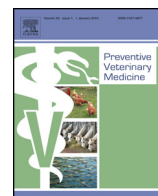




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Zoonotic disease risk perceptions and infection control practices of Australian veterinarians: Call for change in work culture



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ABSTRACT

This study was conducted to determine the perceptions of zoonotic disease risk among Australian veterinarians, the infection control practices they use to protect themselves from zoonotic diseases, and the factors influencing their use of these protective practices. A questionnaire was designed and piloted prior to its administration to veterinarians at the annual Australian Veterinary Association Conference in May 2011. The questionnaire comprised 21 closed, semi-closed and open questions. Data from the questionnaire were analyzed using ordinal logistic regression analyses to determine significant factors for veterinarians' use of personal protective equipment (PPE).

A total of 344 veterinarians completed the questionnaire of which 63.7% were women, 63.2% worked in small/companion animal practice, and 79.9% worked in private veterinary practice. Of the respondents, 44.9% reported contracting a zoonosis during their careers with 19.7% reporting a suspected case and 25.2% reporting a confirmed incidence. Around 40–60% of veterinarians perceived exposure to zoonosis likely or very likely in a variety of situations. With reference to current national industry guidelines, the reported use of PPE was less than “adequate” for most scenarios except for performing postmortems, surgery or dental procedures. No PPE was used by 60–70% of veterinarians for treating respiratory and neurological cases and by 40–50% when treating gastrointestinal and dermatological cases. Workplace conditions need improvement as 34.8% of workplaces did not have isolation units for infected animals, 21.1% did not have separate eating areas for staff, and 57.1% did not have complete PPE kits for use. Veterinarians were more likely to use PPE if they had undertaken postgraduate education, perceived that zoonosis exposure from animals and procedures was likely, consciously considered PPE use for every case they dealt with and believed that liability issues and risks encouraged use of PPE. In contrast, those working in private practices, those who tended to ‘just hope for the best’ when trying to avoid zoonotic diseases, and those who were not aware of industry guidelines were less likely to use PPE.

The results suggest that veterinarians' perceptions and workplace policies and culture substantially influence their use of PPE. Efforts should be made to encourage veterinarians and their workplaces to use infection control practices to protect themselves and their staff from zoonotic diseases.

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1. Introduction

Zoonotic diseases have become more prominent in recent years with outbreaks of severe acute respiratory syndrome, highly pathogenic avian influenza, Hendra virus and West Nile virus leading to human deaths across multiple countries (Mackenzie et al., 2004; Eagles et al., 2009; Field et al., 2010; Lau et al., 2010; Playford et al., 2010). It has been estimated that around 60% of the infectious organisms pathogenic to humans are zoonotic and that 75% of the all emerging infectious diseases are zoonotic (Cleaveland et al., 2001; Taylor et al., 2001; Haydon et al., 2002; Woolhouse and Gowtage-Sequeria, 2005). Zoonotic diseases can cause endemic disease with long term social and economic effects or dramatic impact and acute disease outbreaks leading to high mortality and morbidity. Recent outbreaks of emerging zoonotic diseases have demonstrated the potential seriousness and widespread exposure that can occur with such pathogens.

Animal health professionals have inherently high risks of exposure to, and infection from, zoonotic diseases. They are likely to be amongst the first people to encounter animals infected with zoonotic pathogens and to engage in high-risk interactions with them. And indeed, infection rates among animal health professionals are high. For example, around 30–40% of the veterinarians surveyed in two studies in the USA reported having been infected with zoonotic diseases (Schnurrenberger et al., 1978; Lipton et al., 2008). The proportions of veterinarians suffering from zoonotic diseases have been reported to be as high as 60–65% in two other studies conducted in the UK and South Africa (Constable and Harrington, 1982; Gummow, 2003). Veterinarians are at a particularly greater risk when investigating or controlling emerging infectious disease outbreaks as evident in the Dutch outbreak of highly pathogenic H7N7 avian influenza virus (Koopmans et al., 2004).

