Video Observation of Infection Control Practices in Veterinary Clinics and a Petting Zoo, with Emphasis on Hand Hygiene and Interventions to Improve Hand Hygiene Compliance

by

Maureen E. C. Anderson

A Thesis
presented to
The University of Guelph

In partial fulfilment of requirements
for the degree of
Doctor of Philosophy
in
Pathobiology

Guelph, Ontario, Canada

© Maureen E. C. Anderson, April 2013
VIDEO OBSERVATION OF INFECTION CONTROL PRACTICES IN VETERINARY CLINICS AND A PETTING ZOO, WITH EMPHASIS ON HAND HYGIENE AND INTERVENTIONS TO IMPROVE HAND HYGIENE COMPLIANCE

Maureen E. C. Anderson
University of Guelph, 2013

Advisor:
Professor J. S. Weese

This thesis is an investigation of the use of various infection control practices, including hand hygiene, in companion animal veterinary clinics and a public petting zoo.

Video observation of petting zoo visitors found overall hand hygiene compliance was 58% (340/583). Improved signage with offering hand sanitizer (odds ratio (OR) 3.38, p<0.001) and verbal hand hygiene reminders (OR 1.73, p=0.037) had a significant positive association with compliance.

Video observation of preoperative preparation practices in ten veterinary clinics found contact times with preparatory solutions were often shorter than recommended: 10-462s for patients and 7-529s for surgeons using soap and water. Practices that did not conform to guidelines available in major companion animal surgical textbooks were commonly observed.

A survey of veterinary staff found that over 80% of respondents ranked hand hygiene as of high importance in all clinical situations queried. The most frequently reported reason for not performing hand hygiene was forgetting to do so (40%, 141/353).

Video observation of various infection control practices in 47 veterinary clinics found that poor sharps handling practices were common, yet only one needlestick injury was observed. Exam tables were cleaned following 76% (2015/2646) of appointments, and contact time with spray used to do so ranged from 0-4611s (mean 39s, median 9s). Appropriate personal protective clothing was worn for 72% (3518/4903) of staff-animal contacts.

Video observation of hand hygiene practices in 38 veterinary clinics found overall hand hygiene compliance was 14% (1473/10894). Soap and water was used for 87% (1182/1353) of observed hand hygiene attempts with a mean contact time of 4s (median 2s, range 1-49s). A hand hygiene poster campaign had no significant effect on compliance.
There is clearly room for improvement with regard to many frequently used infection control measures in veterinary clinics in Ontario. Use of active interventions to improve practices such as hand hygiene should be investigated in clinics, as such measures have been effective in other settings. The video monitoring system used in this research may be a useful tool for conducting these and similar studies in the future. A better infection control culture needs to be established in veterinary medicine.
Acknowledgements

This work could not have been completed without the help of many people. I especially thank the members of my advisory committee, Drs. Jan Sargeant and Ben Chapman, for the many hours they spent helping me to refine my research projects, reading and commenting on the manuscripts, and generously sharing their experience and advice. I am most grateful to my advisor, Dr. Scott Weese, from whom I have learned so much and who has provided me so many opportunities over the last 11 years that I can never hope to fully repay him. I hope to be able to continue to work with Scott, Jan and Ben throughout my career to come.

I am tremendously appreciative of the financial support of the Canadian Institutes for Health Research (PhD Fellowship Program) and the Ontario Veterinary College Pet Trust. This research also would not have been possible without all of the veterinary clinics and their staff members who were willing to place their trust in me - a complete stranger to many - to perform video surveillance in their facilities, and who also took the time to complete the research survey and provide their feedback. Thank you all.

Finally, I wish to thank all my friends, who have forgiven me time and again for being out of touch or not making it to various events because of work, and who were there to provide an outlet for destressing. Thanks in particular to my PhD-mate, Jason Stull, who was always a sympathetic ear regarding the strifes of graduate life. I am also grateful to my “kits,” Bonnie and Clyde, who provided me with much comfort and company through the long hours of video coding and writing (as long as they’d had their dinner). My thanks and love also go to my partner, Michael Kalistchuk, who has been a first hand witness to (and sometimes victim of) the many exhausted days and nights of this process, and yet still provided hugs and a shoulder to cry on when they were needed most. Last but certainly not least, my gratitude goes to my parents for their constant love, support, and encouragement throughout my studies and my life.
Declaration of Work Performed

I declare that all the work reported in this thesis was performed by
Maureen E. C. Anderson
with the exception of the following:

Coding of video footage from the petting zoo (Chapter 2) was performed by
Brittany A. Foster and Kyle Runeckles

Coding of video footage for preoperative preparation procedures (Chapter 3) was performed by
Brittany A. Foster
Table of Contents

Acknowledgements iv
Declaration of Work Performed v
Table of Contents vi
List of Tables x
List of Figures xiii
List of Appendices xiv

CHAPTER 1: Introduction, Objectives and Hypotheses, Literature Review 1
1.0 Introduction 2
1.1 Objectives and Hypotheses 4
1.2 Literature Review 6
  1.2.1 Introduction 6
  1.2.2 Hand hygiene fundamentals 7
    1.2.2.1 Microbiota of the hands 7
    1.2.2.2 Hand hygiene agents 8
    1.2.2.3 Skin damage due to hand hygiene 10
    1.2.2.4 Hand hygiene technique 10
    1.2.2.5 Hand hygiene timing 12
  1.2.3 Infection control at public animal exhibits 13
  1.2.4 Infection control in veterinary clinics 14
    1.2.4.1 Hospital-associated infections in human healthcare and veterinary medicine 14
    1.2.4.2 Surgical site infections in human healthcare and veterinary medicine 22
  1.2.5 Monitoring infection control practices 27
  1.2.6 Conclusion 28
  1.2.7 References 32

CHAPTER 2: Video observation of hand hygiene practices at a petting zoo and the impact of hand hygiene interventions 46
2.0 Abstract 47
2.1 Introduction 48
2.2 Materials & Methods 49
  2.2.1 Statistical analysis 50
CHAPTER 3: Observational study of patient and surgeon preoperative preparation in ten companion animal clinics in Ontario, Canada

3.0 Abstract 64
3.1 Introduction 65
3.2 Materials & Methods 66
  3.2.1 Statistical analysis 67
  3.2.2 Review of preoperative preparation guidelines in veterinary textbooks 68
3.3 Results 68
  3.3.1 Patient preparation 68
  3.3.2 Surgeon preparation 70
  3.3.3 Review of preoperative preparation guidelines in veterinary textbooks 72
3.4 Discussion 72
3.5 Conclusion 77
3.6 Acknowledgements 83
3.7 References 84

CHAPTER 4: Self-reported hand hygiene perceptions and barriers among companion animal clinic personnel in Ontario, Canada

4.0 Abstract 88
4.1 Introduction 89
4.2 Materials & Methods 90
  4.2.1 Statistical analysis 91
4.3 Results 92
  4.3.1 Quantitative analysis 94
4.4 Discussion 94
4.5 Conclusion 99
4.6 Acknowledgements 107
# CHAPTER 5: Video observation of sharps handling and infection control practices during routine companion animal appointments

5.0 Abstract
5.1 Introduction
5.2 Materials & Methods
  5.2.1 Statistical analysis
5.3 Results
  5.3.1 Sharps handling
  5.3.2 Environmental cleaning
  5.3.3 Personal protective clothing (PPC)
  5.3.4 Animal restraint
  5.3.5 Other observations
5.4 Discussion
5.5 Conclusion
5.6 Acknowledgements
5.7 References

# CHAPTER 6: Video observation of hand hygiene practices during routine companion animal appointments and the effect of a poster intervention on hand hygiene compliance

6.0 Abstract
6.1 Introduction
6.2 Materials & Methods
  6.2.1 Clinic recruitment
  6.2.2 Video observation
  6.2.3 Poster intervention
  6.2.4 Participant consent
  6.2.5 Follow-up survey
  6.2.6 Video coding - Scheme
  6.2.7 Video coding - Process
  6.2.8 Statistical analysis
6.3 Results
  6.3.1 Quantitative analysis - Hand hygiene compliance
  6.3.2 Quantitative analysis - Hand hygiene product contact time
  6.3.3 Follow-up survey
6.4 Discussion
6.5 Conclusion
6.6 Acknowledgements
6.7 References

CHAPTER 7: Discussion & Conclusion
7.0 Discussion
7.1 Conclusion

APPENDICES
## List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1.2.1</td>
<td>Relative efficacy of various classes of biocides commonly used in hand hygiene products against different types of microorganisms&lt;sup&gt;1&lt;/sup&gt;</td>
<td>30</td>
</tr>
<tr>
<td>Table 2.1</td>
<td>Characteristics of visitors to the petting zoo for which video data were coded for each of the five hand hygiene intervention periods</td>
<td>56</td>
</tr>
<tr>
<td>Table 2.2</td>
<td>Univariable logistic regression analysis of factors associated with performing hand hygiene&lt;sup&gt;1&lt;/sup&gt; during a visit to a petting zoo (N=583)</td>
<td>57</td>
</tr>
<tr>
<td>Table 2.3</td>
<td>Multivariable logistic regression analysis of factors associated with performing hand hygiene&lt;sup&gt;1&lt;/sup&gt; during a visit to a petting zoo (N=583)</td>
<td>58</td>
</tr>
<tr>
<td>Table 3.1</td>
<td>Agents used for routine preoperative patient preparation and surgeon preparation in 10 companion animal clinics in Ontario, as reported on-site by clinic staff, including manufacturers’ recommended contact times as per product labels</td>
<td>78</td>
</tr>
<tr>
<td>Table 3.2</td>
<td>Number of preoperative patient preparation procedures (“patient preps”), including surgical site or intended surgical procedure, in 10 companion animal clinics in Ontario recorded using video observation</td>
<td>79</td>
</tr>
<tr>
<td>Table 3.3</td>
<td>Contact times for soap-and-water and alcohol used in different steps&lt;sup&gt;8&lt;/sup&gt; of preoperative patient preparation in 10 companion animal clinics in Ontario recorded using video observation</td>
<td>80</td>
</tr>
<tr>
<td>Table 3.4</td>
<td>Number of surgeons and preoperative surgeon preparation procedures (“surgeon preps”) in 10 companion animal clinics in Ontario recorded using video observation, as well as type of preparation agent used (soap-and-water or alcohol-based hand rub) and mean and range of contact time with agent</td>
<td>81</td>
</tr>
<tr>
<td>Table 3.5</td>
<td>Comparison of recommendations for preoperative patient and surgeon preparation from three major small animal surgery textbooks available in Ontario since 2010</td>
<td>82</td>
</tr>
<tr>
<td>Table 4.1</td>
<td>Distribution by gender and role of survey respondents from 49 companion animal clinics in Ontario</td>
<td>101</td>
</tr>
<tr>
<td>Table 4.2</td>
<td>Ranking by staff from 49 companion animal clinics in Ontario of the perceived importance of hand hygiene in various scenarios</td>
<td>102</td>
</tr>
</tbody>
</table>
Table 4.3  Univariable associations with a p-value <0.10 between each of 4 separate outcomes and 6 predetermined variables of interest\(^1\), as per the results of a survey of personnel from 49 companion animal clinics in Ontario

Table 5.1  Distribution by gender and role of study participants from 47 companion animal clinics in Ontario

Table 5.2  Selected sharps handling behaviours observed during 1359 routine companion animal appointments in 47 veterinary clinics in Ontario, and their independent associations with ready availability of an approved sharps disposal container

Table 5.3  Commonly observed types of inappropriate personal protective clothing (PPC) observed during 4903 staff-animal contacts during 2713 routine appointments in 47 companion animal clinics in Ontario

Table 5.4  Additional observations of factors relating to infection control made during video monitoring of 47 companion animal clinics in Ontario

Table 6.1  Common procedures considered “clean” or “dirty,” warranting hand hygiene before or after being performed, respectively, for the purposes of a video coding scheme used to measure hand hygiene compliance in companion animal veterinary clinics

Table 6.2  Information coded at the clinic, appointment, individual and hand hygiene opportunity level from video monitoring footage collected at 38 companion animal veterinary clinics in Ontario

Table 6.3  Selected descriptive data for 38 companion animal veterinary clinics in Ontario included in the analysis for the video observation hand hygiene intervention trial

Table 6.4  Distribution of hand hygiene opportunities observed during 2278 routine companion animal appointments in 38 veterinary clinics in Ontario, according to opportunity type and whether a hand hygiene attempt was observed, not performed or not observed

Table 6.5  Contact times with water alone, soap, and alcohol-based hand sanitizer observed during 1343 hand hygiene attempts associated with routine companion animal appointments at 38 veterinary clinics in Ontario
Table 6.6  Hand hygiene technique scores\(^1\) for 379 hand hygiene attempts with product contact times > 1 s observed in 35 companion animal veterinary clinics in Ontario

Table 6.7  Hand drying techniques observed for 1332 hand hygiene attempts associated with routine companion animal appointments at 38 veterinary clinics in Ontario

Table 6.8  \(p\)-values for each of the fixed and random effects in the final multivariable mixed logistic regression model for observed hand hygiene compliance for opportunities associated with routine companion animal appointments at 38 veterinary clinics in Ontario (\(n = 10894\))

Table 6.9  \(p\)-values for each of the fixed and random effects in the final multivariable mixed linear regression model for product contact time for hand hygiene attempts associated with routine companion animal appointments at 38 veterinary clinics in Ontario (\(n = 1330\))
List of Figures

| Figure 1.2.1 | Hand hygiene technique training poster from the Ontario Ministry of Health and Long-Term Care (2007) showing appropriate technique for hand hygiene with soap and water and with alcohol-based hand sanitizer (63) | 31 |
| Figure 2.1 | Diagram of the layout of the petting zoo exhibit, including location of overhead surveillance cameras, hand hygiene stations (sink and hand sanitizer bottles) and additional signage used during specific hand hygiene intervention periods | 59 |
| Figure 4.1 | Ranking by companion animal veterinary staff (n = 348) of their own clinic (n = 49) on a scale of 0 (worst) to 10 (best) in terms of good hand hygiene practices among veterinary clinics in general | 104 |
| Figure 4.2 | Ranking by companion animal veterinary staff of the potential effectiveness (1 = not effective, 7 = very effective) of different hand hygiene interventions for permanently improving hand hygiene practices in their respective clinics | 105 |
| Figure 4.3 | Proportion of companion animal clinics from which at least one survey respondent indicated that a particular hand hygiene intervention was already in use at the clinic (n=49) | 106 |
| Figure 6.1 | Probabilities for each variable and interaction included in the final multivariable random effects logistic regression model for observed hand hygiene compliance for opportunities associated with routine companion animal appointments at 38 veterinary clinics in Ontario (n = 10894) | 172 |
| Figure 6.2 | Median values (geometric means) for each variable and interaction included in the final multivariable random effects linear regression model for product contact time for hand hygiene attempts associated with routine companion animal appointments at 38 veterinary clinics in Ontario (n = 1330) | 173 |
| Figure 6.3 | Self-perceived impacts of a hand hygiene poster intervention on individual hand hygiene awareness and practices, ranked on a scale of 1 (not at all) to 7 (very much), as reported by 271 staff members from 37 companion animal veterinary clinics in Ontario | 174 |
## List of Appendices

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix 4.1</td>
<td>Survey distributed to veterinary clinic staff following a video observation study evaluating the effectiveness of a hand hygiene poster campaign to improve hand hygiene compliance</td>
<td>187</td>
</tr>
<tr>
<td>Appendix 6.1</td>
<td>Posters used as an intervention to help improve hand hygiene compliance among staff in companion animal veterinary clinics in Ontario. A: Poster A, which was mounted in exam rooms (actual size 22 cm x 28 cm); B: Poster B, which was mounted in backroom areas (actual size 28 cm x 22 cm)</td>
<td>194</td>
</tr>
<tr>
<td>Appendix 6.2</td>
<td>Justification for the key elements included on Posters A and B (see Appendix 6.1) designed to help improve hand hygiene compliance among staff in companion animal veterinary clinics in Ontario.</td>
<td>197</td>
</tr>
<tr>
<td>Appendix 6.3</td>
<td>Additional details of video coding scheme used to measure hand hygiene compliance in companion animal veterinary clinics</td>
<td>198</td>
</tr>
<tr>
<td>Appendix 6.4</td>
<td>All contrasts of associations for variables included in the final multivariable random effects logistic regression model for observed hand hygiene compliance for opportunities associated with routine companion animal appointments at 38 veterinary clinics in Ontario (n = 10894)</td>
<td>200</td>
</tr>
<tr>
<td>Appendix 6.5</td>
<td>Histogram and normal quantile plot for residuals of the final multivariable random effects linear regression model for product contact time at the sample level (hand hygiene attempt) after log transformation of the outcome</td>
<td>203</td>
</tr>
<tr>
<td>Appendix 6.6</td>
<td>All contrasts of associations for variables included in the final multivariable random effects linear regression model for product contact time for hand hygiene attempts associated with routine companion animal appointments at 38 veterinary clinics in Ontario (n = 1330)</td>
<td>204</td>
</tr>
</tbody>
</table>
CHAPTER 1:

Introduction
Objectives & Hypotheses
Literature Review
1.0 Introduction

Human and animal health are inextricably intertwined. Recognition of this fact is a key element of the “one health” concept which, though not a new idea, has been garnering increasing attention in recent decades. The link between human and animal health is particularly clear when it comes to infectious diseases. It has been estimated that 61% of known pathogens affecting humans are zoonotic (i.e. they can be transmitted between animals and people), and that 75% of emerging diseases in people are zoonoses (1,2). Widespread epidemics of zoonotic diseases, such as severe acute respiratory syndrome (SARS) and H1N1 “swine” influenza, and large outbreaks caused by foodborne zoonotic pathogens such as *Salmonella* spp., typically receive extensive media coverage due to the large number of people acutely affected.

