management strategy

Start

Clients

Bystanders

Good infection control difficult in private practice

Consultation with veterinarians is essential

Qualitative Study

Consultation with veterinary personnel about:

- HeV risks perceptions
- Barriers to & enablers of IC in private practice

AIM
Gain a deeper understanding of the IC & related HeV issues equine veterinarians experienced

We report on a particular recurrent theme:
Risk communication difficulties between vets & horse owners and their effect on veterinary IC and HeV management in private veterinary practice

Qualitative methods

- 21 face-to-face in-depth semi-structured interviews:
- When: December 2009 - September 2010
- Where: East coast between Far-North & South-East Queensland
- Who: Veterinary personnel from equine and mixed practices
- 8 open ended questions about:
- HeV risks perception & management issues
- Related Infection control & Workplace health & safety issues
- Recruitment: Yellow pages & word of mouth
- Thematic analysis of responses

Results

Geographic distribution of participants

14 equine or mixed practices

18 Veterinarians (10 equine, 8 mixed/equine)

2 Veterinary nurses

3 Practice manager

Participant profile	No.	Average Age (range)	Years since graduation (range)	% of those doing equine work
	13	48.5 (38-63)	22.9 (8-40)	52.1 (2-100)
	8	35.8 (21-48)	13.1 (0-27)	36.4 (2-93)

Participant's experience with equine Hendra virus cases

11 had dealt with at least 1 confirmed case of HeV

1 had dealt with at least 1 suspected case of HeV

9 had not dealt with any HeV case

Participants reported that:

- Some horse owners were unresponsive to HeV risk warnings
- Some horse owners refused to comply with veterinary safety instructions
- Some horse owners refused to have their horses tested for HeV because of cost
- Some horse owners refused to have their horses tested for HeV because of mandatory euthanasia of the positive animals

"I find great difficulty dealing with owners because it is a power play and ultimately we are responsible of the safety of all involved, but some owners don't believe that, which compromises the legal situation. We usually end up taking risks out of concern for the welfare of the animal but we end up with less authority over the handling of the horse."
(Participant 4)

Consequently, horse owners' lack of compliance with veterinary health & safety instructions was viewed as:

- A barrier to good veterinary infection control
- A barrier to adequate management of potential case of HeV
- A barrier to biosecurity & public health
- Increasing OHS risk for veterinary staff and bystanders
- Increasing OHS veterinary liability

Some vets found the client issue challenging

BUT

Some vets developed strategies to address this issue

Participants' strategies to address risk communication difficulties with horse owners:

- Explaining to horse owners confidently and authoritatively about HeV risks to human health & the benefits of compliance with veterinary safety instructions
- Bringing their own trained assistance
- Declining horse owner assistance if he/she refuses to comply with veterinary safety instructions
- Moving proceedings to clinical veterinary premises to gain control of the safety situation
- Refusing to deal with a horse unless the owner complies with safety instructions
- Documenting proceedings

Conclusion

- Veterinarians need to be aware of the infection control, OHS and legal issues associated with clients & potential HeV cases and develop strategies to mitigate communication risks with clients
- Some veterinarians may need training or coaching in effective client management strategies to ensure client compliance with veterinary infection control instructions
- Additional sources of information for clients about HeV may also improve their understanding of the risks involved & motivate their compliance with veterinary instructions

SOME OWNERS BURR UP AT THE COST ...

"IF ONLY HE HAD LISTENED TO ME, HE WOULDN'T BE HERE TODAY!"

"I DON'T WANT THE HORSE TESTED, IF YOU WANT TO GET THE HORSE, WHY DON'T YOU GET THE HORSE?"

Participant 17

WHEN YOU MENTION THE WORD 'HENDRA'...

"HE IS NO BROTHER, I DON'T WANT HIM NEAR MY HORSE!"

"I DON'T WANT THE HORSE TESTED FOR HENDRA, IF THEY TEST IT, THEY'LL HAVE TO BE PUT DOWN, MY HORSE HAS BEEN PUT THROUGH AND I WOULDN'T LET ANYONE PUT MY OWN CHILDREN..."

Participant 20

Participants reported that:

"SOME OF THESE HORSES ARE A REALITY CHECK, THEY'VE GOT TO BE TESTED!"

Participant 13

Participant 4:

"THE CLIENT WAS VERY UPSET AND STAYED IN THE STALL OVERNIGHT WITH THE RAGING HORSE. I TRIED TO GET HIM OUT, BUT HE WOULDN'T LISTEN!"

Participant 4

Disclosure of interest statement: Funding for this project was initially provided by Australia Biotechnology Cooperative Research Centre for Emerging Zoonotic Diseases & subsequently by the Action Research Centre for Public Health and Tropical Medicine

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Appendix C4:

Mendez D. Is there a disconnection between veterinary undergraduate infection control training and infection control experiences during extramural professional training?
 Presentation given to the One Health Research Group, School of Public Health and Tropical Medicine – James Cook University; 2014 February 12; Townsville, Australia. (Study 4)



Is there a disconnection between veterinary undergraduate infection control training and infection control experiences during extramural professional training?