A range of efficacious preventive practices have been developed to reduce or counter the risks of zoonotic disease exposure. However, their effectiveness depends on their uptake by animal health practitioners. Yet to date, we know very little about veterinarians' perceptions of risks posed by zoonotic diseases and the practices they undertake to protect themselves from these. Limited studies conducted to date indicate that awareness of zoonotic disease risks and uptake of infection control practices is very low among veterinary practices and veterinarians as individuals (Jensen and Lings, 1999; Lipton et al., 2008; Wright et al., 2008). After a survey of US veterinarians, Wright et al. (2008) concluded that "most US veterinarians are not aware of appropriate personal protective equipment use and do not engage in practices that may help reduce zoonotic disease transmission".

Very limited work has been done in Australia to understand the zoonotic disease risk perceptions and infection control practices of veterinarians but this has now become important with increasing numbers of equine Hendra virus cases (Mendez et al., 2012). Therefore, this study was conducted with the objectives to understand the perceptions of zoonotic disease risk among Australian veterinarians, the infection control practices they use to protect themselves

and their staff from zoonotic diseases, and the factors influencing their use of these protective practices. We anticipate that the findings from this study will provide objective evidence of the current work practices among veterinarians in Australia that can help the industry and public health authorities to enhance science based zoonosis prevention policy for veterinary practice.

2. Methods

2.1. Study design

This study was conducted as a cross-sectional study with the target population defined as English-speaking veterinarians across all sectors of the industry in Australia. The source population for this study was Australian registered veterinarians attending the 2011 Australian Veterinary Association (AVA) Conference in Adelaide, South Australia.

The target sample size was calculated to be 384. Attendees at the conference who were not veterinarians, or not registered to practice veterinary medicine in Australia, were excluded from participating in the study. The procedures for this study were approved by The University of Sydney Human Research Ethics Committee (05/2011, protocol number 13550).

2.2. Questionnaire design

A questionnaire was developed based on the reviewed literature. It was four pages in length and comprised 21 questions: three open questions, ten semi-closed questions and eight closed questions. The questionnaire was divided into three sections – zoonotic disease perceptions, infection control practices, and respondents' demographic and veterinary work information – and was piloted on four veterinarians from different veterinary backgrounds before implementation. A copy of the questionnaire is available from the corresponding author on request.

2.3. Questionnaire implementation

The questionnaire was distributed between 16 and 20 May 2011 in the Trade Exhibition Hall of the conference venue. Conference attendees were approached and asked if they would be involved in the research project. If the individual agreed to participate, they were verbally confirmed to be an Australian registered veterinarian, then handed a survey pack containing an Introductory Letter, a Participant Information Statement, the questionnaire, a stamped self-addressed envelope and a raffle ticket.

The study was promoted in a paragraph of written text in the conference proceedings as well as announcements made in the Trade Exhibition Hall and at a few of the conference lectures. An incentive to participation (five AUD100 gift vouchers) was offered to improve response rate, with the winners drawn by raffle on the final day of the conference.

2.4. Data management and analysis

Data from the questionnaire were managed using a custom designed Microsoft Excel database and later imported into the SAS statistical program (2002–2003; SAS Institute Inc., Cary, NC, USA) which was used for all further analyses, unless indicated otherwise.

Explanatory variables were created from the questions about perceptions, workplace conditions and demographics in the questionnaire. Summary statistics were calculated for continuous explanatory variables and frequency tables/bar charts created for each categorical variable to obtain information about their distribution. All of the continuous variables were then categorized for further analyses. Respondents' workplace postcode was categorized to reflect their State and remoteness of their location based on the Accessibility/Remoteness Index of Australia. The eleven questions about veterinarians' likelihood of exposure to zoonoses from various species and procedures were combined to create an index representing these questions with three categories representing the perceptions of low, medium and high likelihood of exposure to zoonoses.