While control of epidemics is clearly important, the burden of sporadic and endemic zoonotic disease, though much more difficult to quantify, must not be ignored. Infections that occur at this level cannot be dealt with in quite the same way, by using epidemic preparedness plans, outbreak control strategies, product recalls and other similar approaches. Members of the public need to take some responsibility for their own health, by practicing simple, everyday infection control measures, such as hand hygiene, covering a cough and safe food handling, to help decrease the risk of pathogen transmission between themselves, their environment, other people and animals. The role of public health organizations and government agencies is not to “watch over the shoulder” of every person to ensure these steps are taken, but to find the best ways to educate and motivate individuals to undertake this responsibility themselves. If done successfully, the burden of disease on healthcare, public health and society in general could be significantly decreased, freeing resources to help handle problems that are more effectively dealt with at an agency or regulatory level.

Infection control in healthcare is, in a way, the next level up from infection control within the community. Many different people are involved in activities within healthcare facilities, including healthcare workers, support staff and patients, and each person must be relied upon to do their part in order to keep pathogen transmission at bay. There are increased risks in this environment, with many ill and susceptible individuals, so it makes sense that there is more training and emphasis on infection control practices for employees and patients within the healthcare system compared to the general public. Although there are many measures taken in hospitals to help control pathogen transmission, from building design and control of airflow to cohorting and isolation of various patients, the simple practice of hand hygiene is still considered the most important measure for preventing hospital-associated infections (3). Before the antibiotic era, the discovery of the effects of hand hygiene, use of antiseptics and aseptic
technique, coupled with the understanding of the germ theory of disease, may have had the greatest impact on patient survival with regard to infectious diseases of any other medical advancement (3-5). With the dawn of antibiotics, many thought infectious diseases would become a thing of the past altogether (6), and the focus on prevention measures may have lapsed due to the ease with which infections could seemingly be treated. However, in the late 20th and early 21st century, with the effectiveness of the antibiotic arsenal waning, prevention has come to the forefront once again.

Contact with animals sometimes “flies under the radar” with regard to infectious diseases and public health. While there are certainly many more pathogens that can be transmitted between humans than between humans and animals, given how commonly people have contact with pets or animals in private and public venues, and the potential for animals to act as carriers or vectors of a wide variety of microbes capable of infecting humans, they are a significant source to consider. From a veterinary perspective, it is equally important to bear in mind that just as animals can act as carriers or vectors of human diseases, so humans can act as carriers or vectors of animal diseases. Thus, infection control measures such as hand hygiene become equally important for protecting the health of patients and staff in veterinary clinics as they are in human healthcare facilities, regardless of patients and staff in veterinary clinics being of different species. Until recently there has been relatively little focus on everyday infection control practices in veterinary medicine. As in public health, what is needed is not necessarily more regulation and top-down “big brother is watching”-type measures, but rather development and use of monitoring systems and other tools to gather information about what is being done, how and why, and to find the critical control points and the kinds of interventions that will be most effective for promoting sound infection control practices, in order to improve the “one health” of humans and animals alike.
1.1 Objectives and Hypotheses

The overall goals of this PhD research project were to investigate the current use of hand hygiene and other frequently used (e.g. everyday) infection control measures, primarily in non-equine companion animal veterinary clinics in Ontario as well as at a public petting zoo, to evaluate the effectiveness of specific interventions for improving hand hygiene in these settings, and to gain a better understanding of the factors involved in routine infection control around animals compared to in human healthcare. A secondary goal was to evaluate the use of a video recording system for monitoring a variety of routine practices in veterinary clinics and a busy public venue.

Study 1 (Chapter 2): Video observation of hand hygiene practices at a petting zoo and the impact of hand hygiene interventions

The objectives of this initial study were to determine overall hand hygiene compliance of visitors to a public petting zoo using video webcams, and to evaluate the impact of active and passive interventions on hand hygiene compliance. It was hypothesized that compliance would be similar to that reported in previous studies (~40%), and that active interventions would have a significant positive effect on compliance.

Study 2 (Chapter 3): Observational study of patient and surgeon preoperative preparation in ten companion animal clinics in Ontario, Canada

The objectives of this pilot study were to describe preoperative patient and surgeon preparation practices in a small sample of companion animal veterinary clinics, to investigate factors that may be associated with specific key practices, and to determine if there were any areas that consistently did not meet current guidelines. It was hypothesized that a wide variety of practices would be observed for common procedures, and that at least some of them would not conform to guidelines available in major companion animal surgery textbooks. This study also served as a trial to assess the feasibility of using wireless video webcams to monitor activities in veterinary clinics.
Study 3 (Chapter 4): Self-reported hand hygiene perceptions and barriers among companion animal veterinary clinic personnel in Ontario, Canada

The objectives of this study were to describe the perceived importance of hand hygiene at various times and as an overall infection control measure among companion animal veterinary clinic staff, as well as potential barriers and other factors that may be associated with hand hygiene compliance. It was hypothesized that participants would place only moderate importance on hand hygiene, and that the major barriers would include lack of time and lack of conveniently located hand hygiene stations.

Study 4 (Chapter 5): Video observation of sharps handling and infection control practices during routine companion animal appointments

The objectives of this study were to describe sharps handling practices, the occurrence of observable needlestick and sharps injuries (NSIs), the use of personal protective clothing (PPC) and environmental cleaning associated with routine companion animal appointments, in addition to various clinic-level infection control-related practices, in veterinary clinics in Ontario. As NSIs among veterinary staff are a common occurrence based on other studies, it was anticipated that at least a small number of NSIs would be observed associated with high-risk practices such as recapping of needles. It was also hypothesized that use of PPC would vary considerably by clinic, and that contact times for environmental disinfectants would typically be short (<30 s).

Study 5 (Chapter 6): Video observation of hand hygiene practices during routine companion animal appointments and the effect of a poster intervention on hand hygiene compliance

The objectives of this study were to describe hand hygiene practices associated with routine appointments in companion animal clinics in Ontario, and the effectiveness of a poster campaign to improve hand hygiene compliance. It was hypothesized that hand hygiene compliance would be lower than self-reported compliance in other studies (<40%), and that the poster campaign would have a small but detectable effect on compliance (20-30%).
1.2 Literature Review

1.2.1 Introduction

Zoonotic pathogens transmitted by companion animals and other animals that may have direct contact with the public often receive little attention, likely because they do not typically result in dramatic large-scale disease outbreaks. Yet, according to the “one health” concept (7), controlling the spread of pathogens between animals and people and even between animals themselves has the potential to impact the health of humans and animals alike. For example, animals in public exhibits such as petting zoos have the potential to transmit pathogens to a large number of people in the community. Numerous outbreaks of disease associated with petting zoos have been documented (8), but it is likely that many instances of transmission, particularly those resulting in sporadic gastrointestinal illness, go undetected (9). Careful attention to animal health and infection control at these venues is therefore important to public health.

Most companion animals have a limited ability to spread infection in terms of the number of people with whom they have contact. Possible exceptions to this may include animals such as therapy dogs and animals used in an educational function, as these pets have contact with larger numbers of people (10). However, pet contact among people is common. It was estimated that in 2006 60% of US households owned a pet (11), that in 2008 56% of Canadian households owned a dog or cat (12), and in a 2010 survey of individuals visiting two primary care medical clinics in Waterloo, Ontario, 64% had a pet in their household, and at least one member of non-pet owning households had regular (weekly) animal contact outside the home (13). Furthermore, companion animals often have very close contact with the people with whom they live and interact, which increases the risk of disease transmission. Small companion animals (primarily dogs and cats) live in people’s homes; they may be present in food preparation and eating areas; they may share sleeping areas with their owners (e.g. bed, couch); they have frequent contact with people’s hands through petting and grooming; and they often have face-to-face contact through kissing and licking (14). It has also been shown that a small percentage of even clinically normal pets can carry potentially harmful zoonotic pathogens (10,15-21), although it is likely that all pets harbor multiple zoonotic microbes of various kinds that could be transmitted to humans and cause disease under certain conditions (e.g. high-risk individuals who are very young, very old, immunocompromised or pregnant). The health of companion animals therefore also has the potential to significantly impact the health of humans and vice versa. Veterinary clinics are community hubs where animals and people of many different backgrounds and health statuses may encounter one another, making them a prime location for transmission and amplification of both zoonotic and companion animal-specific pathogens. Infection control efforts within these facilities are therefore of paramount importance to controlling disease spread. Disease outbreaks within or originating from veterinary clinics involving patients, staff and community members have been reported (22-25), and many others may go unreported or unnoticed.
One of the most basic infection control measures that can be used by lay and professional individuals alike in any of these situations is hand hygiene. Hands are likely the most common vehicle by which pathogens are transferred to the mouth (26), as well as to and from individuals and their environment. The simple practice of hand hygiene has garnered a great deal of focus in the human healthcare and infection control field, yet it has been relatively neglected with regard to veterinary healthcare and the handling of animals.

**1.2.2 Hand hygiene fundamentals**

**1.2.2.1 Microbiota of the hands**

The normal microbiota of the hands consists of at least two different microbial populations. The transient microbiota are bacteria (and occasionally viruses and fungi) that are easily picked up from and deposited on surfaces with which the skin has contact. This population is the most likely to include pathogenic organisms (3,27,28). The resident microbiota, which live on the skin’s surface as well as under the superficial cells of the stratum corneum, are primarily bacteria that have an established microbial niche in the skin of the hands, in which they normally live in equilibrium with each other. The resident microbiota also have a protective function for healthy skin in that they help prevent colonization with other (potentially pathogenic) bacteria (27). Opportunistic pathogens may be a part of either the transient or resident microbiota, and can cause infection if the skin is damaged (27,28). Reported total bacterial counts on the hands of healthcare workers range from $2.0 \times 10^4$ to $4.6 \times 10^6$ CFU, including a wide range of bacterial groups such as staphylococci (e.g. *Staphylococcus aureus*, coagulase-negative staphylococci), streptococci, enterococci, corynebacteria, *Pseudomonas* spp., *Klebsiella* spp., *Acinetobacter* spp., *Serratia* spp. and fungal organisms such as *Candida* spp., with up to 17 different species being isolated from a single sample (3,29,30).

In the context of infection control, the goal of hand hygiene is to reduce (or eliminate) the transient microbiota of the hands asatraumatically as possible, in order to decrease the likelihood of transfer of pathogenic or opportunistic microbes from the hands to other surfaces, tissues or individuals (27,28). This may be accomplished by physical removal of the microbes from the skin, or use of antimicrobial compounds that kill or neutralize the microbes. The resident microbiota are more difficult to remove but they are also less likely to be pathogenic (3,31). Complete elimination of the resident microbiota (i.e. sterilization of the skin) is not desirable, as this cannot be accomplished without causing significant damage to the skin. Such damage provides niches for opportunistic pathogens to cause infection, resulting in pain and discomfort as well as increased risk of transmission due to the larger number of pathogenic bacteria present on the skin (27,29,32).
Hand hygiene can be broken down into several components, all of which need to be properly addressed for hand hygiene to be effective. These components are: use of a suitable cleaning/disinfecting agent, proper technique (which includes allowing suitable contact time with the selected cleaning/disinfecting agent, ensuring cleaning of all contaminated parts of the hands, and avoiding recontamination of hands immediately after hand hygiene is performed), and timing (frequency) of hand hygiene.

1.2.2.2 Hand hygiene agents

Agents used for performing hand hygiene include water, plain soaps, antibacterial soaps, and waterless hand sanitizers (WHSs) (which include alcohol-based hand sanitizers (AHSs) and non-alcohol-based hand sanitizers (NAHSs)). The goal of using any of these agents is to either physically remove the transient microbiota (including potential pathogens) from the hands or to kill the transient microbiota if possible, with or without having some residual action against microbial contaminants. In the US, the Food and Drug Administration (FDA) regulates licensing of all antiseptic handwash products and WHSs intended for use by healthcare workers (3). A standardized evaluation procedure is used, based on a modified standard procedure of ASTM International (formerly the American Society for Testing and Materials (ASTM)), which must ultimately result in a $2\log_{10}$ reduction in the indicator organism on the hands within five minutes after the first use of the product, and a $3\log_{10}$ reduction within five minutes after the tenth use (33). Products intended for use as preoperative scrubs or rubs are tested using a different standardized protocol over several days, and must ultimately result in a $1\log_{10}$ reduction in the total number of bacteria on the hands within one minute of the first use, a $2\log_{10}$ reduction within one minute of use on the second day and a $3\log_{10}$ reduction within one minute of use on the fifth day. Also, the bacterial count on the hands cannot exceed the baseline level within six hours on the first day while the hands remain gloved (33). In Canada, Health Canada requires similar testing based on standard European (European Committee for Standardization, CEN) and North American (ASTM International) test methods for different classes of hand hygiene and preoperative hand and patient preparation products intended for use in healthcare facilities under the Food and Drugs Act (34).

Soaps

Although simply rinsing hands with water can remove some superficial skin cells and loosely-adherent bacteria through mechanical flushing action (27), in the clinical setting the use of soap (either antimicrobial or non-antimicrobial depending on the specific situation) and water is recommended (3,35,36). All soaps must be used in combination with water in order to be effective. Soaps or detergents are primarily emulsifying agents that break up oils to help mechanically remove contamination from the
hands via the flushing action of the water (3,31). Plain soap has no residual activity against microorganisms. In some cases, washing with plain soap has been shown to be inadequate for removal of pathogens from the hands of healthcare workers, and may even result in increased bacterial counts on hands (37,38). Use of antibacterial soap is therefore typically recommended in healthcare settings; however, innate or acquired resistance to the biocides used in many antibacterial soaps (which may also be used in WHSs) has been reported, and there is concern that some of the resistance mechanisms involved may either co-select for antimicrobial-resistance or offer cross-protection against certain antimicrobials (39,40). For this reason, antimicrobial soap should not be used in lower-risk situations (e.g. homes, general public restrooms) where it is likely unnecessary (41,42). Unfortunately, due to consumer perceptions and pressures, such unwarranted use of antibacterial products has become common (43,44).

**Waterless hand sanitizers (WHSs)**

Waterless hand sanitizers have become very common in healthcare settings and even in busy public areas. One of their primary advantages is their convenience, because water (and therefore sinks/plumbing and equipment/materials for drying hands) is unnecessary. Alcohol-based hand sanitizers rely on the action of the alcohol component to rapidly kill microorganisms by denaturing and coagulating proteins and disrupting the cellular membrane, leading to lysis (27). These products are generally most effective at an alcohol concentration of 65-90%, depending on the specific alcohol they contain (3,27). After application, the alcohol component evaporates relatively quickly, but many AHSs also contain other active ingredients (e.g. chlorhexidine, quaternary ammonium compounds, octenidine, triclosan) that remain on the skin and provide some residual antiseptic action (3). A disadvantage of AHSs is that they are flammable due to their high alcohol content, and this has been an issue in terms of placing AHS dispensers in some public places and schools in particular (45-47). Rarely individuals have also consumed AHS in an attempt to inebriate themselves (47), and there are concerns about the potential for children to ingest a toxic quantity accidentally (46). These products may contain propanol, isopropanol or ethanol. Ethanol used in these products can be denatured in order to make it toxic and/or extremely bitter-tasting so as to deter consumption (47). Propanol and isopropanol are toxic and have no inebriating effects in people (48).