Diana.Mendez@jcu.edu.au

Background


Occupational health risks in veterinary nursing: an exploratory study
IM on SIRET and EORTCP


Journal of Occupational Medicine and Toxicology
 Research: **Exposure rate of needlestick and sharps injuries among Australian veterinarians**
 Peter A. Leggat^{1,2}, Derek R. Smith³ and Richard Speare⁴

Veterinary Infection Control (IC) generally suboptimal

Zoonotic disease risk perceptions and infection control practices of Australian veterinarians: Call for change in work culture
 Karen Dowd¹, Melanie Taylor², Jenny-Ann L.M.L. Toribio³, Claire Hooker⁴, Navneet K. Dhand^{4*}

Background

Hendra  a trigger for veterinary IC improvements



7 human infections
 4 vet personnel + 1 lay vet assistant
 4 human deaths (3 vet profession related)

State and National HeV management campaign 2009-2010

- Human Death due to HeV
- Non-lethal infection with HeV
- Vet personnel or associated

Background

"Old school vets always considered getting infected with a zoonosis as a badge of honour...We should question the Uni training that used to say that the likelihood to catch an infectious disease is low." (V8/Pe)

"No way in the world would I put a mask or gloves on unless I saw something dramatic." (V13/Pi)

"I think overall we, as vets, were pretty grubby...to get around with blood on your shirt all day that is just what veterinarians did." (V16/Pi)

2009-2010 Interviews of equine veterinarians from QLD

"Seeing a mate die I think is enough. Obviously you think of self-preservation. I have a life to live...Dying is a pretty big cost." (V5/Pd)

"With time I have become a bit slack. I have gone backwards, because the gloves, masks and overalls are back in the back of the car now." (V5/Pd)

Background

"Old school vets always considered getting infected with a zoonosis as a badge of honour...We should question the Uni training that used to say that the likelihood to catch an infectious disease is low." (V8/Pe)

"No way in the world would I..."

"I think overall we, as vets, were..."

What are the factors determining veterinary infection control behaviours?
 Knowledge? Culture? Beliefs? Risk perception?...

"Seeing a mate die I think is enough. Obviously you think of self-preservation. I have a life to live...Dying is a pretty big cost." (V5/Pd)

...slack. I have gone backwards, because the gloves, masks and overalls are back in the back of the car now." (V5/Pd)

Background

"Students are very well aware of the risks to the point of being scared to do things." (V7/Pa)

These days young vets lack confidence around horses because of their lack of experience through their training and personal life." (V1/Pa)

Most of what I learnt was from watching two of the head associates at the clinic." (V14/Pj)

2009-2010 Interviews of equine veterinarians from QLD

"Coming out of Uni the biggest issue was not whether I could follow protocols it was getting the practice of using those protocols." (V17/Pm)

Hopefully they [the students] will go into practice in clinics where they follow best practice." (V7/Pa)

Poor mentorship is a problem. Training is very important. A principal vet can teach a lot to younger vets." (V8/Pe)

Background

"Students are very well aware of the risks to the point of being scared to do things." (V7/Pa)

These days young vets lack confidence around horses because of their lack of experience through their training and personal life." (V1/Pa)

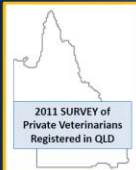
"Coming out of Uni the biggest

Is there a disconnection between veterinary undergraduate IC training and IC experiences during extramural professional training?

will go into practice in clinics where they follow best practice." (V7/Pa)

principal vet can teach a lot to younger vets." (V8/Pe)

Background



2011 SURVEY of Private Veterinarians Registered in QLD

Level of concern about ABLV in veterinary practice (n=534)		
Extremely		14.2% (76)
Moderately		36.1% (193)
A little		30.3% (162)
Not at all		19.3% (103)


Country of graduation	Vaccinated against rabies (ever)			Vaccinated against rabies (current)		
	Yes (n=148)	No (n=393)	p-value	Yes (n=72)	No (n=469)	p-value
Australia	77% (114)	96.7% (380)	<0.001	79.2% (57)	93.2% (437)	<0.001
Overseas	23% (34)	3.3% (13)		20.8% (15)	6.8% (32)	

27.3% had been vaccinated at least once in the past & 13.3% considered themselves currently vaccinated

BUT...

31.9% of OS vets with current vaccination vs 11.5% of Australian vets with current vaccination

Background



Level of concern about ABLV in veterinary practice (n=534)		
Extremely		14.2% (76)
Moderately		36.1% (193)

Why doesn't risk perception equate to adequate risk mitigation?

Assuming IC undergraduate training is adequate when do vets start developing suboptimal IC work habits?

Country of graduation	Vaccinated against rabies (ever)			Vaccinated against rabies (current)		
	Yes (n=148)	No (n=393)	p-value	Yes (n=72)	No (n=469)	p-value
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31.9% of OS vets with current vaccination vs 11.5% of Australian vets with current vaccination

The Study

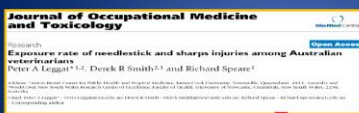
Is there a disconnection between veterinary undergraduate infection control training and infection control experiences during extramural professional training?

- 5th year veterinary students @ UQ and JCU
- Semester 2 - 2013
- Survey (online/ Survey Monkey)

💡💡💡💡....