The outcome variable – adequate use of PPE – was based on 11 questions concerning the use of PPE in various situations (Table 1). For all of the 11 questions, respondents were asked to select as many options as applicable from the following: no PPE; overalls/gowns; gloves; surgical mask; goggles/face shield. Then they were asked to nominate which, if any, of these situations they would use a P2 or N95 respirator. PPE use for the different situations identified in the survey was categorized into three categories: no PPE used; adequate PPE used; or inadequate PPE used. The assessment of adequate PPE was based on minimal PPE use recommendations from the National Association of State Public Health Veterinarians (Scheftel et al., 2010) and the AVA Guidelines for Veterinary Personal Biosecurity (AVA, 2011) as evaluated by two of the authors (NKD and JAT). Respondents were then classified into four ordered groups based on proportion of the 11 situations for which they used adequate PPE: <25%; 25 to <50%; 50 to <75%; and ≥75%.

Association between the outcome variable and the explanatory variables were investigated by performing ordinal regression analyses. Initially, univariable analyses were conducted to evaluate the association between each explanatory variable and the outcome assisted by UniLogistic SAS macro (Dhand, 2010). The variables having some association with the outcome in univariable analyses ($P < 0.25$) were then tested for collinearity using the Spearman rank correlation coefficient and Chi-square test. One of the pair of collinear variables (correlation coefficient $> |0.7|$ and Chi-square P -value < 0.05) was excluded from multivariable analyses based on biological plausibility. Similarly, variables with $> 10\%$ of missing observations were excluded from multivariable analyses.

All the explanatory variables eligible for multivariable analyses were included in multivariable analyses using a manual forward stepwise selection method assisted by the MultiLogistic SAS macro (Dhand, 2009). Variables with P -value < 0.05 were retained in the final model. Respondents' age, gender and type of veterinary work were considered potential confounders, tested by inclusion in the final model and retained when a $> 20\%$ change in the coefficients of another variable was seen. Biologically plausible interactions between variables in the final model were tested and retained if $P < 0.05$.

3. Results

Response rate for the survey was calculated to be 42.4%. A total of 812 registered veterinarians attended the conference, of which of 344 completed the questionnaire.

3.1. Demographic information

Of the 344 respondents 63.7% were female and 36.3% male. Detailed distribution of respondents by age and gender is presented in Supplementary Table 1. Respondents were highly experienced with a median of 17 years since graduation and 15 years in practice; 27.7% had completed a Masters degree/Australian and New Zealand College of Veterinary Scientists membership/PhD,

Table 1

Level of personal protective equipment (PPE) used for various work situations and procedures by Australian veterinarians in a survey in 2011.

Veterinary work situations and procedures	PPE considered adequate ^a	No PPE No. (%)	Inadequate PPE No. (%)	Adequate PPE No. (%)	Total
1. Handling healthy animals	Overalls/gown or gloves	254 (77.0)	0 (0.0)	76 (23.0)	330
2. Handling clinically sick animals	Overalls/gown or gloves	140 (43.3)	0 (0.0)	183 (56.7)	323
3. Performing surgery	Overalls/gown and gloves	9 (2.8)	56 (17.7)	252 (79.5)	317
4. Performing post mortems	Overalls/gown and gloves	10 (3.1)	57 (17.8)	253 (79.1)	320
5. Conception and parturition procedures	Overalls/gown and gloves	37 (12.8)	106 (36.8)	145 (50.3)	288
6. Handling animal feces and urine	Overalls/gown and gloves	28 (8.5)	223 (67.4)	80 (24.2)	331
7. Performing dental procedures	Overalls/gown and gloves and face shield/goggles	12 (3.9)	37 (12.1)	257 (84.0)	306
8. Treating dermatology cases	Overalls/gown and gloves	166 (53.5)	25 (8.1)	119 (38.4)	310
9. Treating respiratory cases	Overalls/gown and gloves	207 (67.0)	61 (19.7)	41 (13.3)	309
10. Treating gastrointestinal cases	Overalls/gown and gloves	127 (40.4)	109 (34.7)	78 (24.8)	314
11. Treating neurological cases	Overalls/gown or gloves	219 (71.3)	0 (0.0)	88 (28.7)	307