Non-alcohol-based hand sanitizers may contain a variety of compounds, with various mechanisms of action, intended to have the same rapid-kill effect as alcohol. Objective studies demonstrating the efficacy of NAHS in vitro or in vivo, as well as studies comparing NAHSs and AHSs, are few (49-52), which is why NAHSs were not considered in the most recent hand hygiene guidelines produced by the Centers for Disease Control and Prevention (CDC) (3,27). More recently, novel
guanidine-based disinfectants have been investigated for potential use in topical prophylaxis and treatment of skin infections (53,54) and as NAHS (55). The NAHS investigated by Agthe et al. (55) showed equal microbiological efficacy to AHS in vitro, was well tolerated by hospital personnel and was not significantly irritating to the skin. The clinical efficacy and cost of this product have yet to be directly compared to AHS, but it has the potential to become an alternative in situations where WHS is desirable but there is a need or desire to avoid alcohol-based products.

The major disadvantage of WHSs (both alcohol- and non-alcohol-based) is that they do not physically remove microorganisms from the skin. There are some microorganisms that are inherently resistant to even the non-specific killing action of alcohol (e.g. clostridial spores, Cryptosporidium oocysts, certain non-enveloped viruses)(Table 1.2.1), therefore AHSs are theoretically ineffective at controlling contamination with these types of pathogens (3). Significant (i.e. visible) amounts of dirt, debris or other contaminants are not removed by using WHS, and may protect microorganisms from the action of the active ingredients in these products. If there is suspected contamination with an alcohol-resistant pathogen or if hands are visibly soiled, it is recommended that soap and water be used instead of a WHS (3,56,57). However, it has been shown that AHS may still be more effective than soap and water at reducing bacterial counts when small amounts of contamination (i.e. blood) are present on the hands (58).

1.2.2.3 Skin damage due to hand hygiene

Frequent hand washing using any soap or alcohol-based agent can result in significant skin damage (e.g. drying, chapping, cracking). This can be a major deterrent to compliance, and also makes the skin harder to clean and more likely to become infected or colonized with pathogenic organisms (3,27,32). Many hand hygiene products therefore also contain moisturizing agents to help prevent skin damage from drying (3,59). Hand washing with antibacterial soap (particularly products containing high concentrations of chlorhexidine (4%)) has been found to be the most damaging (27), which is another reason AHSs have become increasingly popular alternatives for hand hygiene. It has been recommended that healthcare facilities also provide staff with ready-access to separate hand moisturizing products to help prevent irritant contact dermatitis (31,32).

1.2.2.4 Hand hygiene technique

Hand hygiene technique and duration are critical for effective reduction of the transient microbiota. For hand washing with soap and water, recommended techniques are well described (3,31,56,57) and generally include the following steps: use of luke-warm water, initial wetting of hands,
application of an appropriate amount of soap, lathering of soap, scrubbing of hands in a systematic fashion, rinsing and drying. An example of a hand hygiene technique training poster is shown in Figure 1.2.1. Water temperature is important to help prevent additional skin damage that can result from repeated use of hot water (27,60). Bar soap should not be used for routine hand hygiene in healthcare settings, as bars can become contaminated with dirt and debris and ultimately increase transmission of microbes from person to person with sequential use (61). Liquid soap in a convenient dispenser should be used instead. However, if bar soap is employed, it is recommended that only small cakes be used and they must be set out on racks so that they dry between uses (3,56). Lathering of soap is facilitated by use of foaming soaps; however, it is important that adequate contact time with the soap is maintained even though the lathering process is significantly shortened. It is generally recommended that soap be applied for a minimum of 10-20 seconds before rinsing (3,31,57,62-64) with the entire hand washing procedure taking 40-60 seconds (3,56). Scrubbing technique is frequently compromised when time constraints become an issue. Areas of the hand most often missed during washing are under the nails, the back of the fingers, the back of the hands and parts of the thumbs (31).

Drying of hands is also an important step in the hand washing process, as bacteria are more easily transferred from hands when the skin is wet (65). Warm air driers eliminate towel litter, but they may cause excessive drying of the skin. It has also been shown that warm air driers as well as newer jet air driers may actually increase the potential for transmission of some pathogens (66) via spread around a room on the strong air currents produced, although several earlier studies did not support this finding (67-69). Disposable towels are the preferred means of hand drying, as they ensure there is no transmission of bacteria from hand to hand through sequential use by different people, and are more efficient in terms of drying time than warm air dryers (31). The results of studies comparing use of towels and warm air driers for reducing bacterial counts on hands seem to be equivocal (52,67,69,70). Disposable towels are also important to help prevent immediate recontamination of hands after washing through contact with faucet controls (if not automatic) and in some cases door handles. This is done by using the used towel to protect the hands when turning off the water faucet and/or opening the door to exit the room (31,56).

The recommended technique for use of WHSs is generally application of a sufficient amount of the product to one palm, followed by rubbing together of the hands in a systematic fashion (similar to that used for washing with soap and water) until dry. The recommended amount of WHS to use varies by product, but in general enough should be used that at least 20-30 seconds of vigorous rubbing are needed before the hands are once again dry (3,56). As for hand washing, it is important that the product is applied to all areas of the hand, particularly problem areas such as the nail beds, finger webs and back of the hand.
Another advantage of WHSs is that the risk of recontamination of the hands immediately after use is decreased by the lack of a need to touch any object or surface once the product has been dispensed.

1.2.2.5 Hand hygiene timing

Use of an appropriate agent and proper technique for hand hygiene are irrelevant if hand hygiene is not performed at the right time. Hand hygiene should be used after activities that may result in contamination of the hands, as well as before activities that may result in transmission of the transient flora of the hands to a common surface or another person or animal. Individuals have a relatively easy time remembering to wash their hands when they are visibly soiled, with the possible exception of veterinary personnel working in a situation when their hands are expected (or accepted) to be dirty, such as in a barn environment. Unfortunately, in the majority of human and veterinary healthcare situations as well as much of everyday life, microbial contaminants on the hands are not accompanied by visible dirt. In healthcare, be it human or veterinary, hand hygiene should ideally be performed before and after every patient contact (3,31,56,57) – before to prevent transmission of pathogens to the patient, and after to prevent transmission of any pathogens from the patient to the healthcare worker, environmental surfaces or subsequent patients. As much as possible, hand hygiene should be performed immediately before and after patient contact, in order to minimize the opportunity for contamination of the hands or by the hands of the person in question. This requires hand hygiene stations to be readily available in all patient contact areas, or for individuals to carry their own supply of a WHS.

Hand hygiene is also necessary after glove removal in situations where gloves are worn for patient or specimen contact (3,31,56,57). Glove use may be misconstrued as a substitute for hand hygiene, and has been reported as a barrier to hand hygiene in other studies (28,71,72). Pre-existing defects or damage to gloves during use, as well as the potential for contamination of the hands during glove removal make gloves an imperfect barrier (3,57,73); therefore, hand hygiene following glove removal is important. In both healthcare and non-healthcare settings alike, hand hygiene should also be performed after any activity that carries a reasonable risk of hand contamination with potentially harmful pathogens, such as contact with feces (e.g. after using the toilet, scooping dog feces, cleaning a cat litter box), soil or any raw meat/animal product (74,75). Hand hygiene is also recommended before any activity that carries an increased risk of transmission of pathogens from the hands to oneself or a highly-susceptible individual (e.g. preparing or eating food, handling an infant, close contact with an immunocompromised individual) (74,75).
1.2.3 Infection control at public animal exhibits

Petting zoos and other animal exhibits facilitate contact of the public with live animals as part of agricultural fairs and other seasonal or permanent attractions. They are entertaining, but also serve an important educational function for individuals of all ages regarding animals and animal husbandry, and they help to increase compassion for animals of different kinds (8,76). The risk of infectious diseases associated with human-animal contact at public animal exhibits varies according to the animals and individuals involved, as well as the degree of contact that occurs. Risks are higher for young children, with whom petting zoos and similar events are often particularly popular (8,77-80). Risks are also higher among individuals who are immunocompromised and the elderly (8,78,80), all of whom may also potentially visit such exhibits, as well as among pregnant women, who were observed touching animals at 41% (14/34) of petting zoos investigated during one study (81). Based on a general population survey of FoodNet sites in the US, it was estimated that 3.88% of individuals visited a petting zoo or farm in the previous week, and in the UK there are thought to be up to 10 million recreational visitors to open farms and similar venues annually, which indicates how popular these types of activities are (82,83).

Numerous disease outbreaks have been associated with animal contact at public venues. The most commonly reported pathogen in these outbreaks is Escherichia coli O157:H7, but others include Salmonella, Cryptosporidium, Giardia, Coxiella burnetii (Q fever) and dermatophytes (ringworm)(8,79,84-90). There is also potential risk of transmission of other zoonotic pathogens including Campylobacter, methicillin-resistant Staphylococcus aureus (MRSA) and rabies (8,91-93). Most recently, transmission of influenza from swine to humans at agricultural fairs has also been recognized (94-96). While outbreaks receive the greatest attention, there may be a significant level of morbidity from sporadic infections that are not reported to public health officials or linked to petting zoo exposure. Overall, there is limited information regarding the disease burden associated with petting zoos.

Several organizations have published recommendations for management of live animal exhibits such as petting zoos, intended to help decrease the risk of pathogen transmission from animals to the public (8,80,84,97). Some of the key recommendations typically include avoiding use of potentially dangerous or clinically ill animals, taking special precautions to prevent contact between high-risk individuals (e.g. children less than five years of age) and high-risk animals (e.g. young ruminants, birds, reptiles, amphibians), physical layout considerations to control visitor contact with animals and overall flow through the exhibit, exclusion of food and drink for human consumption from the area, and visitor education with particular emphasis on hand hygiene. While these are sound guidelines based on general infection control principles, there has been no objective assessment of the efficacy of their use at public venues.
venues, and implementation of these recommendations is still poor in many facilities (81,92,98). Studies to help pinpoint those factors with the greatest potential to decrease pathogen transmission risk are needed.

According to the National Association of State Public Health Veterinarians, “the recommendation to wash hands is the most important prevention step for reducing the risk for disease transmission associated with animals in public settings.” (8) Failure to perform hand hygiene has been identified as a significant risk factor for disease in numerous outbreaks associated with animal exhibits (77,84,85,90,99). Previous disease outbreaks associated with live animal exhibits have involved both visitors who did and did not report direct contact with animals, and outbreak strains of E. coli and Salmonella have been found on numerous surfaces at petting zoos and in similar environments (77,85,90,99-101). Thus it is recommended that all individuals who enter an animal exhibit perform hand hygiene before leaving the area, regardless of whether they had direct contact with an animal (8). However, hand hygiene compliance at petting zoos and similar public exhibits has been reported to be poor, with mean compliance ranging from 31-38% (76,81,98). Studies have found that the presence of a hand hygiene station on an exit route, the presence of hand hygiene reminder signs, availability of running water and the presence of a staff member within or at the exit of the animal area were all positively associated with hand hygiene compliance (81,98). This suggests that having a well-designed petting zoo that follows recommended guidelines can improve hand hygiene compliance, yet there is still room for improvement even in facilities designed and operated according to current recommendations. Identification of specific interventions that are effective for increasing hand hygiene compliance would be beneficial.

1.2.4 Infection control in veterinary clinics
1.2.4.1 Hospital-associated infections in human healthcare and veterinary medicine

In a 2002 survey of hospitals across Canada, the point prevalence of hospital-associated infections (HAIs) (i.e. infections acquired by patients while in hospital) was estimated at 10.5%, which is similar to the risk reported in other developed countries (102). Hospital-associated infections affect approximately 250,000 patients and kill between 9000 and 12,000 patients in Canadian hospitals every year (103). They are the fourth leading cause of death in Canada (104). Hospital-associated infections are more common among patients in surgical wards and intensive care units, which is attributable to the increased susceptibility of these patients to infection due to the severity of their illnesses and the invasive procedures they undergo (102). Furthermore, HAIs caused by antimicrobial-resistant pathogens are associated with increased mortality, length of hospitalization and overall healthcare costs (from $6000-$30,000 US more per case) compared to those caused by antimicrobial-susceptible organisms (105).
has been estimated that 36.9% of adverse events in Canadian hospitals, including HAIs, are highly preventable (106).

Hospital-associated infections are also an important, though poorly quantified, problem in veterinary medicine. Surgical site infections (SSIs) are the most studied type of HAI in animals, but even for these data on infection rates is limited (see Section 1.2.4.2: Surgical site infections). In addition to animal morbidity, HAIs of any kind can be very concerning and frustrating for owners and veterinarians alike, and zoonotic pathogens may pose a risk to owners, personnel, and their families. As in human medicine, higher-risk animals, such as immunocompromised and surgical patients, may be particularly susceptible to hospital-associated pathogens. Modern advances in veterinary care are making these high-risk patients more common. Treatment of infections with antimicrobials is becoming more problematic due to increasing bacterial antimicrobial resistance. All of these factors have made prevention and control of infections in veterinary hospitals, as in human hospitals, increasingly important considerations.

Results of a survey of biosecurity personnel at 38 AVMA-accredited veterinary teaching hospitals showed that 82% of these facilities reported at least one outbreak of hospital-associated disease in the last five years, and 32% had been forced to close areas of the hospital in order to contain the spread of a pathogen (25). The rate of HAIs is more difficult to assess in most primary-care companion animal veterinary clinics because of the relatively small at-risk population, because these clinics may be ill-equipped to perform adequate surveillance to assess endemic rates and detect outbreaks, and because practitioners may be reluctant to report HAIs due to fear of such adverse events reflecting poorly on them. Hospital-associated infections are therefore likely both under-recognized and under-reported. Nonetheless there are several reports of hospital-associated disease outbreaks in the veterinary literature, some of which include evidence or suspicion of zoonotic transmission as well. These include outbreaks of infection caused by Salmonella Typhimurium and multidrug-resistant Salmonella, as well as hospital-associated and community spread of MRSA between animals and people (22,23,107). Appropriate infection control precautions in veterinary clinics are therefore critical to the health of not only the patients, but also staff and members of the public.

Infection control and hand hygiene: Evidence of the effectiveness of hand hygiene

Hand hygiene is said to be the single most important factor in infection control in hospitals and other healthcare facilities (3). It is also a key intervention point to help prevent the spread of common zoonotic pathogens, including MRSA and enteropathogens, from animals to humans and vice versa.
Recommendations regarding hand hygiene, including when, how and how often it should be performed, appear in guidelines from multiple healthcare-associated organizations (3,31,36,56,109-111).

Many studies in human medicine have looked at the effectiveness of hand hygiene for reducing rates of hospital- or healthcare-associated infections. Larson published two systematic reviews of the topic, covering literature from 1879 to 1986 (112) and 1977 to 1998 (32). Both supported an association between hand hygiene and reduced infection rates, although there were very few prospective clinical trials. Larson pointed out that this was likely due to the dramatic effects of using hand hygiene and aseptic technique on morbidity and mortality that have been demonstrated over centuries, starting with Ignaz Semmelweis and others in the 1800s (5), resulting in these practices being widely adopted in human medicine by the turn of the 20th century. The evidence for causality provided by research studies published since the 1970s is often weak (32,104); however, there are numerous studies that support causal criteria including a temporal relationship, strength of association, consistency of association and “dose” response for hand hygiene and HAIs (112).

Hand hygiene studies tend to suffer from one or more significant limitations due to poor methodology, including but not limited to simultaneous implementation of other measures that may affect pathogen transmission and infection rates (which can artificially inflate or mask the effect of hand hygiene), lack of a control group or use of comparable historical controls (a negative control group is very difficult to justify on ethical grounds (112)), failure to report statistical significance, and the Hawthorne effect (whereby study subjects may alter their behaviour when being observed) (104). Use of historical controls can be particularly problematic when studying disease outbreaks, as it is difficult or impossible to separate the potential effect of an infection control intervention from the natural cycle and extinction of the outbreak itself. One example of this is measuring rates of vancomycin-resistant enterococci (VRE) infection over relatively short periods of time, as these are known to vary considerably even in the absence of any interventions (104,113).