- Pilot study : Dec 2013 after final exams @ JCU only
- Full study: Feb & August 2014 @ both sites

The Study



Journal of Occupational Medicine and Toxicology

Research Article
Exposure rate of needlestick and sharps injuries among Australian veterinarians
Peter A Leggat^{1,2}, Derek R Smith^{1,3} and Richard Speare¹

Qualitative Study 2009-2010 (Mendez et al)

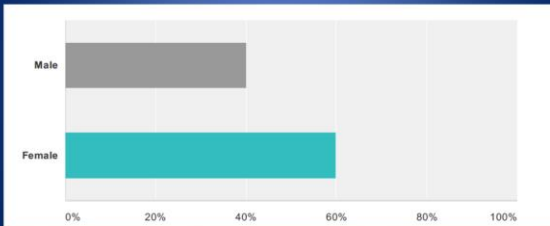
The Questionnaire (multiple choice & open ended):

- Demographic & education background
- Extramural placement history during veterinary undergraduate studies
- Vaccination history
- Knowledge of IC
- Perception of risk to personal health and safety in the private veterinary work environment
- Experiences of infectious risk mitigation during extramural placements in comparison to university acquired knowledge

Results (Pilot study only)

Demographic background

20 Participants/60



Male: 40%

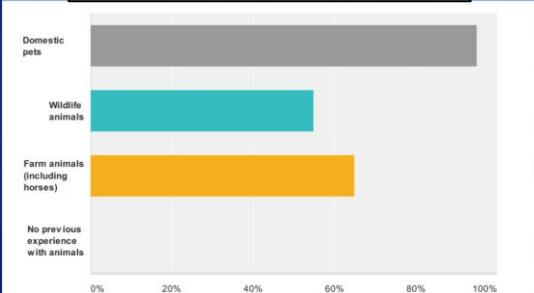
Female: 60%

Average age 27yrs old [22-41]

Results (Pilot study only)

Education background & experience with animals prior to vet studies

30% (6/20) with other degree prior to vet studies



Domestic pets: 100%

Wildlife animals: 55%

Farm animals (including horses): 65%

No previous experience with animals: 0%

Results (Pilot study only)

Placement history

Most placements were:

- In mixed and small animal private vet practices
- QLD < VIC < NSW
- 2-3 weeks long
- At medium size practices (2-4 (+) vets)

90% (18/20) intended to work in private practice

Results (Pilot study only)

Vaccination history

- Q Fever: 100% up to date
- Tetanus: 95% up to date
- Influenza: 35% up to date
- Rabies: 20%

ABLV Ausvet plan & JCU policy

VS

From May 2013

Results (Pilot study only)

- Zoonotic risk perception -

How concerned were they about being affected by occupational risks?

Occupational risk	Very or moderately concerned
Burn out	80% (16/20)
Injury from an animal	75% (15/20)
Litigation	60% (14/20)
Zoonotic disease	45% (9/20)
Injury from equipment	35% (7/20)
Sharps injury	20% (4/20)
Infection from humans	15% (3/20)

Results (Pilot study only)

- Zoonotic risk perception -

How concerned were they about being affected by occupational risks?

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Zoonotic disease	45% (9/20)
Injury from equipment	35% (7/20)
Sharps injury	20% (4/20)
Infection from humans	15% (3/20)

"At the time [before Hendra], human safety was not being kicked [by a horse patient], not being trampled on, avoiding any physical injury...Zoonoses were not a big one on my list." [V14/P1] [Interviews 2009-10]

"There are also other risks when dealing with horses: injury. In the last year I have sustained two broken ribs, a hit to the head and a tear of the cartilage near the sternum." [V5/Pd] [Interviews 2009-10]

Results (Pilot study only)

- Zoonotic risk perception -

How concerned were they about contracting an infectious disease from a range of animals appearing healthy?

Rated highest risk sources of zoonotic infections:

- Bats 80% (16/20)
- Horses 65% (13/20)
- Reptiles 65% (13/20)

FYI: Amphibians were rated as "not at all" a risk source of infectious disease by 65% (13/20) of participants

Results (Pilot study only)

- Zoonotic risk perception -

How concerned were they about contracting an infectious disease from a range of animals appearing ill?

Rated highest risk sources of zoonotic infections:

- Bats 89.5% (17/19)
- Horses 89.5% (17/19)
- Birds 78.9% (15/19)
- Reptiles 73.7% (14/19)

FYI: Amphibians appearing ill were rated as "not at all" a risk source of infectious disease by 47.4% (9/19) of participants

Results (Pilot study only)

- Risk perception -

How concerned were they about contracting a range infectious diseases?

Mostly concerned about contracting:

- Hendra 84.2% (16/19)
- Leptospirosis 68.4% (13/19)
- Salmonellosis 63.2% (12/19)
- ABLV 63.2% (12/19)

Results (Pilot study only)

- IC knowledge (theoretical) -

How did they rate the importance of following a range of standard veterinary IC procedures?