^a The assessment of adequate or inadequate PPE use was based on *minimal* (not ideal) PPE use recommendations from the National Association of State Public Health Veterinarians (Scheftel et al., 2010) and the Australian Veterinary Association Guidelines for Veterinary Personal Biosecurity (AVA, 2011) as evaluated by two of the authors (NKD and JAT).

and 15.6% had completed a Graduate Certificate/Graduate Diploma. Respondents completed a median of 35 h of continuing veterinary education in any 12 month period.

Of the respondents providing information on type of veterinary work (321/344), more than half (63.2%) worked in small animal/companion animal practices (including exotics and wildlife work), 25.2% in mixed animal practices, 7.5% in large animal only practices and 4.1% in equine only practices. A majority worked in private veterinary practice (79.9%), with lower numbers in academia/research/teaching hospital and government (20.1%). Approximately two third of respondents (63.5%) were employees and 36.5% were veterinary practice owners or business partners.

Of the respondents providing information about their postcode (326/344), the proportion of veterinarians from various states and territories participating in the survey was fairly similar to the proportion of the registered veterinarians in their respective state except for South Australia (Supplementary Fig. 1), which was over-represented because it was the state hosting the conference. Approximately half of the respondents were from major cities (49.5%), 46.1% were from regional areas, and 4.4% were from remote or very remote areas.

3.2. Reported zoonotic infections

A little under half of the respondents (44.9%; 153/341) reported having contracted a zoonotic infection during the course of their veterinary work, with 25.2% reporting a confirmed incidence and 19.7% reporting a suspected incidence. The highest number of reported zoonotic infections by a single respondent was five although the majority had a single infection (83.6%, 163/195). The most frequent zoonosis contracted was dermatophytosis (45.1%), but there were also reports of the following (in descending order of their relative frequencies): Q fever (8.7%), other dermatologic conditions (6.7%), cat bite infections/cat scratch fever (6.2%), brucellosis (5.1%), psittacosis (4.6%), leptospirosis (4.1%), sarcoptes/parasites (4.1%), gastrointestinal conditions (4.1%), toxoplasmosis (3.6%), respiratory conditions (2.1%), orf virus/hand warts (2.1%), Chlamydiosis (1.5%) and miscellaneous other infections (1.5%).

3.3. Zoonotic disease perceptions and risk awareness

Respondents were asked about their perception of the likelihood of exposure to zoonoses from performing various veterinary procedures and for various animal species. Approximately 40–60% of the respondents considered exposure to zoonoses likely or very likely from most procedures and most animal species (Supplementary Fig. 2a and b). About a third of the respondents were concerned or very concerned for themselves or their colleagues (35.3%) about the risk of contracting a zoonosis, with a similar proportion being concerned for their clients (36.4%).

Less than half of the respondents felt they had a high level of knowledge about zoonotic diseases (41.5%). Over two thirds of respondents (69.3%) were not aware of any industry guidelines or standards relating to zoonotic disease. Of those who were aware of industry standards,

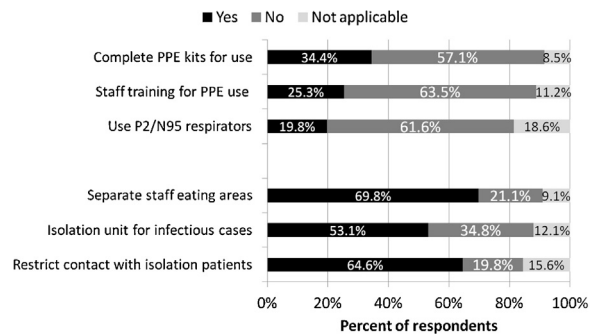


Fig. 1. Infection control practices in the workplace reported by Australian veterinarians in a survey conducted in 2011.

the majority (70.4%) were aware of equine standards related primarily to Hendra virus, with the remaining respondents identifying both the Australian Veterinary Association and Special Interest Group guidelines and Government/AUSVETPLAN standards (14.8% each).