Backman et al. (104) reviewed 31 original studies looking at hand hygiene interventions published between 1996-2006. Of these, 20 studies were given a quality score of 2 or higher based on not containing any fatal flaws (as per Larson (114)), and 16/20 (80%) of these studies reported a significant reduction in HAIs associated with a hand hygiene intervention. The following are examples of the better-quality (score of 3) observational studies reviewed: Won et al. (115) observed a significant decrease in HAI rates in a neonatal intensive care unit from 15.13 to 10.69 cases per 1000 patient-days (p=0.003) during a multimodal hand hygiene promotion campaign. Zerr et al. (116) similarly found a decrease in
hospital-associated rotavirus infection risk in a children’s hospital over a four-year period from 5.9 to 2.2 cases per 1000 patient discharges (p=0.01) following implementation of a multimodal house-wide hand hygiene improvement program. Ng et al. (117) observed a 2.8-fold reduction in the incidence of late onset systemic infection among very low birth weight infants over a 36-month period, following introduction of a hand hygiene protocol involving use of an AHS and gloving. However, compliance data were not reported in this study and it was not possible to separate the effects of the hand rub versus glove use. Gordin et al. (118) found a 21% reduction in hospital-associated MRSA infections and a 41% decrease in VRE infections over a three year period, following introduction of AHS in a 287-bed tertiary care facility that previously only used antibacterial (0.3% triclosan) soap, although the authors did not report any measure of use of the AHS versus soap. Hilburn et al. (119) reported a 36.1% decrease in HAI rates over a ten-month period in an orthopedic surgical ward of an acute care facility after introduction of an AHS gel, however the statistical significance (p-value) was not reported, and no compliance data were provided. The limitations of these studies must be taken into consideration when interpreting the results, but their existence does not mean that the benefits of hand hygiene described in these studies should be dismissed.

There is also a relatively small number of studies that have failed to demonstrate a positive effect of hand hygiene on infection control. Larson et al. (113) saw no significant decrease in hospital-associated MRSA infection rates over six months in a 250-bed metropolitan hospital with implementation of an administrative intervention to improve hand hygiene practices, although a significant decrease in VRE infection rates was reported over the same time period. Lam et al. (120) observed a decrease in HAI rates in a 12-bed neonatal intensive care unit six months after a one-year intervention program was completed, but the trend did not reach statistical significance, possibly because the follow-up observation period was relatively short. Also, increased use of AHS as the primary hand hygiene product in healthcare facilities has not resulted in higher Clostridium difficile infection rates, even though C. difficile spores are not killed or removed from the hands by alcohol-based products (118,121,122), although it is possible that the emphasis on improved hand hygiene through use of AHS had a halo effect on other infection control practices (including hand washing), thereby helping to prevent a spike in infection rates. Studies with negative findings may suffer from the same limitations discussed above (e.g. lack of a control group, use of historical controls, concurrent interventions masking effects) as well as inadequate sample size (104). It is also important to differentiate a failure to achieve sufficient compliance with a hand hygiene protocol from failure of a hand hygiene protocol to have its desired effect on limiting disease transmission. However, it is equally true that the effectiveness of any protocol is irrelevant if it is
not sufficiently practical that personnel will comply with it and still be able to perform their required duties.

Even though attempts to improve hand hygiene have not always been effective at reducing transmission of infectious pathogens, there is sufficient evidence that improving hand hygiene can have a positive impact on infection control in many situations. The impact may be through the direct effects of decreasing the pathogen load on and transmission via people’s hands, or simply through increased awareness of infection control protocols overall. Hand hygiene is a highly visible, easy-to-do means of improving infection control that is applicable in almost all situations, and that can be readily done by anyone, from children to adults, patients to family members, and healthcare workers to veterinary personnel. It is a potentially highly cost-effective infection control tool, as, particularly with the advent of WHSSs, it requires no expensive equipment or building renovations to implement, and has the potential to significantly impact healthcare costs, patient morbidity and mortality.

Infection control and hand hygiene: The challenge of hand hygiene compliance

Compliance with hand hygiene protocols is the most challenging component of achieving efficacy. Numerous studies have looked at hand hygiene compliance in hospitals (3,123). In general, compliance is poor (<50%) even among healthcare workers, who are working in a higher-risk environment and would likely be more aware of the importance of hand hygiene for infection control than members of the general public (28). Also, physicians tend to have lower compliance with hand hygiene protocols than nurses (28,124,125). Major barriers to compliance in many situations include skin irritation (i.e. irritant contact dermatitis), lack of accessibility to hand hygiene stations, time constraints (i.e. too busy), and lack of perceived importance (i.e. that it is generally unimportant, or more likely that it is less important than other tasks/procedures which therefore take precedence over hand hygiene) (3,71). Voss & Widmer (126) calculated that, based on a representative model in an intensive care unit with 12 healthcare workers, 100% hand hygiene compliance using hand washing would consume 16 hours of nursing time in a single day shift, which could interfere with patient care. In comparison, 100% compliance using an AHS from a bedside dispenser would consume only 3 hours per day shift (126). In an overburdened healthcare system, the reasoning that there is simply not enough time to perform hand hygiene as often as it ideally should be has some validity, but if this is the case the issue needs to be addressed by the facility management. Several studies have suggested that upper level management or administrative involvement and support are necessary for hand hygiene protocols to be effective (31,127-129). In some cases people may also simply forget to perform hand hygiene (3); to prevent this, hand hygiene needs to become an automatic habit for healthcare personnel, like covering a sneeze or a cough.
Providing better access to hand hygiene stations and supplies is often the first step to improving hand hygiene compliance, as it aids in minimizing the time required to comply with protocols, and acts as a visual reminder to perform hand hygiene. Because renovating facilities to improve the location of sinks for hand washing is often not feasible, improving access typically involves introducing AHS, introducing a different kind of AHS that is better accepted by personnel (e.g. based on less of a drying effect or better smell), or changing the location or number of AHS dispensers (e.g. providing bedside dispensers or personal dispensers to be carried by each person) (3). Posters are a commonly used type of intervention for promoting a wide variety of ideas and behaviours in many settings, and they are often incorporated into broader multimodal interventions for improving hand hygiene compliance in healthcare facilities (130-132). The impact of hand hygiene poster campaigns is variable and may be short-term, and often cannot be separated from the effect of concurrent interventions (133,134). Introducing or increasing monitoring alone can have a positive impact on compliance, likely at least in part through the Hawthorne effect, as typically people are aware of the monitoring in some way (135,136). However, it is difficult to compare compliance during monitored and unmonitored periods. Feedback systems can also significantly increase compliance (137). Feedback may be from patients, researchers or infection control personnel. Making people aware of how often they neglect to perform hand hygiene, and/or giving them positive feedback when their compliance improves, seems to provide additional incentive to further improve compliance. Currently, use of multimodal interventions is recommended to increase hand hygiene compliance. These interventions may include different combinations of educational or interactive campaigns in various forms for staff and patients, introduction of alternative or additional hand hygiene products, increased monitoring and feedback systems, and critically include the involvement and visible support of upper management (3,56,71,113,134,138,139). However, one of the most crucial factor for improving hand hygiene compliance may be convincing people of its importance and utility in curbing the spread of infectious agents in any situation (3). Good-quality research studies that repeatedly show the benefits of hand hygiene and ongoing educational efforts will hopefully help change people’s attitudes so that hand hygiene becomes something that everyone wants to do, rather than something everyone must be asked to do.

_Infection control and hand hygiene in veterinary medicine_

Compared to infection control in human medicine, infection control in veterinary medicine is still an underdeveloped field. Whether this is a result of a lack of understanding or avoidance of infectious disease issues, or of inadequate training in this area among veterinary personnel is unclear. A study by Murphy et al. (140) investigating environmental disinfection practices, management of infectious patients and antimicrobial use in clean surgical procedures in veterinary clinics identified that none of the 101
participating clinics had a formal infection control program. In a survey of members of the American Veterinary Medical Association performed in 2005, 31% (247/797) of small animal practitioners, and an even lower proportion of large animal and equine practitioners, reported that their practice had written infection control policies, and lack of a written infection control manual was associated with a lower “precaution awareness” score among veterinarians (141). Infection control practices, including hand hygiene, are more likely to be underutilized under these circumstances, and their effectiveness cannot be evaluated without established policies and a formal infection control program, even if the program is very basic. Murphy et al. (140) also showed that veterinarians and technicians generally consider certain aspects of infection control, such as environmental cleaning and disinfection, important measures, yet 40-60% did not know what products were used in their own clinics for disinfecting areas contaminated with infectious body fluids, nor how to properly prepare the products for use. Wright et al. (141) found similar discrepancies in practitioner perceptions of zoonotic disease risk versus personal protective equipment (PPE) used when examining animals with potentially zoonotic infections. For example, less than 30% of small animal practitioners who were concerned about the diseases wore appropriate PPE when examining animals potentially infected with rabies, gastrointestinal parasites, gastrointestinal bacteria or dermatophytes. The same shortfalls may hold true for hand hygiene practices – even among veterinary personnel who acknowledge the importance of hand hygiene, it may not be performed how and when it is recommended.

Literature regarding hand hygiene in veterinary healthcare specifically is limited. A household-based study by Hanselman et al. (17) showed that some dogs and cats share indistinguishable strains of *S. aureus* and *S. pseudintermedius* with humans living in the same household, and self-reported regular hand washing was protective for *S. pseudintermedius* colonization in humans. Traub-Dargatz et al. (142) examined the effectiveness of traditional hand washing versus AHS following basic physical examination of a horse, and found the AHS to be equally or more effective at reducing bacterial counts on the hands. However, it was pointed out that the hands of veterinary personnel working in equine practice may become more heavily soiled on a regular basis than personnel working in a small animal or human hospital, which may require hand washing to remove gross contamination, rather than use of AHS alone for hand hygiene. Anderson et al. (143) found that hand washing following infectious cases and between farms had a protective effect against colonization with MRSA in veterinary personnel who work with horses. Despite the paucity of veterinary hand hygiene studies, hand hygiene is considered equally important as an infection control measure in veterinary clinics as in human healthcare (35,57,108), based on the many comparable procedures performed and infectious disease risks in both settings, as well as basic principles of pathogen transmission.
Hand hygiene compliance in veterinary medicine

There is only a small number of studies regarding compliance with hand hygiene recommendations in veterinary practices. In the survey conducted by Wright et al. (141), 48% (516/1066) of small animal practitioners, and only 18% (57/314) of large animal and 18% (83/456) of equine practitioners, reported always sanitizing or washing their hands before patient contact. Only 55% (590/1069) of small animal practitioners in the same study reported always washing their hands before eating, drinking or smoking while at work, and the same was true for less than a third of large animal and equine practitioners (141). Self-reported compliance among veterinary support staff in another survey-based study was 42% (76/182) (144). The same study found that although 86% (154/182) of respondents believed they should perform hand hygiene more often, only 53% (96/182) had been given information on the importance of hand hygiene from their employers. The most commonly reported barrier to hand hygiene compliance was being too busy (144). In one study using direct observation of personnel in a companion animal teaching hospital, baseline hand hygiene compliance was 21% (117/568 opportunities), which increased to 42% (78/187) two weeks after the end of a multimodal educational campaign emphasizing use of a foaming AHS product (145). However, it was not possible to separate the effect of the campaign from the potential effect of the presence of observers (i.e. Hawthorne effect), and unfortunately there was no additional follow-up performed to determine if there was any longer-term effect.

The perception that hand hygiene is relatively unimportant is likely more problematic in veterinary medicine compared to human medicine. Because there are fewer diseases that can be transmitted from animal-to-person compared to person-to-person, some veterinarians may have a relatively cavalier attitude toward contamination of hands, clothing or equipment with animal blood, body fluids and excreta. However, hand hygiene is also a critical means of preventing potential indirect transmission of non-zoonotic pathogens from animal-to-animal, which makes it important for protecting the health of veterinary patients. Without appropriate attention to infection control efforts, veterinary clinics can become amplifiers of both animal diseases and zoonotic diseases in the community, due to the high flow-through of out-patient animals and their caretakers, the mixing of both sick and susceptible animals (i.e. very young, very old or immunocompromised), the wide variety of patients seen at a clinic (e.g. medical, surgical, oncological, regular health check-ups), and the close interaction of animals, clinic personnel and members of the general public that occurs there. Improving hand hygiene practices in veterinary clinics has the potential to help curb spread of recognized pathogens, and may help to prevent widespread transmission of other emerging pathogens in the future before they are even recognized.
1.2.4.2 Surgical site infections in human healthcare and veterinary medicine

In 2002, surgical site infections (SSIs) were the second most common type of HAI reported in US hospitals, accounting for 244,385 cases or 20% of all HAIs in adults and children outside of intensive care units (146). Every surgery, no matter how minor or in what species, involves creating a breach in the skin’s normal defensive barrier, which renders it more susceptible to infection. Surgical site infections in human medicine are also associated with increased costs: One study found the average total healthcare costs for patients with SSI in the first 8 weeks post discharge were US$5155, compared to US$1773 for control patients (147). Another study, based on 255 case-control pairs, demonstrated significantly increased risk of mortality (relative risk (RR) 2.2, 95% confidence interval (CI) 1.1-4.5) and intensive care unit admission (RR 1.6, 95%CI 1.3-2.0), longer hospital stay (6.5 days, 95%CI 5-8 days), higher costs of hospitalization (US$3089, 95%CI $2139-$4163) and higher risk of readmission within 30 days of discharge (RR 5.5, 95%CI 4.0-7.7) for patients with SSIs (148). Surgical site infection risk in human medicine varies greatly by the procedure performed, as well as by facility, with reported rates ranging from 0.99-7.06% (149). Although numerous factors can contribute to the risk of SSI, the three that are considered the most reliable predictors are the preoperative physical status of the patient, the level of contamination of the surgical site (i.e. clean, clean-contaminated, contaminated, or dirty) and the duration of surgery (150).

Data on SSIs in veterinary medicine are limited compared to those available in human medicine, in part because there are no overriding monitoring systems such as the National Healthcare Safety Network (NHSN) to which these infections can be reported, and most veterinary facilities do not have an equivalent internal reporting system. Estimates of SSI risk in animals are generally only available from large specialized facilities or from multi-centre studies, and these are highly variable, ranging from 0.8-18.1% in dogs and cats (151-153). Considering the number of pets that undergo both elective and non-elective surgery every day, even a relatively low rate of post-operative infection has the potential to affect tens of thousands of animals every year. The agents of SSIs are most commonly opportunistic bacteria that are part of the normal skin flora (Streptococcus spp., Staphylococcus spp.), but incisions are susceptible to infection by many species of bacteria (as well as fungi in rare cases) including members of the gastrointestinal flora (enterococci, Enterobacteriaceae) and, of greater concern, some antimicrobial-resistant pathogens such as MDR enterococci, Acinetobacter baumannii, extended-spectrum beta-lactamase (ESBL) Enterobacteriaceae, Pseudomonas aeruginosa, MRSA and (in dogs in particular) methicillin-resistant S. pseudintermedius (MRSP) (151,154). Most of these agents are capable of causing infection in humans and animals alike, so there is potential for zoonotic transmission, particularly if both animal and human have some kind of compromise to the body’s natural defenses, such as an incision,
traumatic wound or systemic immunosuppression. Although many SSIs are simply inconvenient and uncomfortable nuisances that are relatively easily treated, they can also be life-threatening complications. It is impossible to prevent all SSIs; nonetheless, all reasonable steps should be taken to decrease the risk and reduce the preventable fraction of SSIs (151,155). The potential effects of such infections are broad, as they can affect patients (e.g. illness and death), pet owners (e.g. economic costs, pet loss, risk of exposure to zoonotic pathogens) and veterinary hospitals (e.g. economic loss from providing subsidized care to animals with HAIs, loss of reputation, legal liability for HAIs).

Control of the risk of SSIs can be divided into pre-operative, intra-operative and post-operative periods. Pre-operative measures include aseptic preparation of the surgeon(s)/surgical assistant(s), all instruments and materials that will have contact with sterile body sites, and the surgical site itself. Intra-operative measures include adherence to aseptic technique, minimizing tissue trauma and overall surgical time, and may include use of peri-operative antimicrobials depending on the procedure. Post-operative measures include primarily proper wound care (e.g. bandaging if appropriate, keeping the wound clean and dry, removing discharge, minimizing direct contact), adequate restriction of patient movement to avoid disrupting the surgical site, and possibly ongoing antimicrobial therapy (i.e. if contamination of the wound likely occurred during surgery due to the nature of the procedure or a break in aseptic technique). Microbial contamination of a surgical site is a prerequisite for all SSIs, therefore one of the primary goals of SSI prevention practices is to reduce the spread of microbes to and at the surgical site, beginning in the preoperative period. At no time are the tissues more susceptible to invasion than during the surgical procedure itself, which makes preoperative preparation of both the patient and surgeon critical for SSI prevention. The focus of the following review will be on appropriate pre-operative preparation of surgical personnel and the patient, although this is clearly only one component of SSI prevention.