IC procedures	Very important - Important	Moderately important
Cleaning equipment after use	84.2% (16/19)	15.8% (3/19)
Disinfection of premises & equipment	84.2% (16/19)	15.8% (3/19)
Following IC best practice principles	89.5% (17/19)	10.5% (2/19)
Hand washing	94.8% (18/19)	5.3% (1/19)
Observing food & beverage exclusion zones	84.2% (16/19)	15.8% (3/19)
Putting sharps in sharps disposal units	100% (19/19)	0
Restraining animals	100% (19/19)	0
Using personal protective equipment (PPE)	100% (19/19)	0

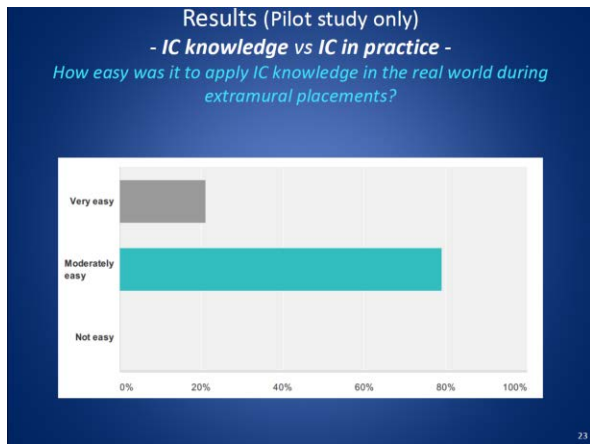
Results (Pilot study only)

- IC knowledge vs IC in practice -

How confident did they feel using PPE while on extramural placement?

Responses:

- It was provided and left to me to determine if I wanted to use it.
- Comparing two equine placements - the more highly regarded practice did not consistently use PPE for things such as dentals compared to a smaller remote clinic which routinely used some PPE (glasses and mask). Although there was comment made that they were only doing it because I was a student and didn't want any negative feedback to the bosses.
- PPE was made available and if indicated its usage was encouraged.
- I feel judged by the vets for wanted to use them so didn't feel to confident but I still used them.



Results (Pilot study only)

- IC knowledge vs IC in practice -

How easy was it to apply IC knowledge in the real world during extramural placements?

Responses

Think of hazard and then think of what you need to protect yourself.

We are taught a golden standard whereas in practice there are many financial constraints that may limit availability and range of PPE available.

Some clients take offense to wearing mask and glasses and gloves.

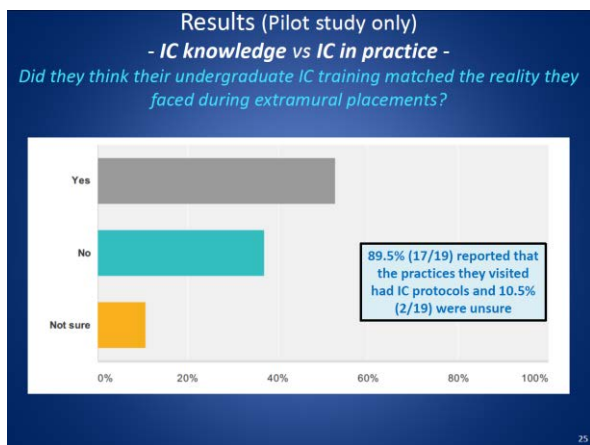
The practice had in place specific infection control protocols for particular presentations, such as parvovirus which were easily followed, the prior learning of the basis on which protocols are developed made understanding why, and applying the protocol very relevant

Some things just seem more common sense now such as disposing of sharps and segregating eating and drinking areas away from potential hazards.

Complacency amongst older professionals is somewhat difficult to overcome

Until recently, it was accepted by many to remove the needle cap with your mouth whilst stabilising a blood vessel - I remember starting my degree and we were not corrected about this. Now it's such a no-no, and with good reason!

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Results (Pilot study only)

- IC knowledge vs IC in practice -

Did they think their undergraduate IC training matched the reality they faced during extramural placements?

Responses

They did not believe it was practical

Not as realistic in a clinical setting

Little attempt by the practice to enforce PPE

Availability of equipment was lacking. There was a stigma associated with using appropriate PPE.

No obvious risk assessment plans/protocols. These may have been available just wasn't obvious and I wasn't made aware of them.

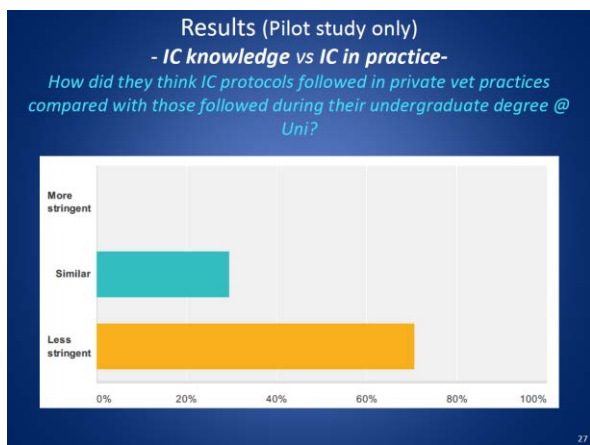
I was uncertain that the level of PPE that one or two of the vets carried along with them to farm visits were of sufficient quality.

The level of protection expected by university and the gold standard OHS standards were nowhere near reality. Infection was left on in one clinic, chemical exposure was high. PPE is option but sometimes seen as 'uncool' and rarely used.

In reality not all PPE was used and there was no interest in the order they were put on or how they were disposed. The foot bath was inappropriate. There was attempt to do the right thing but by not doing things properly it felt pointless to do it at all.

Goal standard was not met. Lack of hand washing and regular cleaning of tables was not consistent throughout my placements. Lack of goggles and mask for horse dentals was shocking!