Respondents were asked to identify their most important information sources for infection control and zoonoses. These were identified as veterinary journals or text books (36.4%) and government bulletins/information bulletins (36.4%), with relatively fewer considering colleagues (9.3%) and pharmaceutical representatives (1.2%) as their most important information source. Other information sources were identified by 5.6% of respondents, and for these the internet and university education were the most common sources reported (2.5% and 1.3%, respectively).

3.4. Infection control practices

Veterinarians participating in the study were asked about their workplace environment and their infection control practices including the use of personal protective equipment (PPE), defined as overalls/gown, surgical mask, disposable gloves, eye protection (such as goggles/face shield) and P2 or N95 respirators. Results regarding workplace conditions presented in Fig. 1 indicate poor availability of PPE equipment (34.4%) and training (25.3%). The levels of PPE worn in 11 different veterinary work situations are presented in Table 1. Less than a third of the veterinarians reported using adequate PPE for handling healthy animals or animal feces and urine and for treating gastrointestinal, respiratory or neurological cases. However, more than 75% of the respondents used adequate PPE for performing postmortems, surgery or dental procedures. Note that minimal (not ideal) levels of PPE were considered “adequate” in our analyses, and the proportions of veterinarians using infection control practices would be even lower if ideal levels are used to define “adequate” PPE.

Respondents were also asked about the factors that discouraged or encouraged use of PPE. Interestingly, less than 20% of the respondents believed that the followings factors were very or extremely likely to act as deterrents for using PPE: cost of PPE kits (10.7%), concerns about heat stress when wearing PPE (14.1%), safety concerns about wearing PPE (15.7%), adverse animal reactions to PPE (11.4%), negative client perceptions about vet wearing PPE (11.8%),

Some of the respondents also identified other deterrents to PPE use such as absence of perceived risk or attitudinal reasons, performance issues when wearing PPE gear (e.g. poor visibility) and availability of PPE gear. Of the factors that encouraged use of PPE, perceived risk to self was identified as the most likely reason to encourage use of PPE (68.8%), followed by professional experience with previous zoonotic cases (56.7%), liability issues (40.7%) and recommendations of industry guidelines or standard operating procedures (37.5%). However, practices of competing vets or good client perceptions about wearing PPE were considered unlikely to encourage PPE use.

3.5. Perceptions about infection control practices

Respondents were asked to indicate their level of agreement with the statements about infection control practices and PPE. Nearly all of the respondents broadly agreed (agreed or strongly agreed) that using PPE was an effective way of reducing the risk of zoonotic disease (91.5%) and that hand washing was an effective way of reducing zoonotic disease risk (93.9%). Practicing good equipment hygiene was agreed to be an effective way of reducing zoonotic disease risks by 84.2% of respondents. Nearly three quarters of respondents (72.5%) felt they were able to take effective action in their workplace to protect themselves from zoonotic disease risks, 17.0% consciously considered PPE for every case they dealt with but about half of the respondents (52.8%) practiced stringent infection control practices only when they thought they were necessary. Interestingly, 24.3% felt that their colleagues think they are being overly cautious when they use PPE. Detailed responses are presented in Supplementary Table 2.

3.6. Association of perceptions and demographics with the adequate use of PPE

Univariable ordinal logistic regression analysis identified 33 explanatory variables with some association with the outcome variable – adequate use of PPE ($P < 0.25$). Of these, age and years since graduation were highly correlated (Correlation coefficient 0.85; P -value < 0.001) and the latter was excluded to avoid the problem of collinearity in multivariable models. A level of 10% or more of missing observations was identified for six variables, all from the same question about workplace conditions (due to these respondents selecting the 'not applicable' option). These six variables were excluded from the multivariable analysis. All the remaining variables were tested in multivariable analyses. The final multivariable model contained seven variables with significant associations with the use of PPE (Table 2). None of the interactions was significant.