Pre-operative preparation procedures

The importance of preoperative preparation of the patient and surgeon was first reported by Joseph Lister in 1867, and by the turn of the 20th century he and others had shown that such measures could have a dramatic impact on SSI rates and ultimately patient survival (4,156,157). Since then, preoperative preparation has become such a basic standard practice that published studies can only compare the impact of different techniques on various outcomes, as the absolute effect was so clearly demonstrated more than a century ago. Pre-operative preparation of the surgeon’s hands and the surgical site is not meant to “sterilize” the skin. In order to sterilize the skin, even the resident microbial flora would have to be eliminated, which cannot be achieved with mechanical scrubbing or topical antiseptics without causing severe tissue trauma. The goal of preoperative hand antisepsis, as well as surgical site
skin preparation, is to eliminate the transient microbiota and to reduce the resident microbiota while avoiding rapid rebound growth, in order to decrease the risk of direct contamination of sterile tissues at the surgical site, and indirect contamination of sterile tissues via surgical instruments and gloves (3,31,158).

**Surgical site preparation**

Surgical site preparation follows the same principles as hand preparation in that it always proceeds from what should be the cleanest area (immediately around where the incision will be made) to the least clean area (where the prepared area meets any unprepared area, farthest from where the incision will be made)(159,160). In human medicine, hair at the surgical site was traditionally either clipped or shaved if it would otherwise interfere with performance of any part of the surgical procedure, or application of adhesive drapes or bandages, and because hair was associated with a lack of cleanliness (161). It has since been found that shaving the surgical site actually increases the risk of SSI (150,161), possibly because it causes microabrasions (or more obvious trauma) to the skin that are then prone to colonization with opportunistic pathogens. There is insufficient evidence to determine if hair removal by other means (clipping or depilatory cream) has a negative effect on the occurrence of SSIs, nor when hair should be removed for humans (relative to the time of surgery) if it is necessary (161). Currently it is recommended by the CDC that if clipping is required, it should be done immediately before the rest of the pre-operative preparation of the skin in order to minimize time for bacterial invasion and overgrowth within the traumatized skin (150). Hair removal is almost always necessary for veterinary patients, which typically have dense hair coats. A companion animal veterinary study found that animals clipped after induction of anesthesia were at lower risk of post-operative infection than animals clipped just prior to induction (162). This could possibly be related to the relative degree of skin trauma caused when clipping a sedated versus anesthetized animal, rather than the elapsed time between clipping and surgery. A more recent study found that clipping of hair over four hours prior to surgery increased the odds of SSI in dogs by a factor of 4.0 (152). In humans and animals, skin is then gently scrubbed with an antiseptic solution, generally containing a chlorhexidine or povidone-iodine soap similar to that traditionally used by surgeons for hand scrubbing. In veterinary practice it is recommended that hair removal and the initial scrub are performed outside the surgical suite (159,160) in order to avoid heavy contamination of the surgical environment. The skin is then wiped or “painted” using disposable gauze sponges with one or more (in sequence) antiseptic solutions or tinctures, also typically containing chlorhexidine or povidone-iodine, starting with the cleanest area and moving outward (i.e. in a concentric ring pattern) (150,159,160,163,164). A recent study found that a chlorhexidine-alcohol combination was superior to povidone-iodine scrub-and-paint for prevention of SSIs in humans (165). Other studies have found that
use of a povidone-iodine solution as a paint or spray alone was equally effective as scrub-and-paint with
the same solution (166,167). Empirical extrapolation of this finding to veterinary medicine must be done
with caution, if at all, as scrubbing may be more necessary for animals if their hair coat and underlying
skin are more heavily contaminated with dirt and debris than bare human skin. The recommended contact
time for skin preparation products varies, generally ranging from 0.5-3 minutes (159,160,163), but in all
cases the skin must be allowed to dry before the surgical procedure begins, particularly with use of
products containing alcohol as these are flammable (155).

Preoperative hand antisepsis

Preoperative preparation techniques continue to evolve in attempts to improve their efficacy (i.e.
ability to remove or kill microorganisms on the skin), efficiency (i.e. time required to perform) and safety
(i.e. minimizing trauma to the skin, particularly with repeated use). The most basic technique is simply to
wash one’s hands with soap and water; alone this is considered grossly inadequate by human surgical
standards, but may still be the only preparation performed by some veterinarians depending on the
surgical procedure, species and environment. Recommended surgical scrub technique involves first
removing gross contamination of the hands and under the finger nails by means of a basic hand wash with
either antimicrobial or plain soap and a nail pick (3,31,56,150,160,164). Traditionally this was followed
by lathering with either a chlorhexidine or povidone-iodine soap (typically impregnated into a sponge)
and then careful scrubbing of the hands and forearms to the level of the elbow using a soft-bristled brush.
Chlorhexidine soap has been shown to be more effective for reducing bacterial counts on the hands than
povidone-iodine soap (168). Scrubbing should proceed in order from the cleanest part of the hand (the
most likely to come in contact with the surgical site, i.e. the fingertips) to the least clean part of the arm
which may come in contact with the surgical site (i.e. the forearm distal to the elbow). Soap is then rinsed
from the hands with running water, keeping the hands elevated so that water is only allowed to run off the
arms proximally (i.e. toward the elbows) (150,159,160). Careful drying of the hands in the same
sequence as the scrub using a sterile towel is then performed (150). Studies looking at duration of
scrubbing have found no additional benefit to scrubbing for more than 5 minutes, in terms of the
reduction of the microbial flora of the hands (3). A review by Tanner et al. (168) concluded that
scrubbing for longer than even 2 minutes is unnecessary. Soap-and-water scrub, typically involving the
use of a brush, is still the procedure most commonly used by veterinary surgeons (169); however, use of a
brush for scrubbing may cause skin damage with repeated use, and is not necessary if preoperative
alcohol-based hand rubs are used, which is the current recommendation (56,156). Numerous studies have
shown alcohol-based products used for pre-operative hand antisepsis, as for alcohol-based products used
for routine hand hygiene, to be superior to antibacterial soap for reducing bacterial counts on the hands.
In one clinical study, use of alcohol-based hand rub did not significantly affect the risk of SSI compared to use of traditional antimicrobial soap scrub, but the protocol for application was better tolerated by staff (170). If hands are visibly soiled, an alcohol-based rub may be used following a hand wash with plain soap, so long as hands are dry when the product is applied (3,56,160,164); however, sequential use of preoperative soap-and-water hand scrub and alcohol-based hand rub is not recommended (56), but has been reported among veterinary surgeons (169).

Gowning and gloving

Preoperative hand antisepsis and drying of the surgeons hands is typically followed by donning of a sterile gown and sterile gloves (3,150,160,164). Various techniques for doing this exist (159,160,171), but the goal is always to avoid any contact of the outside surface of the sleeves and front of the gown and of the outside surface of the gloves with any non-sterile surface, including the hands. The use of sterile surgical gloves is an important component of aseptic technique that provides an effective barrier between the microbiota of the surgeon’s hands and the surgical site. Some surgeons will don two sets of gloves, one over the other, which provides an additional barrier between the hands and the surgical site (150), and also allows one set to be removed following patient draping and the initial incision, which are the highest risk procedures in terms of contamination of gloves prior to entering the sterile site (163). However, glove use does not negate the need for proper preoperative hand antisepsis. The accepted quality control limit for defects in medical gloves large enough to leak water is 1.5% (172). In one study of glove punctures in human orthopedic surgeries, perforations were found in 2/200 (1%) unused control gloves (173). Furthermore, glove punctures have been reported to occur in up to 34-43% of human surgical procedures (174-176). In a study performed at two companion animal hospitals, glove punctures were found in one or both gloves in 148/382 (38.7%) glove pairs, and personnel were typically unable to predict whether or not a glove defect was present at the end of procedures (177). Similar results were reported at another companion animal hospital where a defective glove was detected following 51/231 (22%) surgical procedures, and personnel were only aware of a glove puncture in 3.8% of cases (178). Proper hand antisepsis prior to gloving for surgery therefore remains critical.

Compliance with preoperative preparation procedures in veterinary medicine

While basic guidelines for preoperative preparation in veterinary medicine are published in surgical textbooks (159,160,163), and a small number of other easily accessible sources (35), the veterinary literature contains a relative paucity of information on the comparison of different means of surgeon and surgical site preparation. Anecdotally, these procedures vary considerably between clinics, and there has been no evaluation of practices currently in use. An understanding of current practices is
needed to determine whether they are adequate and whether educational efforts aimed toward improving these preoperative practices in veterinary clinics are necessary.

1.2.5 Monitoring infection control practices

The ability to monitor and evaluate infection control practices, particularly hand hygiene, is important from both a research and a routine infection control perspective. However, accurate monitoring can be very challenging in the clinical setting, including human healthcare facilities and veterinary clinics. The gold standard for measuring hand hygiene compliance in human healthcare is direct observation, typically performed by an observer on the clinic floor (3,56,135,179), although this has been challenged as the optimal means of monitoring hand hygiene (180). Direct observation is very labour intensive, and also prone to bias on the part of the observer and due to Hawthorne effect, so it may produce a falsely elevated estimate of compliance (181,182). As previously mentioned, there is one veterinary study that used this method to measure hand hygiene compliance in a companion animal teaching hospital (145). The 21% increase between the baseline period and the follow-up period two months later was attributed to a multimodal educational campaign; however, it is also possible that study participants may have become sensitized to the observers during the initial evaluation, prompting them to perform hand hygiene more often when being observed during the follow-up period, regardless of whether or not the intervention had resulted in a true increase in compliance in the interim.

Total volume of hand hygiene product used based on supply orders can be used as a surrogate measure of hand hygiene compliance, or electronic counters can be installed in wall dispensers to record how often soap or AHS is used, which provides slightly more information (183,184). These counting systems do not provide information on timing or adequacy of hand hygiene attempts, nor an estimate of hand hygiene compliance as a percentage of hand hygiene opportunities, but may be useful for inferring improvement in hand hygiene compliance following an intervention if there is evidence of increased use in the same clinical setting. Recently, more advanced remote computer-based monitoring systems have been designed and marketed for use in healthcare facilities. Swoboda et al. (185) described the use of a system that monitored entry/exit of personnel into/from patient rooms, as well as use of hand hygiene stations (sinks and sanitizers) and toilets. The system was also able to provide voice prompts to perform hand hygiene on exit from a patient room. Use of the system resulted in improvement in hand hygiene compliance and HAI rates. Boscart et al. (186) described development of a similar system using portable badges equipped with infrared detectors and radio frequency transceivers, worn by nurses, that detected use of wall-mounted and personal clip-on AHS dispensers, and that could provide automatic hand hygiene reminder signals at appropriate times (187,188). Other systems (e.g. HandGiene,
www.handgienecorp.com) that employ radio-frequency identification (RFID) technology can also monitor personnel on an individual basis in terms of their movement within the building, hand hygiene opportunities and duration of hand hygiene events, but these systems can be prohibitively expensive (189). A non-RFID system has been described which recorded location and timing of hand hygiene events for each healthcare worker based on portable “motes” carried by individuals and beacons placed at strategic locations throughout the building and at each hand hygiene station (189,190). All data from the system were off-loaded wirelessly to a portable server, thereby providing results in real time with no need for manual input of data. Unfortunately, there are few published reports describing the implementation and accuracy of many of the automated hand hygiene monitoring systems currently available (188).

Video surveillance has not been frequently used for monitoring hand hygiene compliance or infection control practices in hospitals, possibly due to patient confidentiality issues, the large number of different areas that would have to be monitored, and the large amount of time required to review and analyze video data (182,191). However, use of such a system in a small animal veterinary clinic is more feasible, as many clinics are designed around a central treatment room or area where the majority of nonsurgical procedures are performed, and many have relatively small numbers of staff working at any given time. Video observation has several potential advantages over direct observation by a live observer. The ability to watch video recordings repeatedly or in slow motion may increase observational specificity, and facilitates data collection regarding multiple simultaneous activities if necessary (191,192). Videos can be watched more than once or by more than one individual and observations compared to help reduce observer bias (191,192). Use of strategically placed or hidden cameras may also be less intrusive and less readily apparent than a live observer, and cameras can be put in place in advance of the observation period in order to desensitize study subjects to their presence, which may help decrease Hawthorne effects and provide a more accurate measure of the practices of interest (191). Video observation of hand hygiene practices has been used successfully in food handling studies (192,193), and could potentially be applied in other scenarios as well, such as at a small petting zoo. Additionally, video observation can be used to monitor infection control practices other than hand hygiene.

1.2.6 Conclusion

The importance of hand hygiene for control of pathogen transmission between people is well established, but it is also critical to the control of pathogen transmission between humans and animals and the indirect transmission of pathogens between animals via humans. Better hand hygiene compliance at venues such as petting zoos has the potential to positively impact public health, but investigation of interventions to improve compliance are needed in order to determine effective means of achieving this
goal. Hand hygiene in veterinary clinics, along with other basic infection control measures, is particularly crucial, as these facilities can be a “mixing pot” of animals and people covering a wide range of health and disease-carrier states. Although the magnitude of the issue of HAIs in veterinary medicine is poorly defined, prevention of these kinds of infections is becoming more important with continued medical advances and also increasing client expectations. There is limited information on routine hand hygiene practices among veterinary staff, but what there is suggests that compliance is low. There is a similar paucity of reports regarding routine preoperative hand hygiene practices and preoperative patient preparation, which are critical for decreasing the risk of hospital-associated SSIs. Additional objective investigation of practices such as hand hygiene and preoperative practices is needed in order to help guide efforts to educate, train and motivate veterinary personnel to effectively utilize these crucial infection control measures.
### Table 1.2.1: Relative efficacy of various classes of biocides commonly used in hand hygiene products against different types of microorganisms

<table>
<thead>
<tr>
<th>Microorganism</th>
<th>Alcohols</th>
<th>Biguanides (chlorhexidine)</th>
<th>Quaternary ammonium compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mycoplasmas</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Gram-positive bacteria</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Gram-negative bacteria</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Pseudomonads</td>
<td>++</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>Enveloped viruses</td>
<td>+</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Chlamydiae</td>
<td>±</td>
<td>±</td>
<td>–</td>
</tr>
<tr>
<td>Non-enveloped viruses</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Fungal spores</td>
<td>±</td>
<td>±</td>
<td>±</td>
</tr>
<tr>
<td>Acid-fast bacteria</td>
<td>+</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Bacterial spores</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Coccidia</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

++ highly effective; + effective; ± limited activity; – no activity

1 based on table from (35)
Figure 1.2.1: Hand hygiene technique training poster from the Ontario Ministry of Health and Long Term Care (2007) showing appropriate technique for hand hygiene with soap and water and with alcohol-based hand sanitizer (63).

Handwashing

To wash hands properly, rub all parts of the hands and wrists with soap and water or an alcohol-based hand rub. Wash hands for at least 15 seconds or more. Pay special attention to fingertips, between fingers, backs of hands and base of the thumbs.

- Keep nails short
- Remove watches, rings and bracelets
- Do not use artificial nails
- Avoid chipped nail varnish
- Wash wrists and forearms if they are likely to have been contaminated
- Make sure that sleeves are rolled up and do not get wet during washing

If you have any questions regarding cuts, sores, allergies or pre-existing skin conditions, call Telehealth Ontario at 1-866-797-0000, TTY 1-866-797-0007.

Handwashing with soap and water

Cleaning with alcohol-based hand rub

- Apply 1 to 2 pumps of product to palm of dry hands.
- Rub hands together, palm to palm.
- Rub in between and around fingers.
- Rub back of each hand with palm of other hand.
- Rub fingertips of each hand in opposite palm.
- Rub each thumb clasped in opposite hand.
- Rub each wrist clasped in opposite hand.
- Rub hands until product is dry. Do not use paper towels.
1.2.7 References


37


CHAPTER 2:

Video observation of hand hygiene practices at a petting zoo and the impact of hand hygiene interventions

2.0 Abstract

Petting zoos are popular attractions, but can also be associated with zoonotic disease outbreaks. Hand hygiene is critical to reduce disease risks, however compliance can be poor. Video observation of petting zoo visitors was used to assess animal and environmental contact and hand hygiene compliance. Compliance was also compared over five hand hygiene intervention periods. Descriptive statistics and multivariable logistic regression were used for analysis. Overall hand hygiene compliance was 58% (340/583). Two interventions had a significant positive association with hand hygiene compliance (improved signage with offering hand sanitizer, odds ratio (OR)=3.38, p<0.001; verbal hand hygiene reminders, OR=1.73, p=0.037). There is clearly a need to improve hand hygiene compliance at this and other animal exhibits. This preliminary study was the first to demonstrate a positive impact of a hand hygiene intervention at a petting zoo. The findings suggest that active, rather than passive, interventions are more effective for increasing compliance.
2.1 Introduction

Petting zoos and other animal exhibits facilitate contact of the public with live animals as part of agricultural fairs and other seasonal or permanent attractions. They are entertaining, but also serve an important educational function for individuals of all ages regarding animals and animal husbandry, and they help to increase compassion for animals of different kinds (1, 2). However, any type of human-animal contact is associated with a risk of infectious disease transmission, which varies according to the animals involved, the individuals in contact with them and the degree of contact that occurs. Risks are higher for young children, with whom petting zoos and similar events are often particularly popular (2-6, 7). Risks are also higher among individuals who are immunocompromised and the elderly (2, 4, 6, 7), all of whom may potentially visit such exhibits.