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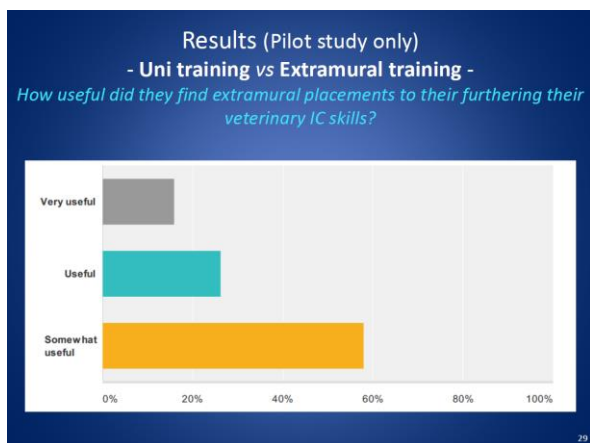
Results (Pilot study only)

- Uni training vs Extramural training -

How useful did they find extramural placements to their developing a range of veterinary skills?

Veterinary skills	Very useful - useful	Somewhat useful	Useless
Animal handling	89.5%	10.5%	0
Communication with clients	84.2%	15.8%	0
Communication with colleagues	94.8%	5.2%	0
Compliance with WHS*	47.4%	47.4%	5.2%
Following IC procedures	52.6%	47.4%	0
Personal infectious disease prevention	47.4%	42.1%	10.5%
Personal injury prevention	57.9%	36.9%	5.2%
Use of PPE	57.9%	36.9%	5.2%

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Responses

I will attempt to instigate the things we have learnt into the practice I am working at next year.

No

I still think that as a student and having previous experience in the human medical field, there is much complacency out in real practice regarding PPE and zoonotic risk. Hand washing - a very simple measure to prevent zoonosis was almost non-existent in large animal practice which I experienced.

I would like to see better chemical control in private practice, I think it is also the responsibility of an individual veterinarian to take care of their personal risks and exposure, we have been trained and it our choice on what we risk. I do however think if you have clients or other colleges including nurses and student you are no longer only risking yourself and vet should be made aware of the risk of exposing other people to chemical toxicity and infections.

It feels as though the previous generations of vets look down upon the new generation wanting to wear PPE or have better practices. The general attitude could be described as a 'toughen up' mentality. I believe this is one of the key problems with infection control in veterinary practice. The new players want to fit in so although they know the correct way to go about infection control they are willing to cut corners to be approved by the more senior colleagues.

Most veterinarians I worked with are on the ball with zoonotic diseases and protecting students from animal harm. They freely gave out gloves and sterility was practiced both within and out of the clinic.

Evidence of complacency in the industry is a bit scary. And more of a focus on cost of PPE governing its use is horrible.....surely we can put a price on health

30

Conclusion

Do 5th year veterinary students have ground knowledge to follow adequate IC in private vet practice?

☛ **YES**

- IC theoretical knowledge ☺
- Confidence in apply and implementing IC strategies not optimal ☹
- Zoonotic risk perception ☺

Is there a disconnection between veterinary undergraduate infection control training and infection control experiences during extramural professional training?

☛ **YES**

- IC @ Uni > IC in private practice

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Conclusion

When do young veterinarians start developing suboptimal IC habits?

☛ @ the start of their career

Why do young veterinarians start developing suboptimal IC habits?

☛ The will to conform to a professional identity

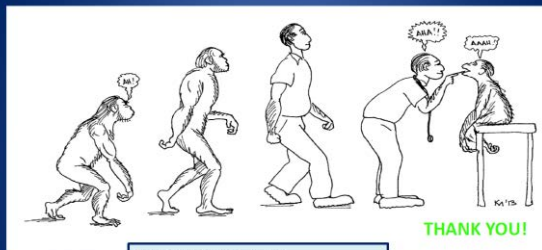
Why does veterinary IC standards persistently remain suboptimal?

☛ Enduring veterinary work culture, transmitted by process described above!...

...+ other factors explored in other studies!

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However, this was only a pilot study...full scale study currently running...will keep you posted!



THANK YOU!



Thanks to funding body:
Centre for Biosecurity & Tropical Infectious Diseases
& Collaborators:
Em. Prof. R. Speare (JCU)
Dr L. Foyle (JCU)
Ass. Prof. R. Cobbold (UQ)

Diana.Mendez@jcu.edu.au

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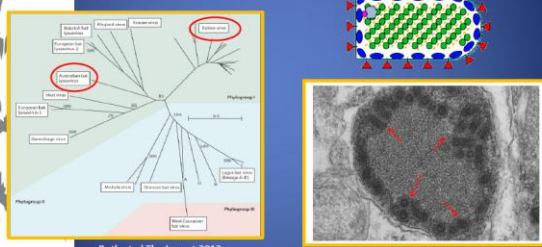
Appendix C5:

Mendez D, Speare R. The new face of Australian bat lyssavirus: a new emerging public health threat. Presentation given at the Queensland Tropical Health Alliance/ Australian College of Tropical Medicine “Tropical Health – Local labs: global impact” conference; 2013 September 7-8, Cairns, Australia. (Studies 3 and 4)

THE NEW FACE OF AUSTRALIAN BAT LYSSAVIRUS: A NEW EMERGING PUBLIC HEALTH THREAT
 D Mendez, R Speare
 School of Public Health, Tropical Medicine & Rehabilitation Sciences

 Diana.Mendez@jcu.edu.au

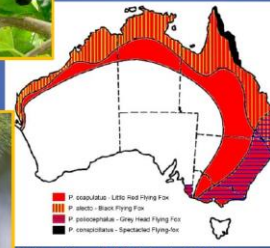
Australian Bat Lyssavirus (ABLV): a sinister family tree!