Gender, age and type of veterinary work were tested for confounding. Gender was not a confounder. Age confounded the association of the variable 'postgraduate education' with the outcome but both the variables were non-significant in this model (results from this model are not shown). The variable 'type of veterinary work' confounded the association of three variables with the outcome – postgraduate education, awareness of guidelines

and veterinary environment – and resulted in exclusion of the last two variables (Table 2). The assumption of cumulative logits tested using Score test in SAS LOGISTIC procedure was valid for the final model and its variants.

4. Discussion

This study successfully evaluated infection control practices used by veterinarians and identified some factors associated with the use of PPE. However, it had three main limitations.

First, the sample was a convenience sample of veterinarians attending the AVA conference, which may not be representative of the wider population of Australian registered veterinarians. Although it is not uncommon to select a non-random sample for conducting observational studies, it does impact the external validity of the study. However, veterinarians attending the AVA conference represented 26.1% of the total number of Australian registered veterinarians in 2011, as determined from the States and Territories individual veterinary registration board registration figures. Also, the distribution of respondents by state was similar to the expected distribution, suggesting that the sample was reasonably representative of Australian veterinarians. However, if a bias were present, we expect that the results presented in this manuscript would represent a 'best case' because attendance at such a conference suggests a level of engagement with the industry and that these individuals have some level of awareness of industry issues and undertake continuing professional development. Therefore, the practices in the entire population of Australian veterinarians are likely to be even less adequate than observed in this study.

The second limitation was the response rate of the study. Although a response rate of 42.4% is quite reasonable, it does mean that 57.6% of the veterinarians present at the conference did not participate in the study. This could have biased study results if the perceptions and practices of participating veterinarians were systematically different from non-participating veterinarians.

Thirdly, like any other epidemiological survey, the information about both the outcome (infection control practices) and explanatory variables was provided by the respondents and it was not possible to confirm this information. This could have introduced some information bias, both in the explanatory and outcome variables, but it is likely to be very minimal as most of the questions were about respondents' day to day work.

This study was conducted to identify veterinarians' perceptions of zoonotic disease risks, the infection control practices they use to protect themselves from zoonotic diseases and the factors influencing these practices. That 44.9% of the respondents reported having contracted zoonoses (with 25.2% reporting a confirmed incidence) is evidence of the risks faced by veterinarians during the course of their veterinary work. The levels of confirmed incidence are similar to those reported in two studies conducted in the USA (Schnurrenberger et al., 1978; Lipton et al., 2008) but lower than those reported in other studies conducted in the UK and South Africa (Constable and Harrington, 1982; Gummow, 2003). It is difficult to compare the proportions

Table 2Final multivariable models for adequate level of personal protective equipment (PPE) use^a based on a survey of Australian veterinarians in 2011.