Numerous disease outbreaks have been associated with animal contact at public venues. The most commonly reported pathogen in these outbreaks is *Escherichia coli* O157:H7, but other pathogens include *Salmonella*, *Cryptosporidium*, *Giardia*, *Coxiella burnetii* (Q fever) and dermatophytes (ringworm) (2, 5, 7-13). There is also potential risk for the transmission of other zoonotic pathogens including *Campylobacter* and rabies (2, 14, 15). While outbreaks receive the greatest attention, there may also be a significant level of morbidity from sporadic infections that are not reported to public health officials or linked to petting zoo exposure. Studies have shown contact with cattle and/or farm visits to be significant risk factors for sporadic infection by *Cryptosporidium* (16), *E. coli* O157:H7 (17), and *Campylobacter* (14). Overall, there is limited information regarding the disease burden associated with petting zoos.

Several organizations have published recommendations for management of live animal exhibits such as petting zoos, intended to help decrease the risk of infectious disease transmission from animals to the public, and all of them include some mention of the promotion of hand hygiene among visitors (2, 6, 8, 18). According to the National Association of State Public Health Veterinarians, “the recommendation to wash hands is the most important prevention step for reducing the risk for disease transmission associated with animals in public settings.”(2) Failure to perform hand hygiene has been identified as a significant risk factor for disease in numerous outbreaks associated with animal exhibits (3, 8, 9, 13, 19). Yet hand hygiene compliance at petting zoos and similar public exhibits has been reported to be poor (1, 20), and there has been no objective assessment of means to increase visitor adherence to hand hygiene recommendations at these venues.
The objectives of this study were to determine overall hand hygiene compliance of visitors to a popular petting zoo, by indirect observation using video webcams, and to evaluate the impact of selected interventions on hand hygiene compliance.

2.2 Materials & Methods

The study was performed in March 2009 at a petting zoo held as part of the University of Guelph’s open house weekend. Current guidelines (2) were followed for the design and operation of the event. The petting zoo was set up with unidirectional traffic flow in a large indoor breezeway as shown in Figure 2.1. Each animal pen was supervised by 1-2 exhibit personnel at all times. Signage (primarily 22 cm x 29 cm posters) was posted at the entrance to the exhibit and on each animal pen reminding visitors that food and beverages were prohibited in the area and to perform hand hygiene before leaving. Liquid antimicrobial soap containing 0.3% triclosan (Bacti-Stat, Ecolab Inc., St. Paul, MN, USA) and paper towels were provided at the sink station, and a step stool was present to help children reach the water faucet. A minimum of two bottles of an alcohol-based hand sanitizer containing 62% ethyl alcohol (One Step, Belvedere International Inc., Toronto, ON, Canada) with pump dispensers were available on the adjacent tables at all times, in addition to the bottles used by personnel to dispense sanitizer during the designated intervention periods.

Two webcams (QuickCam Pro 5000, Logitech, Freemont, CA) were placed in overhead locations: one focused on the side of the exhibit with the animal pens, and one focused on the opposite side of the room where the hand hygiene stations were located. The cameras were connected by USB cables to a computer in a secure adjacent room. The cameras and wiring were visible to the public but were relatively inconspicuous and above line-of-sight. Visitors to the petting zoo were not informed that a study was being conducted or that they would be on camera. Consent was not obtained from visitors on the basis that doing so would significantly bias their behaviours, no other identifying information was being gathered, all images were kept secure at all times and none would be publicly displayed or published. This study was approved by the University of Guelph Research Ethics Board.

Video monitoring was performed for a total of 6 h over the course of 1 day. Each 1 h time block was randomly assigned to one of the following hand hygiene interventions: 1) two personnel stationed near the exit offering to dispense hand sanitizer from a bottle to petting zoo visitors as they exited, 2) a combination of increased signage and personnel stationed near the exit offering hand sanitizer, 3) two circulating personnel reminding visitors to perform hand hygiene before leaving the exhibit, 4) increased signage alone, 5) baseline (no additional intervention, recorded during two non-consecutive blocks).
Exhibit personnel involved in hand hygiene interventions were in addition to those supervising the animal pens, and were identifiable by their name tags and/or coveralls. Increased signage consisted of three 60 cm x 90 cm poster boards with brightly-coloured reminders to perform hand hygiene and arrows directing people to the hand hygiene stations. The primary written messages were “wash your hands” and “bring home the memories, not the germs,” along with various pictorial figures. The boards were posted at the positions indicated in Figure 1 during the appropriate time blocks. Verbal reminders from personnel were primarily variations of “Please wash your hands or use the hand sanitizer before you leave.” The interventions did not address technique for either hand washing or hand sanitizer use.

Video data were coded by two research assistants, both trained by the same author (MA) to ensure consistency. Data were coded for all visitors to the exhibit for 20 min out of each hour, beginning 20 min after the introduction of or change in the hand hygiene intervention. Codes were used for each of the following: age category (adult, child, young child, baby), gender, carrying an object/food/drink, touched a pen, touched an animal, entered a pen; use of each of the following: water, soap, paper towel, hand sanitizer; contact with an animal or pen following hand hygiene (i.e. by going back around the barrier counter to the flow of traffic). A child was defined as an individual who subjectively appeared to be between the ages of six and 16 years. A young child was defined as an individual who appeared to be between the ages of two and five years. A baby was defined as a child who appeared to be less than two years of age. Any independently ambulatory child was assumed to be at least two years old (i.e. not classified as a baby). Contact with pens/animals and entering a pen were recorded as separate events (e.g. an individual who entered a pen was not recorded as having touched a pen or animal unless a separate instance of this was observed).

2.2.1 Statistical analysis

All statistical analyses were performed using a statistical software package (STATA Intercooled 10.1, StataCorp, College Station, TX). Pairwise correlation of predictor variables was tested using Spearman correlation analysis. For pairs of predictor variables with absolute correlation values >0.75, the less informative variable was dropped.

A manual backward stepwise selection approach was used to create a final multivariable logistic regression model. All predictor variables unconditionally associated with the outcome (performed hand hygiene) at \( p \leq 0.20 \) were initially included in the multivariable model. Variables with a \( p \leq 0.05 \) were retained in the final model. The presence of confounding was evaluated by removing each insignificant variable one at a time, and noting the effect on the coefficients of the remaining variables. If any of the
coefficients for the remaining variables changed by more than 25%, then the eliminated variable was deemed to be a confounder and restored to the model. Furthermore, a likelihood ratio test (LRT) was used to assess the effect of removing any group of variables prior to dropping them; if the LRT was significant ($p \leq 0.05$) then the group of variables was left in the model. A Pearson $X^2$ goodness-of-fit test was used to assess the fit of the model ($p \leq 0.05$).

2.3 Results

In total, data were collected for 583 visitors, ranging from 31 to 144 during the individual observation periods. Based on the number of individuals for which data were collected over the selected time periods, it was estimated that the petting zoo was visited by a total of approximately 1700 individuals over the 6 h during which the study was performed. For the first hour, data were coded for all visitors to the exhibit as there was no risk of overlap with the previous intervention, and because there were considerably fewer visitors overall during this period.

Of the 583 observed visitors, 377 (65%) were noted to have entered an animal pen or touched an animal or animal pen while in the exhibit. Some form of hand hygiene (either using water, soap and water or hand sanitizer) was performed by 340 (58%) visitors. The proportion of individuals performing hand hygiene during the different intervention periods ranged from 50-77%. Hand washing was performed by 53/159 (33%) adults, 56/138 (41%) children and 22/42 (52%) young children who performed hand hygiene, whereas hand sanitizer was used by 112/159 (70%) adults, 97/138 (70%) children and 23/42 (55%) young children who performed hand hygiene. Both soap and water washing and hand sanitizer were used by 35 (6%) visitors (12 adults, 18 children, 5 young children), 11 (2%) visitors (6 adults, 3 children, 2 young children) used water without soap, and one adult used water without soap followed by hand sanitizer. Although use of water alone is typically considered inadequate for effectively decreasing microbial contamination of the skin (except to help remove gross contamination), the use of the sink station by these individuals was still considered an attempt to perform hand hygiene (albeit potentially ineffective). Of the 377 individuals who were noted to have contact with an animal or pen, 267 (71%) performed hand hygiene. Food or drink were carried into the exhibit area by 56 (10%) visitors, of which 29 (52%) had contact with an animal or pen, and of these 19 (66%) performed hand hygiene. Of the 340 visitors who performed hand hygiene, 30 (9%) had additional contact with an animal or pen before leaving the exhibit. Other descriptive statistics are presented in Table 2.1.

Variables that were found to be unconditionally associated with the performance of any type of hand hygiene are shown in Table 2.2. The results of the multivariable analysis are shown in Table 2.3.
Two of the interventions were significantly associated with performing hand hygiene (improved signage and personnel offering hand sanitizer, odds ratio (OR)=3.38, p<0.001; hand hygiene reminders from personnel, OR=1.73, p=0.037). Older children were the most likely individuals to perform hand hygiene (OR=1.67, p=0.034). A Pearson $X^2$ goodness-of-fit test showed the model fit adequately (p=0.1976).

Subjectively, older children appeared to perform hand hygiene voluntarily, although it was not possible to determine if they were being verbally prompted. Many children seemed to follow the example of other children and adults around them. Although data regarding duration of hand washing or rubbing were not recorded, subjectively it appeared that pre-teens spent more time washing their hands than teenagers. The step stool at the sink was used very consistently by children to help reach the faucet.

2.4 Discussion

The observed hand hygiene compliance (58%) is consistent with the upper end of the range of hand hygiene compliance at petting zoos and similar venues reported in other studies (1, 20). One of these studies, which used unannounced direct observation of visitors to 36 petting zoos, found that the presence of a hand hygiene station on an exit route, the presence of hand hygiene reminder signs and availability of running water were all positively associated with hand hygiene compliance (20). These combined results suggest that having a well-designed petting zoo that follows recommended guidelines can result in relatively high hand hygiene compliance. The one-way layout of the exhibit may have also contributed to the relatively high baseline compliance (50%). However, the findings of this study still indicate that a large percentage of visitors did not perform what is widely accepted to be one of the most important infection control measures at petting zoos. Of visitors who had direct contact with an animal or pen, 110/377 (29%) still failed to perform hand hygiene, and the same was true for 133/206 (65%) individuals who did not have such contact. Previous disease outbreaks associated with live animal exhibits have involved individuals who did not report direct contact with animals, and outbreak strains of E. coli and Salmonella have been found on numerous surfaces at petting zoo and similar environments (3, 9, 13, 19, 22). It is therefore recommended that all individuals who enter an animal exhibit perform hand hygiene before leaving the area, regardless of whether they had direct contact with an animal, due to the risk of indirect transmission (2, 7, 13). Based on the findings of this study, there is clearly room for improvement in hand hygiene compliance even at events designed and operated according to current recommendations, and additional educational efforts are still necessary to help increase overall compliance.
Hand sanitizer was used by 198/583 (34%) visitors instead of washing their hands at the sink (i.e. using running water). Line-ups for the sink may have affected this proportion, as a small number of visitors were noted to leave the line-up after standing in it for some time. It is unlikely that the personnel offering to dispense hand sanitizer had a negative effect on hand washing, as these personnel were stationed close to the exit, several metres past the sink station. Ensuring that an adequate number of hand hygiene stations (accessible to children and adults) and sufficient product are available for the number of visitors expected at a given venue may be critical to optimizing hand hygiene compliance. Alcohol-based hand sanitizers have been shown to be equally effective to soap-and-water hand washing for reducing hand contamination with coliform bacteria (such as *E. coli* 0157:H7) in a livestock-show setting (23), and for reducing overall bacterial load on the hands following contact with horses (24). Waterless hand sanitizers are often more convenient to use in barns and temporary animal exhibits where access to sinks may be limited. Although some studies have reported that hand sanitizer availability reduced the risk of disease associated with animal contact, other studies have shown no protective effect (2, 5, 9, 13). It is also important to recognize that alcohol-based hand sanitizers are ineffective against some pathogens that may be encountered in a petting zoo environment (e.g. *Cryptosporidium*, clostridial spores), and their effectiveness may be significantly impaired when hands are visibly soiled. In these instances, hand washing with soap and water to physically remove gross contamination and alcohol-resistant pathogens is recommended (2, 6). The use of water alone by 11 individuals demonstrates a need for public education regarding the relative ineffectiveness of this practice as a means of hand hygiene compared to washing with soap and water or using hand sanitizer.

The finding that children had better compliance with hand hygiene than adults is consistent with the findings in at least one other study (1). This may be due to increased awareness of the need for hand hygiene among school-aged children if there is growing use and emphasis on hand hygiene in schools, or due to parents instructing their children to perform hand hygiene after visiting the exhibit but failing to do so themselves. While healthy adults are generally at lower risk of infection than children, it is still important for parents and guardians to perform hand hygiene, as indirect transmission may result from contamination of their own hands followed by close contact with their children. Adults have also commonly been involved in outbreaks of disease associated with animal exhibits (19, 21, 22). Young children were not significantly more likely to perform hand hygiene than adults. The reason for this may in part be due to the inability of children of this age to access or use the hand hygiene stations without assistance from an adult, as some were not tall enough to reach the hand sanitizer bottles on the tables, or the faucet controls at the sink (despite the presence of the step stool), on their own. A negative association was found between hand hygiene and being a baby. Thirteen babies were included in the
study, only one of which was noted to have her hands washed or sanitized by the accompanying adult, while one other baby was observed touching a pen railing, and another entered a pen. Infants less than two years of age are less likely to benefit from briefly seeing and contacting animals in a petting zoo compared to older children who are much more cognizant of and responsive to the experience. The cost-benefit for a baby in terms of the risk of infectious disease transmission from either direct contact with the petting zoo environment or animals, or indirect contact via the person accompanying the baby, is less easily justified.

This preliminary study is the first to demonstrate the positive impact of a hand hygiene intervention at a petting zoo. Based on the final multivariable model (Table 2.3), the most effective hand hygiene intervention was a combination of improved signage and having personnel stationed along the exit route from the exhibit actively dispensing hand sanitizer. Neither the increased signage alone nor personnel offering hand sanitizer alone had a significant effect on hand hygiene compliance, although it is important to note that a relatively small number of individuals (31) visited the petting zoo during the time period where personnel offering hand sanitizer was the sole intervention. Therefore, there may have been insufficient power to identify a statistically significant effect. The other intervention that had a significant effect was having personnel reminding visitors to perform hand hygiene before leaving. These findings suggest that active interventions, rather than passive interventions such as increased or more prominent signage, are more effective for increasing hand hygiene compliance. Active interventions may be more likely to be noticed, more difficult to ignore or may be taken more seriously. Based on this, having designated personnel to supervise the hand hygiene area at an animal exhibit and provide verbal reminders to visitors to perform hand hygiene could be considered an important safety measure, just as having personnel to supervise animal areas is considered important for the safety of visitors (and animals).

Use of indirect video surveillance for observation of hand hygiene practices at the petting zoo had several advantages. It allowed observation and analysis of almost all visitors during the selected periods, thereby reducing observer bias, which can occur when only a few individuals from a crowd can be observed at a time. It also significantly reduced (or possibly eliminated) any Hawthorne effect, whereby persons who are aware that they are being observed may be more likely to alter their behaviour (25), which in this case would have likely resulted in an inflated compliance rate. Although video surveillance has been used previously to assess hand hygiene compliance in other settings such as the food industry (26) and healthcare facilities (27), this is the first report of its use at a live animal exhibit. This was also the first study in which both interaction with the petting zoo environment and hand hygiene behavior were recorded for each individual, thus permitting differentiation of actions by individuals who were shown to
have contact with animals and animal pens from the actions of individuals who entered the exhibit but did not have such contact. Limitations of this observation technique included difficulty with identifying subtle actions which may have resulted in direct contact with animals or their pens, particularly during very busy periods when the view of some individuals was obscured by crowding. However, this same problem can occur when direct observation is used.

The study was limited to observations made at a single petting zoo on a single day. This resulted in one of the intervention periods including a much smaller number of visitors compared to the other intervention periods due to the time of day. The original intention was to repeat the video observation at the petting zoo the following day, implementing the interventions at different times, in order to minimize this effect. Unfortunately, due to technical problems data from the second day of the event were not available for analysis.