Both et al The Lancet 2012
 Gould et al Virus Res 1998

ABLV: wildlife reservoirs

Pteropus-ABLV strain

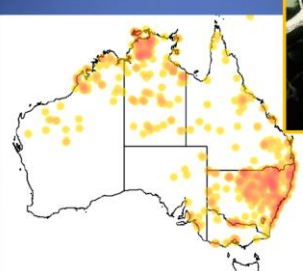


Pteropus alecto, *Pteropus scapulatus*, *Pteropus poliocephalus*, *Pteropus conspicillatus*

Adapted from Hall & Richards (2000)

ABLV: wildlife reservoirs

Saccolaimus-ABLV strain



Saccolaimus flaviventris

<http://bivie.ala.org.au/species/Saccolaimus+flaviventris>

ABLV: a wildlife health issue

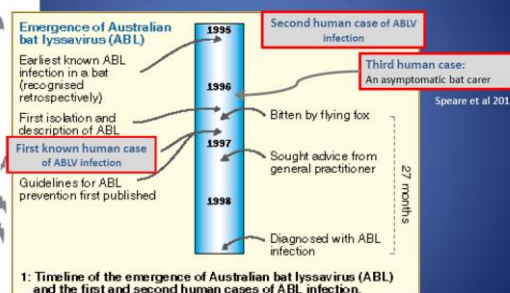
Table 2: ABLV cases in Australian bats as confirmed by FAT, PCR, IHC and/or Virus Isolation^a to June 2012^b

	NSW	NT	QLD**	VIC	WA	SA	TOTALS (by year)
1995	0	0	1 ^a	0	0	0	1
1996	1	0	9	1	0	0	11
1997	2	1	27	0	0	0	30
1998	1	0	26	0	0	0	27
1999	0	0	5	0	0	0	5
2000	1	0	14	0	0	0	15
2001	0	0	9	1	4	0	14
2002	4	0	10	2	1	0	17
2003	6	0	3	2	0	0	11
2004	5	0	6	1	0	0	12
2005	6	0	3	0	0	0	9
2006	2	0	4	0	0	0	6
2007	6	0	2	0	0	0	8
2008	0	0	0	0	0	0	0
2009	2	0	10 ^a	0	0	0	12
2010	0	0	8	0	1	0	9
2011	0	0	5 ^a	1	0	0	6
2012	0	0	1	0	0	0 ^a	1
TOTALS (by State)	41	1	146	9	6	0 ^a	203

Australian Wildlife Health Network ABLV Report June 2012

ABLV prevalence amongst bats <1%

Emergence of ABLV: a rare human health issue



1: Timeline of the emergence of Australian bat lyssavirus (ABLV) and the first and second human cases of ABLV infection.

Hannah et al MIA 2000

ABLV: a rare but fatal rabies-like illness

Long incubation
Encephalitis
Paralysis
↓
Delirium
↓
Convulsions
↓
Respiratory paralysis
↓
Death

2: Immunofluorescent antibody stain of a brain impression smear, showing intense "gold dust" fluorescence and several cytoplasmic (Negri-like) inclusion bodies (arrows), indicating the presence of Australian bat lyssavirus.

Hannah et al MJA 2000

ABLV: wildlife reservoirs & human populations

Australia - Population Density Map (2011)

Legend:
 ■ Australian Little Red Flying Fox
 ■ Eastern Small Flying Fox
 ■ Antipodesian Shearwater Flying Fox
 ■ Commonwealth Koala/Emu/Quokka

ABLV prevention: avoid bats

BAT VIRUS WARNING

WARNING
DO NOT HANDLE FLYING FOXES
IF YOU MUST HANDLE THEM, WEAR GLOVES AND A MASK
WASH YOUR HANDS THOROUGHLY WITH SOAP AND WATER
FOR AT LEAST 20 SECONDS

Avoid the bats: blame the bats?!

I'm not sure whether you're a flying fox or some kind of weird, dirty, old sexual pervert but if you are a flying fox then you'd better jolly well get out of these botanical gardens quick smart because you're not welcome.

ABLV: blame the bats?!

Volunteers defend bats

Protect the Humans not the Vampires
FAMILY TREE

Rabies vaccine: cross protective against ABLV

Rabies vaccine: cross protective against ABLV

Vaccine

Rabies human diploid cell vaccine elicits cross-neutralising and cross-protecting immune responses against European and Australian bat lyssaviruses

S.M. Brookes*, G. Parsons, N. Johnson, L.M. McElhinney, A.R. Fooks

ABLV prevention: vaccination

AUSVETPLAN

Disease Strategy
Australian bat lyssavirus
Version 3.0, 2009

Vaccination of humans
Pre-exposure vaccination (with rabies vaccine) of people who handle bats and ABLV minimises the risk of human infection.

Groups most at risk in Australia include those who work with, treat or handle bats and people who work with ABLV. They include bat and wildlife carers, zoo keepers and zoo-based veterinarians, researchers, laboratory staff, and veterinarians and veterinary nurses who provide services to wildlife carer groups. These individuals are routinely vaccinated against rabies, and their level of protection is monitored.