Variables and categories	Final model excluding potential confounders			Model including the confounder 'Primary type of veterinary work'		
	Odds ratio	95% CI	P-value	Odds ratio	95% CI	P-value
Likelihood of zoonosis exposure from animals and procedures ^b			<0.001			<0.001
Low likelihood of exposure	1.00			1.00		
Medium likelihood of exposure	3.70	1.64, 8.60		2.94	1.31, 6.76	
High likelihood of exposure	5.86	2.58, 13.73		5.08	2.25, 11.76	
Liability issues and risks encourage PPE use			0.005			0.010
A little or not at all	1.00			1.00		
Moderately	2.41	1.38, 4.23		2.19	1.26, 3.84	
Very or extremely	1.29	0.76, 2.19		1.17	0.69, 2.01	
PPE use is consciously considered for every case			0.001			0.002
Disagree or strongly disagree	1.00			1.00		
Neutral	2.09	1.27, 3.48		1.87	1.13, 3.13	
Agree or strongly agree	2.49	1.36, 4.59		2.70	1.46, 5.04	
Hope for the best when trying to avoid zoonotic diseases			0.004			<0.001
Disagree or strongly disagree	1.00			1.00		
Neutral	0.70	0.41, 1.21		0.65	0.37, 1.12	
Agree or strongly agree	0.40	0.23, 0.69		0.34	0.20, 0.59	
Postgraduate education level			0.036			0.012
No post graduate education	1.00			1.00		
Graduate certificate or Diploma	1.16	0.65, 2.09		1.21	0.67, 2.18	
Masters degree, ANZCVS ^c membership or PhD	1.96	1.17, 3.28		2.21	1.31, 3.73	
Awareness of industry guidelines or Standard Operating Procedures			0.033			
No	1.00			–	–	–
Yes	1.65	1.04, 2.64		–	–	–
Veterinary environment			0.001			
Private practice	1.00			–	–	–
Non private practice ^d	2.70	1.49, 4.93		–	–	–
Primary type of veterinary work						0.029
Small animal practice ^e	–	–	–	1.00		
Large animal practice	–	–	–	3.17	1.30, 7.92	
Mixed animal practice	–	–	–	1.53	0.93, 2.52	
Equine practice	–	–	–	2.23	0.66, 7.87	

^a Respondents were classified into four ordered groups based on the proportion of situations for which they used adequate PPE: <25%; 25 to <50%; 50 to <75%; and ≥75%.

^b Variable created by combining information from all questions about veterinarians' likelihood of exposure to zoonoses from various species and procedures.

^c Australia and New Zealand College of Veterinary Scientists.

^d Includes referral clinic, laboratory, government organizations and research institutions.

^e Includes practice of companion animals/exotic pets/wildlife/zoo animals.

from different studies directly as they were conducted at different times in different source populations, but they do confirm that veterinarians are at higher risk of zoonotic disease infections.

Despite higher levels of zoonoses, about half of the veterinarians perceived that they were at low level of risk (a little likely/not likely/not at all likely) of being exposed to zoonotic diseases from various animal species and procedures. Perceived risk of zoonotic infections was a significant driver for adequate use of PPE, as those perceiving the likelihood of exposure to zoonosis to be low, were less likely to use adequate PPE (Table 2), potentially exposing themselves to a higher risk of zoonotic infections. This is a logical association and concurs with established theories of health behavior (such as the protection motivation theory), which suggests that perceived risk influences motivation to take protective action (Rogers, 1975; Rogers and Prentice-Dunn, 1997).

It was interesting to note that those aware of the veterinary industry guidelines or standard operating procedures related to zoonotic disease were significantly more likely to use adequate PPE suggesting that awareness does increase risk perceptions resulting in greater uptake of infection

control practices. Similarly, those with postgraduate qualifications were more likely to use adequate PPE. Veterinarians with postgraduate education can be considered more likely to be informed about current industry issues as well as to be more aware of infection control practices. These findings suggest that both awareness and education are important factors influencing the use of PPE and should be considered by the AVA, veterinary schools and animal health authorities to improve adequate use of PPE.

A somewhat similar association is reflected by the greater use of PPE by those who consciously consider using PPE for every case and poorer use of PPE by those who 'hope for the best' when trying to avoid zoonotic diseases. This latter perception appears to convey a sense that zoonotic exposure cannot be controlled, in contrast to the former perception which reflects a sense of conscious control and active decision making. A perceived lack of control in relation to a risk is known to reduce the uptake of protective behaviors (Schwarzer, 1992; Maddux, 1993) and this may be an issue that could be addressed in future training and education programs.

In addition to education and awareness, liability was the other factor that influenced the use of PPE. Failure to provide what is considered a safe work environment or to protect employees from infectious materials within the workplace could have serious legal implications for veterinarians regarding duty of care, which may be translated into legal liabilities. To date, most claims in the USA relating to zoonotic diseases have been associated with animal attacks and exposure to rabies (Babcock et al., 2008). However, legal cases have occurred in the USA in which veterinarians have been held liable for zoonotic disease infections contracted by staff, due to inappropriate isolation procedures, lack of education or unsafe work practices (Wright et al., 2008). With the increasingly litigious culture in Australia, this situation can be expected to start occurring more frequently in this country, further highlighting the need to improve workplace conditions and uptake of infection control practices.