2.5 Conclusion

Despite the availability of guidelines to help reduce zoonotic disease risks associated with live animal exhibits, implementation of these recommendations is still poor in many facilities (15, 20). Despite the relatively small sample size, this preliminary study provides evidence that different hand hygiene interventions can have a positive impact on hand hygiene compliance among visitors. Additional studies, on a larger scale and at multiple venues, are needed to confirm these findings and to help pinpoint the key interventions that are of the most benefit. In this study, interventions involving active reminders from personnel to perform hand hygiene were the most effective at increasing hand hygiene compliance.

The risk of infectious disease transmission between animals and people in any setting can never be completely eliminated. However, by increasing adherence to management and safety recommendations and increasing hand hygiene compliance among visitors at public animal exhibits the risk can be reduced. This will allow these exhibits to continue to play their role in educating the public about animals and animal husbandry and promoting compassion towards different animal species.
Table 2.1: Characteristics of visitors to the petting zoo for which video data were coded for each of the five hand hygiene intervention periods

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Intervention period</th>
<th></th>
<th></th>
<th></th>
<th>Total (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No intervention</td>
<td>Personnel offering HS</td>
<td>Personnel offering HS and</td>
<td>HH reminders from personnel</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(baseline)</td>
<td></td>
<td>improved signage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>-</td>
<td>118</td>
<td>144</td>
<td>31</td>
<td>102</td>
<td>80</td>
</tr>
<tr>
<td>Age category</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>63</td>
<td>76</td>
<td>16</td>
<td>62</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Child</td>
<td>41</td>
<td>52</td>
<td>13</td>
<td>22</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Young child</td>
<td>12</td>
<td>14</td>
<td>2</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Baby</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>54</td>
<td>74</td>
<td>10</td>
<td>39</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>64</td>
<td>70</td>
<td>21</td>
<td>63</td>
<td>53</td>
</tr>
<tr>
<td>Carrying object</td>
<td>None</td>
<td>90</td>
<td>109</td>
<td>23</td>
<td>53</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>Food/ drink</td>
<td>3</td>
<td>11</td>
<td>3</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Other¹</td>
<td>25</td>
<td>24</td>
<td>5</td>
<td>28</td>
<td>4</td>
</tr>
<tr>
<td>Touched pen</td>
<td>No</td>
<td>61</td>
<td>52</td>
<td>14</td>
<td>29</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>57</td>
<td>92</td>
<td>17</td>
<td>73</td>
<td>42</td>
</tr>
<tr>
<td>Touched animal</td>
<td>No</td>
<td>56</td>
<td>92</td>
<td>14</td>
<td>58</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>62</td>
<td>52</td>
<td>17</td>
<td>44</td>
<td>40</td>
</tr>
<tr>
<td>Entered pen</td>
<td>No</td>
<td>81</td>
<td>98</td>
<td>17</td>
<td>65</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>37</td>
<td>46</td>
<td>14</td>
<td>37</td>
<td>35</td>
</tr>
<tr>
<td>Used soap</td>
<td>No</td>
<td>93</td>
<td>113</td>
<td>29</td>
<td>69</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>25</td>
<td>31</td>
<td>2</td>
<td>33</td>
<td>7</td>
</tr>
<tr>
<td>Used HS</td>
<td>No</td>
<td>84</td>
<td>98</td>
<td>12</td>
<td>47</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>34</td>
<td>46</td>
<td>19</td>
<td>55</td>
<td>44</td>
</tr>
<tr>
<td>Used water only</td>
<td>No</td>
<td>118</td>
<td>136</td>
<td>31</td>
<td>102</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

HS=hand sanitizer, HH=hand hygiene
¹Other objects being carried by visitors included: cameras, coats, papers, strollers, balloons, toys, books, bags, backpacks, pacifiers, and canes.
### Table 2.2: Univariable logistic regression analysis of factors associated with performing hand hygiene\(^1\) during a visit to a petting zoo (N=583)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>n(%)</th>
<th>Performed HH n(%)</th>
<th>OR</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>Baseline 1 &amp; 2</td>
<td>262(45)</td>
<td>132(50)</td>
<td>1.00</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td></td>
<td>Personnel offering HS</td>
<td>31(5)</td>
<td>20(65)</td>
<td>1.79</td>
<td>0.83-3.89</td>
<td>0.140</td>
</tr>
<tr>
<td></td>
<td>Personnel offering HS and improved signage</td>
<td>102(17)</td>
<td>79(77)</td>
<td>3.38</td>
<td>2.00-5.71</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>HH reminders from personnel</td>
<td>80(14)</td>
<td>51(64)</td>
<td>1.73</td>
<td>1.03-2.90</td>
<td>0.037</td>
</tr>
<tr>
<td></td>
<td>Improved signage only</td>
<td>108(19)</td>
<td>58(54)</td>
<td>1.14</td>
<td>0.73-1.79</td>
<td>0.561</td>
</tr>
<tr>
<td>Age category</td>
<td>Adult</td>
<td>326(56)</td>
<td>159(49)</td>
<td>1.00</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td></td>
<td>Child</td>
<td>189(32)</td>
<td>138(73)</td>
<td>2.84</td>
<td>1.93-4.19</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Young child</td>
<td>55(9)</td>
<td>42(76)</td>
<td>3.39</td>
<td>1.76-6.56</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Baby</td>
<td>13(2)</td>
<td>1(8)</td>
<td>0.09</td>
<td>0.01-0.68</td>
<td>0.020</td>
</tr>
<tr>
<td>Carrying object</td>
<td>None</td>
<td>413(71)</td>
<td>249(60)</td>
<td>1.00</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td></td>
<td>Food/drink</td>
<td>56(10)</td>
<td>26(46)</td>
<td>0.57</td>
<td>0.33-1.00</td>
<td>0.050</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>114(20)</td>
<td>65(57)</td>
<td>0.87</td>
<td>0.57-1.33</td>
<td>0.529</td>
</tr>
<tr>
<td>Touched pen</td>
<td>No</td>
<td>235(40)</td>
<td>79(34)</td>
<td>1.00</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>348(60)</td>
<td>261(75)</td>
<td>5.92</td>
<td>4.12-8.52</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Touched animal</td>
<td>No</td>
<td>328(56)</td>
<td>148(45)</td>
<td>1.00</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>255(44)</td>
<td>192(75)</td>
<td>3.71</td>
<td>2.59-5.30</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Entered pen</td>
<td>No</td>
<td>396(68)</td>
<td>190(48)</td>
<td>1.00</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>187(32)</td>
<td>150(80)</td>
<td>4.40</td>
<td>2.92-6.62</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

HH=hand hygiene, OR=odds ratio, CI=confidence interval, Ref=referent, HS=hand sanitizer

\(^1\)Including the use of water alone, soap and water, or hand sanitizer for cleaning the hands
Table 2.3: Multivariable logistic regression analysis of factors associated with performing hand hygiene\textsuperscript{1} during a visit to a petting zoo (N=583)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>OR</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baseline 1 &amp; 2</td>
<td>1.00</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td></td>
<td>Personnel offering HS</td>
<td>1.91</td>
<td>0.79-4.61</td>
<td>0.148</td>
</tr>
<tr>
<td></td>
<td>Personnel offering HS and</td>
<td>4.03</td>
<td>2.20-7.36</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>improved signage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HH reminders from personnel</td>
<td>1.94</td>
<td>1.08-3.50</td>
<td>0.026</td>
</tr>
<tr>
<td></td>
<td>Improved signage only</td>
<td>1.34</td>
<td>0.80-2.23</td>
<td>0.262</td>
</tr>
<tr>
<td>Age category</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>1.00</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td></td>
<td>Child</td>
<td>1.67</td>
<td>1.04-2.67</td>
<td>0.034</td>
</tr>
<tr>
<td></td>
<td>Young child</td>
<td>1.17</td>
<td>0.54-2.51</td>
<td>0.692</td>
</tr>
<tr>
<td></td>
<td>Baby</td>
<td>0.09</td>
<td>0.01-0.76</td>
<td>0.027</td>
</tr>
<tr>
<td>Touched pen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>1.00</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3.92</td>
<td>2.58-5.97</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Entered pen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>1.00</td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>2.00</td>
<td>1.19-3.34</td>
<td>0.008</td>
</tr>
</tbody>
</table>

\textsuperscript{1}Including the use of water alone, soap and water, or hand sanitizer for cleaning the hands

OR=odds ratio, CI=confidence interval, Ref=referent, HS=hand sanitizer, HH=hand hygiene
Figure 2.1: Diagram of the layout of the petting zoo exhibit, including location of overhead surveillance cameras, hand hygiene stations (sink and hand sanitizer bottles) and additional signage used during specific hand hygiene intervention periods.
2.6 Acknowledgements

The authors thank Brittany A. Foster and Kyle Runeckles for their assistance with coding of the video footage, and Dr. David Pearl for discussions concerning possible statistical analyses. There was no funding source for this study. The authors declare that they have no conflicts of interest.
References


CHAPTER 3:

Observational study of patient and surgeon preoperative preparation in ten companion animal clinics in Ontario, Canada

Maureen EC Anderson
Brittany A Foster
J Scott Weese
3.0 Abstract

Background: Surgical site infections (SSIs) are a recognized risk of any surgical procedure in veterinary medicine. One of the keys to prevention of SSIs is reducing exposure of the surgical site to endogenous and exogenous microbes, beginning in the preoperative period. While guidelines are available for preoperative preparation procedures, there has been no objective investigation of compliance with these recommendations in veterinary practices. The objectives of this pilot study were to describe preoperative patient and surgeon preparation practices in a sample of non-equine companion animal veterinary clinics, and to determine if there were any areas that consistently did not meet current guidelines.

Results: Observation of preparation practices was performed in 10 clinics over 9-14 days each using up to 3 small wireless surveillance cameras. Data were coded for 148 surgical patients, and 31 surgeons performing 190 preoperative preparations. When patient hair removal was observed, it was most commonly done using clippers (117/133, 88%), and in only one case was it performed prior to anesthetic induction. Patient contact time with soap ranged from 10-462 s (average of clinic means 75 s, average of clinic medians 67 s), and with alcohol from 3-220 s (average of clinic means 44 s, average of clinic medians 37 s). Alcohol-based hand rub (AHR) was used preoperatively in 2/10 facilities, but soap-and-water hand scrub was most commonly used at all clinics. Proximal-to-distal scrubbing was noted in 95/142 (67%) of soap-and-water scrubs. Contact time during surgeon hand preparation ranged from 7-529 s (average mean 121 s, average median 122 s) for soap-and-water and from 4-123 s (average mean 25 s, average median 19 s) for AHR. No significant changes in practices were identified over time during the observation period. Practices that did not conform to guidelines available in major companion animal surgical textbooks were commonly observed.

Conclusions: Some preoperative preparation practices were relatively consistent between clinics in this study, while others were quite variable. Contact times with preoperative preparatory solutions for both patients and surgeons were often shorter than recommended. Evidence-based guidelines for these procedures in veterinary medicine should be emphasized and implemented in order to help reduce preventable SSIs, while maintaining efficiency and cost-effectiveness.
3.1 Introduction

Surgical site infections (SSIs) are common hospital-associated complications in human medicine, affecting an estimated 300,000 to 500,000 patients every year in the United States alone (1). While the impact of SSIs is poorly quantitated in veterinary medicine, SSIs are not uncommon, with reported rates ranging from 1-18% in dogs and cats, and these infections can result in significant patient morbidity and mortality (2-4). Hundreds of thousands of pets undergo elective and non-elective surgical procedures every year, and although the risk of SSI is low in most cases, it is never zero, and it can be much greater for some animals. In a time of increasing availability of complex surgical procedures for veterinary patients, patients living longer with more debilitating and immunosuppressive diseases that increase their susceptibility to infection, and increasing concern regarding infections caused by antimicrobial-resistant pathogens that may be more difficult to treat (5-7), the prevention of SSIs warrants more attention than ever before. Not every SSI is preventable, but many are, and the ultimate goal is to reduce the preventable fraction of these infections to zero (8). As medical professionals, veterinarians should take all reasonable precautions to prevent SSIs in their patients. There are risk factors in every surgical case that are beyond the control of the surgeon, which makes addressing those factors which can be controlled all the more important, including pre-operative, intra-operative and post-operative procedures. The importance of preoperative preparation of the patient and surgeon was first reported by Joseph Lister in 1867, and by the turn of the 20th century he and others had shown that such measures could have a dramatic impact on SSI rates and ultimately patient survival (9-11). Since then, preoperative preparation has become such a basic standard practice that published studies can only compare the impact of different techniques on various outcomes, as the absolute effect was so clearly demonstrated more than a century ago.

The focus of this study was preoperative preparation of the patient and surgeon in non-equine companion animal facilities, as it pertains to the reduction of preventable SSIs. Anecdotally, these procedures vary considerably between clinics, and there has been no evaluation of practices currently in use. Basic guidelines for preoperative preparation in veterinary medicine are published in surgical textbooks (12-14), and a small number of other easily accessible sources (15), but the veterinary literature contains a relative paucity of information on the comparison of different means of surgeon and surgical site preparation. The objectives of this pilot study were to describe preoperative patient and surgeon preparation practices in a limited number of companion animal veterinary clinics, to investigate factors that may be associated with specific key practices, and to determine if there were any areas that consistently did not meet currently available guidelines.
3.2 Materials & Methods

A convenience sample of 10 companion animal veterinary clinics in southwestern and eastern Ontario, Canada, was recruited to participate. Each clinic was contacted directly by one of the investigators (MA or JSW) by e-mail or telephone. Data collection was performed from February to August 2010. Wireless indoor video surveillance cameras (Logitech WiLife™ Indoor Video Security System, Logitech, Newark, CA) were installed by one of the investigators (MA) on day 0 to monitor each of the following areas: patient preparation table, surgical scrub sink, gowning and gloving area and surgical table in the surgical suite. Two or three cameras were used at each clinic simultaneously depending on clinic layout, routine preoperative procedures and equipment availability. The cameras were visible to staff but care was taken to position the cameras and secure their power cords to make them as discrete as possible. All indicator lights on the cameras were disabled so there were no visible signs that the cameras were on or off. Video data were recorded by powerline network on a secure, closed laptop computer kept elsewhere in the clinic in an unobtrusive location (e.g. on top of a cupboard, under a desk, on an unused shelf). Cameras were left in place for 9-14 working days (12-20 calendar days), and were motion-activated during the hours when routine surgeries were typically performed in each clinic. The cameras did not record audio data. Written consent was obtained in advance from all personnel whose images would potentially be captured on video, and participants were informed as to the general purpose of the study, but not what specific parameters were being investigated. During either the set-up or take-down site visit to each clinic, a technician or veterinarian was asked to show the investigator (MA) what products were used for preoperative preparation of the surgeon and patient; product names and active ingredients (agents) were recorded, as well as in what order the products were typically used, if applicable. This study was approved by the University of Guelph Research Ethics Board.

A video coding scheme was developed in the form of a fillable spreadsheet (Excel 2008 For Mac, Microsoft Corporation, Redmond, WA) and tested by two of the investigators (MA and BF) using the preliminary data from two clinics. The remaining videos were coded by one investigator (BF). Videos were generally scanned at 2-4 times normal speed, and then watched in real time or slow motion with repeated review as necessary to discern pertinent actions. The spreadsheet data were then imported directly into a statistical software program (STATA Intercooled 10, StatCorp LP, College Station, Texas) to perform descriptive and quantitative analyses. Preoperative patient preparation procedures (“patient preps”), including species, surgical site/procedure (abdominal, neuter, limb, other), hair removal, skin antisepsis technique, transportation to the surgical suite, draping, and performance of a “final prep” (application of a biocide after transportation to and positioning on the surgical table immediately before the procedure began) were analyzed separately from preoperative surgeon preparation procedures.
(“surgeon preps”), including hand antisepsis technique, gowning, gloving and surgical cap/mask use. Patient species and surgical site/procedure were also recorded for surgeon preps unless the procedure for which the surgeon prepared was performed in an off-camera area or room, in which case these variables were recorded as unknown (this also resulted in coding of a larger number of surgeon preps than patient preps). For patient preps, contact time with soap or alcohol was measured as the time from first contact of the skin with the product to the time of first contact of the skin with any other product that would remove it (e.g. alcohol or a biocide solution/tincture). If no subsequent preparation step was observed (e.g. no subsequent step was done, animal was moved off camera, camera was blocked) the total contact time was not recorded. For surgeon preps, contact time was measured from the point the product used first came in contact with the skin to the start of rinsing (if soap and water) or cessation of rubbing (alcohol-based hand rub (AHR)). If the surgeon left the field of view and did not return while still rubbing hands with AHR, no contact time was recorded.