ABLV: post-exposure management

Australian Bat Lyssavirus (Potential exposure)
 Australian bat lyssavirus is a newly isolated but not identical to classical rabies virus. All bites, scratches and mucous membrane exposures from all bats, regardless of the bat's clinical status, should be managed as potential exposures.

Bat or flying fox bite or scratch or mucosal exposure to saliva?

- Immediately wash the area with soap and water gently for at least 5 minutes
- Apply an antiseptic or alcohol based antiseptic (avoid if possible)
- Check vaccination status for rabies

Client details

- Previously vaccinated with rabies vaccine
- Wound
- Client contact details

Urgently seek advice from public health unit

Bat or Flying Fox

- To be retained for testing if available
- To be handled by a person experienced in handling bats

Post Exposure Prophylaxis (PEP)

- Administer rabies immunoglobulin (and rabies vaccine as directed by public health unit if needed)
- Monitor response to therapy at the closest office of the Queensland Ambulance Board or from the DMU
- Complete VMS's post-exposure record form for vaccine administration

Communicable Diseases Control Manual




2013: The new face of ABLV

ABLV 2013: new human victim

GO MINUTES




FEBRUARY 2013

ABLV 2013: increase in number of people seeking post-exposure treatments

CAIRNS

LYSSAVIRUS DEATH SPARKS RUSH ON BAT VACCINE





THE death of Cairns boy Lincoln Flynn, 8, in February from lyssavirus has caused the number of people seeking vaccinations, jump to 273 since January 1.

None of those who sought treatment had lyssavirus and some were exposed to rabies overseas rather than in Australia.


In the same period last year, 131 people sought help and in 2011 it was 142.

ABLV 2013: increase notifications of exposure to bats

BAT SCRATCH ANGUISH
Watch the video







ABLV prevention 2013: educate the children



Sunshine Coast Daily Family of child killed by bat scratch in safety push

Lincoln lyssavirus foundation
Ask any school age child what ABLV is by 2018... and they will know. help us spread the word



Lincoln's legacy will live on through LLF.

ABLV 2013: spillover into Horses

MAY 2013

Quarantined




Significance of latest events: not just about the bats now!

1996 ⇨ 2012

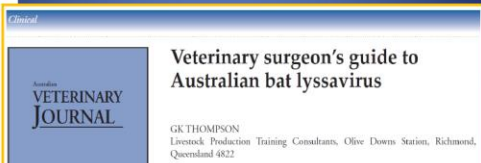


2013 ⇨ onwards



NEW PUBLIC HEALTH THREAT

ABLV and Veterinarians: they should know better!



Australian bat lyssavirus encephalitis. Surveillance has shown that all Australian bats must be considered carriers of this new virus, therefore protective apparel should be used when handling bats. The pre-exposure regimen of inactivated rabies vaccine (Pasteur Mérieux) provides protection against infection. As part of the preventive regimen, at risk groups, such as veterinary surgeons, should seriously consider pre-exposure rabies vaccination. The post-exposure protocol involves administration of

Prevention of ABLV in Veterinary practice: infection control



Zoonotic disease risk perceptions and infection control practices of Australian veterinarians: Call for change in work culture
Preventive Veterinary Medicine 111 (2013) 17–24
Karen Dowd^a, Melanie Taylor^b, Jenny-Ann L.M.L. Toribio^a, Claire Hooker^a, Navneet K. Dhand^{a,c}

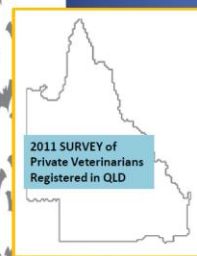
ABLV prevention and Veterinarians: current recommendations

Vaccination of humans
Pre-exposure vaccination (with rabies vaccine) of people who handle bats and ABLV minimises the risk of human infection.

Groups most at risk in Australia include those who work with, treat or handle bats and people who work with ABLV. They include bat and wildlife carers, zoo keepers and zoo-based veterinarians, researchers, laboratory staff, and veterinarians and veterinary nurses who provide services to wildlife carer groups. These individuals are commonly vaccinated against rabies, and their level of protection is monitored.

Pre-exposure prophylaxis for rabies virus and other lyssaviruses (including ABLV)
PreP with rabies vaccine is recommended for:
 • persons liable to receive bites or scratches from bats (this includes bat handlers, veterinarians, wildlife officers and others who come into direct contact with bats in any country, including Australia)
 • travellers and expatriates who will be spending time in rabies-zoonotic areas; PreP should occur following a risk assessment that takes into consideration the likelihood of interaction with animals and access to emergency medical attention
 • persons working with terrestrial animals in rabies-zoonotic areas
 • research laboratory personnel working with any live lyssaviruses.

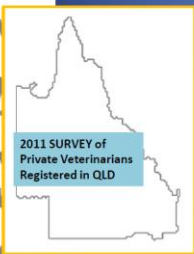
ABLV and Veterinarians: Do they care?