Veterinary work environment was also a significant factor for adequate use of PPE, as those working in referral clinics, laboratory, government or research environments were 2.7 times more likely to use adequate PPE than those working in private practice. This is probably due to the corporate nature of most non-private organizations which can be reasonably expected to have corporate occupational health standards and protocols covering all aspects of operations, of which PPE would be just one consideration. An association has previously been documented between having infection control committees (overseeing infection control programs) in veterinary teaching hospitals and these hospitals having written policy documents on infection control (Benedict et al., 2008). Such programs are expected to be less likely in private veterinary practices, particularly smaller private practices with lower staff numbers. Murphy et al. (2010) also present evidence of this with none of 101 community veterinary clinics in southern Ontario having an infection control program. Similarly, a significant association between the absence of a written infection control policy in the work place and a low precaution awareness (based on reported likelihood to take protective action) was identified among small animal and equine veterinarians in the United States (Wright et al., 2008). Given that 79.9% of the veterinarians in this survey worked in a private veterinary practice, the level of implementation of strict biosecurity protocols in the majority of veterinary workplaces is questionable and an area of concern.

Similarly, the variable 'primary type of veterinary work' was also significantly associated with the use of PPE in the second final model including confounders (Table 2) suggesting that those working in large animal practices were three times more likely to use adequate PPE than those working in small/companion animal practices. There was a similar but non-significant trend for equine veterinarians (Table 2). In contrast, in the US study by Wright et al. (2008), fewer large animal and equine veterinarians reported always washing their hands before eating, drinking or smoking at work than small animal practitioners. In that study, most small animal and equine veterinarians but fewer than half of the large animal practitioners reported always isolating the patient and restricting human access

when dealing with an animal suspected of having a serious zoonotic disease. Further investigations are required to understand the reasons for differences in adequate use of PPE in different practice types but the results of this study support the findings from research conducted in human health settings which show that uptake of infection control practices is influenced by a complex combination of institutional, logistical, social, and psychological factors (Whitby et al., 2007).

The results of this study suggest that there is a real requirement for widespread education and extension regarding zoonotic disease risks in veterinary work. Veterinarians' use of PPE is associated with their perception of the risks, and their determination of risk must necessarily be grounded in their knowledge base and their attitudes, such as their ability to control the threat. Increasing information may help to bring veterinarians' use of PPE more closely in line with zoonotic disease risks. Good quality training can strengthen our communal knowledge about zoonotic disease risks and improve the quality of decision making about PPE use in different practice contexts. Further equipping veterinarians with a framework for risk assessment and risk management (such as presented in the AVA Guidelines for Veterinary Personal Biosecurity) provides a decision tree to assess and implement appropriate action to prevent pathogen transmission in any animal disease context. This is the approach needed to improve the quality of decision making by veterinarians regarding the use of PPE to address their zoonotic disease exposure risks.

5. Conclusions

The study identified that substantial improvement is required in the implementation of infection control practices by veterinarians in Australia. Veterinary workplaces will have to change their culture by proactively training and supporting their staff in infection control practices including the use of PPE. Better education, awareness of the risk of zoonotic diseases and of options to manage this risk and liability issues could drive uptake of infection control practices. Veterinarians who do not consider PPE in the course of their daily work are failing in their duty of care (AVA, 2001) to adopt work practices that do not expose themselves, their staff and others to avoidable risk of zoonotic diseases. Targeted education of veterinarians about zoonotic disease risks is needed, along with a widespread campaign to increase awareness amongst veterinarians of the industry guidelines and standards relating to zoonotic disease, infection control programs, as well as their liabilities and legal responsibilities.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.prevetmed.2013.04.002>.

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