Level of concern about ABLV in veterinary practice (n=534)

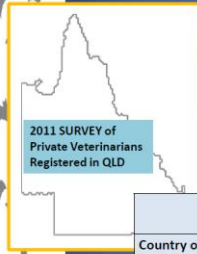
Extremely	14.2% (76)
Moderately	36.1% (193)
A little	30.3% (162)
Not at all	19.3% (103)

Rabies vaccination and Veterinarians: current status



Vaccinated against rabies ever (n=542)	27.3% (148) (95%CI [0.24-0.31])
Vaccination against rabies current (n=542)	13.3% (72) (95%CI [0.10-0.16])

Rabies vaccination and Veterinarians: current status



Country of graduation	Vaccinated against rabies ever		p-value	Vaccinated against rabies current		p-value
	Yes (n=148)	No (n=393)		Yes (n=72)	No (n=469)	
Australia	114 (77%)	380 (96.7%)	<0.001	57 (79.2%)	437 (93.2%)	<0.001
Overseas	34 (23%)	13 (3.3%)		15 (20.8%)	32 (6.8%)	

ABLV and Veterinarians: current recommendations

To protect against a number of diseases able to be caught from animals it is important to ensure sound hygiene and biosecurity measures are used with all contact with animals, particularly contact with their saliva, blood and other body fluids and with associated equipment.

Only people who have been vaccinated against rabies and wearing appropriate personal protective equipment should handle bats and preferably those that have been trained in, or have experience with handling bats.

Advice for Veterinarians
CVD bulletin re: new Hendra virus case on the NSW North Coast
It is recommended veterinarians consider the possibility of Lyssavirus infections when treating suspect Hendra virus cases. Both diseases can present with neurological signs, stamoe and gait changes, pyrexia and general malaise in the early stages. It is important to ensure sound hygiene and biosecurity measures are adopted when handling sick and 'in contact' horses, including their oronasal discharges, blood and other body fluids. Appropriate PPE should be used.
Veterinarians are encouraged to discuss the use of the Hendra vaccine as a risk mitigation tool with horse owners and managers.

ABLV: new public health threat? The challenge of slow emerging zoonoses

Hendra timeline:

- Human Death due to HeV
- Non-lethal infection with HeV

8 outbreaks/14yrs:
7 human infections, 4 human deaths

State and National HeV Management campaign

35 outbreaks/4yrs:
0 human infection

Vaccine for horses Oct 2012

Prevention of ABLV in the Future?

Could this happen?

Available online at www.sciencedirect.com
ScienceDirect
 Veterinary Microbiology 123 (2005) 15–25
ELSEVIER
veterinary microbiology
www.elsevier.com/locate/vetmic

Susceptibility of domestic dogs and cats to Australian bat lyssavirus (ABLV)
 Kenneth A. McColl^a, Tamasine Chamberlain, Ross A. Lunt, Kim M. Newberry, Harvey A. Westbury

Prevention of ABLV in the Future?

Post-exposure prophylaxis

Prevention of ABLV in the Future?

So, which one has ABLV?

NAME THAT VIRUS

Prevention of ABLV in the Future: What are we waiting for?

Pre-exposure prophylaxis for veterinary personnel and veterinary students

By the way I am vaccinated are you?

VACCINATE YOUR VET NOW

RECEPTION

Next

Thank You!

JAMES COOK UNIVERSITY AUSTRALIA

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Appendix C6:

Mendez D, Foyle L, Cobbold R, Speare R. Veterinary infection control: a mismatch between university and clinical placements. Abstract accepted for presentation at the Annual Australian Veterinary Association Conference that will be held in Adelaide in May 2016. **(Study 4)**

Title:

Veterinary infection control: a mismatch between university and clinical placements.

Brief summary of presentation:

Final year veterinary students report discrepancies between infection control as taught at university and their experiences in clinical placements.

Speaker (Name, email & organisation):

Diana Mendez, Diana.Mendez@jcu.edu.au, James Cook University

Additional Authors (Names & organisations):

Leo Foyle, James Cook University

Dr Rowland Cobbold, University of Queensland

Em. Prof. Rick Speare, James Cook University & Tropical Health Solutions

Abstract:

Extramural placements (EMPs) in private practice are an integral part of veterinary undergraduate training. Their purpose is to prepare students for professional life by enhancing their clinical and non-clinical skills. Previous research has shown that veterinary infection control (IC) needs to improve in Australia. The aim of this study was to survey final veterinary students from two Australian Universities in order to determine the role of EMPs in the development of IC skills. Students were asked questions about their zoonotic risk perceptions, their IC knowledge and their IC experiences during their EMPs. Most assessed zoonotic risks adequately and had a good knowledge of IC principles. However, some reported following substandard IC measures during their EMPs, despite identifying this as a problem. This was done to conform to the professional identity portrayed by their EMP mentors. To sustainably improve veterinary IC in Australia the quality of IC training during EMPs needs to be addressed.

- APPENDIX D -
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for
Published Manuscripts

Appendix D1:

Article published in Emerging Infectious Diseases

Content has been removed

Appendix D2:

Articles published or accepted for publication in the Australian Veterinary Journal

Content has been removed

Appendix D3:

Article published in Preventive Veterinary Medicine

Content has been removed

Appendix D4:

Article published in BMC Veterinary Research

Content has been removed

- APPENDIX E -

Co-authors' Consent

for Inclusion of

Published and Submitted Articles

into the Thesis

**Co-authors consent for the inclusion of published and submitted articles into
the following doctoral thesis:**

*“Identifying and understanding the factors affecting infection control and Hendra virus risk management in private veterinary practices in
Queensland, Australia.”*

Presented by Diana Mendez

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