3.2.1 Statistical analysis

Outcomes evaluated using quantitative analysis were limited to contact time (with soap or alcohol for both patients preps and surgeon preps) and performance of a final prep for patients, as these outcomes could be most objectively measured and were considered critical control points in the overall preparation process. Factors included in the linear regression models (contact times) and logistic regression model (final prep) were determined a priori based on what data could be collected from the videos, factors thought to be the most likely to have an effect on the outcome (species, surgical site/procedure), and the need to control for clustering by clinic (initially included as a random effect in all models) and by surgeon (included as a random effect in surgeon prep models). The number of days the cameras had been present at the time of each observation was included in all linear models to determine if the duration of the presence of the cameras had any effect on the outcomes. It was considered unlikely that the presence of the cameras would affect whether or not a final prep was done, as clinics were asked not to consciously alter their normal routines; therefore, this variable was not included in the logistic model for this outcome. The intraclass correlation coefficient (ICC) was calculated for each random effect variable in each linear model in order to assess the amount of correlation at each level, according to a standard formula for multi-level models (16). Residuals for all models were assessed graphically using scatter plots and normal quantile plots, and outliers were further examined to ensure they were not the result of errors in data entry. For the linear models, the normality of best linear unbiased predictors (BLUPs) was assessed using normal quantile plots to evaluate model fit.
3.2.2 Review of preoperative preparation guidelines in veterinary textbooks

A review of preoperative preparation guidelines available in current small animal surgery textbooks was also undertaken. Textbooks were selected based on accessibility and those that were anecdotally most commonly used by veterinarians in Ontario. For textbooks with multiple editions, only the most recent edition was reviewed. All relevant chapters regarding preoperative patient and surgeon preparation were examined, and the recommendations given by each textbook for pre-selected common procedures were summarized in table format.

3.3 Results

A total of 17 clinics were approached to participate in the study. Two did not respond to phone or e-mail inquiries, three declined with no reason given, one declined stating that the clinic was too busy to participate at the time, and one declined stating that the staff were not comfortable with the use of the video cameras. The 10 clinics that agreed to participate in the study were all exclusively companion animal (non-equine) facilities, including single- and multiple-veterinarian practices, primary care and referral clinics, and clinics in both urban and suburban locations across southwestern and eastern Ontario.

In 3 clinics, a sufficient number of cameras was not available to monitor all patient and surgeon preparation areas as well as the surgical suite(s), therefore details of final preparation procedures in the surgical suite could not be recorded in all cases.

Variations in denominator values were due to procedures that were not applicable to a given patient or surgeon (e.g. if gloves were not used then glove contamination was coded as not applicable) and/or procedures that were not performed in view of the camera but may or may not have been performed off-camera (coded as not visible).

The agents contained in the products reportedly used by the participating clinics for routine patient and surgeon preps are shown in Table 3.1.

The fit of all regression models based on graphical assessment of residuals and BLUPs was considered adequate.

3.3.1 Patient preparation

A total of 148 patient preps were recorded. The number of patient preps per clinic and per surgical site/procedure is shown in Table 3.2.
All clinics routinely used clipping for hair removal (117/148 cases, 79%), except for cat neuters for which hair was plucked in 16/25 (64%) cases at five clinics. A razor (shaving) was used once following clipping for an aural surgery. In 10 cases hair had already been removed before the animal was in view of the camera, and in 5 cases no hair removal was performed (4 declaws, 1 small lumpectomy). One clinic regularly clipped and performed all skin preparation steps on patients in the surgical suite. All other clinics clipped and performed at least one skin preparation step prior to moving the patient to the surgical suite. Hair removal prior to anesthetic induction was observed in one patient that appeared heavily sedated.

Application of a soap-and-water scrub during patient prep was observed in all clinics. Soap-and-water scrub was applied with a “back and forth” technique in 9/10 clinics, and with a “circular” technique in 7/10 clinics, but in 4 of the latter clinics “back and forth” was still used more often than the “circular” technique. Application of an alcohol step was observed in 9/10 clinics; this was performed in a “centre to edge” or “concentric circles” pattern in 6/9 clinics, whereas a “top to bottom” linear technique was used in 8/9 clinics. Of the 8 clinics in which another antiseptic step was observed (instead of or in addition to alcohol), 4 used “centre to edge” or “concentric circles”, whereas 6 used “top to bottom”, which was the most common technique used (40/83 observed applications, 48%). Use of multiple techniques was observed at most clinics. Reuse of the same surface of a disposable gauze square after a single contact with the patient’s skin was frequent for application of alcohol (59/62, 95%) and antiseptic (53/60, 88%).

Non-sterile contact (e.g. by clothing, unclipped limbs, drape surfaces previously in contact with unprepared sites) with the surgical site during transportation of the animal to the surgical suite was seen in 39/107 (36%) cases in 7/8 clinics in which this procedure was observed, but non-sterile contact may have actually occurred in a higher proportion of patients than this, as it was not possible to track all animals during the entire transportation procedure due to the fixed camera positions. A total of 27/148 (18%) animals from 9 clinics had their procedures performed in the patient preparation area instead of the surgical suite; these included 22 (81%) cat neuters, 3 procedures on digits (including declaws), drainage of an aural hematoma and debridement of two preexistent surgical incision sites on the same animal. Out of 64 procedures for which a final preparation step in surgery was observed, non-sterile contact with the surgical site was observed during 7 (11%). In a multivariable mixed-effects logistic regression model including clinic as a random effect and surgical site and species as fixed effects, final prep in surgery was significantly less likely to be performed for neuters compared to abdominal surgeries (odds ratio (OR) 0.13, p=0.013, 95%CI 0.02-0.65), and was more likely to be performed for dogs compared to cats (OR 5.2, p=0.005, 95%CI 1.62-16.57).
Contact time with soap (Table 3.3) was recorded for 105 patient preps in 9/10 clinics, and ranged from 10-462 s. The average of the mean contact time for each clinic was 75 s, and the average of the median contact time was 67 s. Contact time with alcohol (Table 3.3) was recorded for 37 patient preps in 8/10 clinics, and ranged from 3-220 s, with the average of mean contact times being 44 s and the average of median contact times being 37 s. A multivariable mixed-effects linear regression model including clinic as a random effect, surgical site/procedure, species and the number of days the cameras were present in the clinic as fixed effects showed that there was no significant difference in soap contact time between species (p=0.511) or surgical site/procedure (partial F-test p=0.145), and the number of days the cameras were present in the clinic also had no significant effect (p=0.075). The ICC for clinics was 0.36. A similar model constructed with the same variables showed that alcohol contact time was significantly longer for dogs compared to cats (26 s, p=0.039, 95%CI 1-51), but surgical site/procedure had no significant effect (partial F-test p=0.314). The number of days the cameras were present had no significant effect (p=0.997), and the ICC for clinics was 0.35.

3.3.2 Surgeon preparation

A total of 190 surgeon preps performed by 31 individual surgeons were recorded. The number of surgeons observed and the number and type of surgeon preps performed at each clinic are shown in Table 3.4. The mean number of surgeon preps observed per surgeon was 6 (range 1-21, median 4).

Contact time with soap-and-water was recorded for 144 surgeon preps in 10/10 clinics, and ranged from 7-529 s. The average of the mean contact time for each clinic was 121 s, and the average of the median contact time was 122 s. The 11 shortest soap-and-water scrubs (range 7-19 s) all preceded cat neuters. For cat neuters, scrub duration ranged from none (following a previous surgery) to 153 s (mean 38 s, n = 23) at 6/10 clinics, while duration of scrubs for dog neuters ranged from 25-402 s (mean 114 s, n = 18) at 7/10 clinics. The mean duration of scrubs prior to abdominal surgeries ranged from 20-313 s (mean 114 s, n = 52) at 9/10 clinics. Scrubs done with a bristle sponge ranged in length from 17-529 s (mean 166 s, n = 121) at 9/10 clinics; the remaining scrubs were performed without any brush or sponge at 4/10 clinics and ranged in length from 7-90 s (mean 28 s, n = 23). Proximal to distal scrubbing (e.g. scrubbing from arms to hands instead of hands to arms) was noted in 95/142 (67%) soap-and-water surgeon preps at 9/10 clinics, for 25/31(81%) surgeons.

Alcohol-based hand rub was used for preoperative hand antisepsis by 9 surgeons in 2/10 facilities, but even at these clinics soap-and-water scrub was more commonly used (see Table 3.4). Only one of the two clinics used an AHR that was labeled for preoperative hand antisepsis (alcohol-based surgical hand
rub, ASHR) as opposed to an AHR intended for routine hand hygiene, although in the latter clinic use of the AHR was always preceded by a basic hand wash with 4% chlorhexidine soap. Contact time with alcohol was recorded for 37 procedures and ranged from 4-123 s. The average of the mean contact time for each clinic was 25 s, and the average of the median contact time was 19 s. Use of AHR was not observed prior to any neuters. Other notable practices that were observed during surgeon prep included two individuals shaking their hands to dry (instead of rubbing to dry) when using AHR (10).

The mixed-effects linear regression model for surgeon prep soap-and-water contact time included clinic and surgeon as random effects, and surgical site/procedure, species and the number of days the cameras were present in the clinic as fixed effects. Surgeon preps for which the surgical site/procedure and species were unknown were excluded (n=19). The model showed no significant difference in contact time for cats compared to dogs (p=0.130). Soap-and-water contact time was significantly longer for limb procedures compared to abdominal procedures, neuters and all “other” surgical sites (55 s, p=0.011, 95%CI 13-98; 77 s, p=0.001, 95%CI 30-124; 95 s, p<0.001, 95%CI 43-146 respectively) and significantly longer for abdominal procedures compared to all “other” surgical sites (40 s, p= 0.032, 95%CI 3-76). The ICC for clinics was 0.52 and for surgeons was 0.74. The number of days the cameras were present in the clinic had no significant effect on soap-and-water contact time (p=0.380).

Because AHR was only used at two clinics, the model constructed for AHR contact time included surgeon as a random effect, and clinic, surgical site/procedure, species and number of days the cameras were in place all as fixed effects. Surgeon preps for which the surgical site/procedure and species were unknown were excluded (n=11). The only significant factor in the model was surgeon (p=0.0227 for likelihood ratio test vs linear regression model without random effects); however, because the model included only 26 observations it had relatively low power to detect differences in the other variables. The ICC for surgeons was 0.52.

Surgical gloves were used for 176/188 (94%) observed procedures. For 65 (35%) of these the gloving technique used was not seen. Open gloving was used in 61 (32%) cases in 8/10 clinics by 17 surgeons. Closed gloving was used in 50 (27%) cases in 7/10 clinics by 16 surgeons, but poor technique including exposure of fingers or contact with a non-sterile cuff (as when regloving) was observed in 21 of these (5 surgeons)(12). Other contact with the outside of the gloves while donning was seen in 5 cases (4 surgeons) in which the view was unobstructed. Of 12 (6%) surgeries for which gloves were not used, 10 were cat neuters performed at 3 clinics, and 2 were cat declaws performed at 2 clinics. For two procedures use of gloves could not be confirmed due to camera obstruction.
A gown was used in a total of 133/190 (70%) procedures, including 42/63 (67%) abdominal procedures, 11/41 (27%) neuters and 38/39 (97%) limb procedures. In 9 cases, including 2 abdominal procedures at 2 clinics, the gown used had clearly been in contact with non-sterile surfaces or had been used for a previous surgery. Six (19%) surgeons at 3 clinics did not wear a gown for at least one abdominal procedure. A mask was used in 175/190 (92%) procedures, including all abdominal and limb procedures and 26/41 (63%) neuters. A cap was also used in all but 8 cases (involving 2 surgeons) when a mask was used. All procedures for which a mask was not worn were cat neuters, performed at 5 clinics.

3.3.3 Review of preoperative preparation guidelines in veterinary textbooks

The most recent editions of two major small animal surgery textbooks (12,13) that were available at the time of the study were reviewed to compare their recommendations, as well as one of the most recently published small animal surgery textbooks (14). The results of the comparison are shown in Table 3.5. Of note:

- All three textbooks primarily recommended the use of chlorhexidine (CH) or povidone iodine (PI) (either aqueous or tincture) for patient preparation, and two stated that other agents are not recommended, as CH and PI are superior.
- When specified, the recommended agent contact time for patient prep was consistently at least 2 minutes, with the exception of the most recent textbook which also discussed newer one-step prep agents, but emphasized that manufacturer’s instructions should always be followed for any specific product.
- Likewise, recommended contact times for soap-and-water surgeon prep were universally at least 2 minutes, and up to 7 minutes. Recommended contact times for ASHR were 1.5-2 minutes, or as per manufacturer’s instructions.

While all three textbooks favourably discussed the use of ASHR, the more recent the publication, the more the use of ASHR was promoted over soap-and-water scrub.

3.4 Discussion

Microbial contamination of a surgical site is a prerequisite for all SSIs, therefore one of the primary goals of SSI prevention practices is to reduce the spread of microbes to and at the surgical site, beginning in the preoperative period. At no time are the tissues more susceptible to invasion than during the surgical procedure itself, which makes preoperative preparation of both the patient and surgeon critical for SSI prevention.
The goal of preoperative patient skin preparation is to reduce the transient and to some extent the resident microbiota of the skin as rapidly and atraumatically as possible, and to prevent short-term (i.e. hours) rebound growth of opportunistic bacterial pathogens. This helps to protect sterile sites from invasion by the patient’s own endogenous flora, which is critical as the majority of surgical site infections are caused by bacteria that are already carried by the patient at the time of surgery (17). In this study, some preoperative patient preparation practices were relatively consistent between clinics, while others were not. Hair removal was routinely performed using clippers in all clinics after patient induction, and the majority of clinics performed hair removal and at least one preparation step outside the surgical suite, which is consistent with current recommendations and evidence for reducing SSI risk (12-14,18). The techniques with which skin preparation solutions were applied varied considerably between and within clinics, which likely reflects lack of standardized protocols, with subsequent day-to-day differences in staff performing these procedures. A number of different application techniques are used for skin antiseptics in human medicine as well; however, it is typically recommended that application is done in a “cleanest-to-dirtiest” pattern of some kind, starting with a clean applicator (e.g. gauze) at the centre of the prepared area (i.e. the incision site) and moving toward the periphery, usually in concentric circles (12,13,17,19). This helps to avoid contaminants from unprepared areas of skin being dragged onto cleaner areas of skin on the applicator itself. Contact times with skin preparation agents were often far shorter than those recommended by the manufacturer. In only one clinic was the mean contact time with antiseptic soap during patient preparation greater than the minimum recommended contact time for the product used (2-5 minutes, see Table 3.3). Establishing standard clinic protocols for application of these agents could help to avoid critical errors and improve contact times.

Despite numerous studies in the human medical literature, there is still no consensus on what antiseptic agent is best used for surgical site preparation (20). The two most commonly used agents are PI and CH in either alcohol or aqueous solutions (8,17,20,21). Some in vitro and experimental studies show CH has a more rapid immediate and/or sustained effect than PI, but both are broad-spectrum antiseptics and remain in wide clinical use. A recently published randomized control trial found a lower SSI rate in patients prepared using CH in alcohol versus aqueous PI, but the trial was criticized for not comparing CH in alcohol to PI in alcohol (1). Although in the current study 6/10 clinics reported using a CH or PI product for patient preparation, 4/10 clinics used products containing other agents (chloroxylenol or an ammonium chloride compound) instead. The reasons for selecting these other products were not investigated.
In human patients, skin preparation in the immediate preoperative period involves application of antiseptic in either a single or multiple steps (20). However, the comparatively dense hair coats of animals and other species-specific factors may lead to very different skin conditions and levels of contamination in veterinary patients, therefore a multi-step process is typically used for patient preparation, as was observed in all clinics in this study. However, it is unknown which step of the preparation procedure is the most critical for reducing the microbial flora. Until more information is available, it seems prudent to ensure that each product employed in the protocol is used according to the manufacturer’s recommendations in order to obtain the most benefit.

The goal of preoperative hand antisepsis is similar to that of patient skin preparation, and ultimately helps to protect the patient’s tissues from invasion by exogenous bacteria from the surgeon’s hands. Rapid and atraumatic methods of reducing the microbiota of the skin are particularly important for surgeons who may need to perform the procedure frequently, in order to prevent skin damage that can lead to increased carriage of bacteria on the hands (14). However, adequate contact time with hand preparation agents is crucial to achieve the required reduction of bacterial numbers. Although recommended contact times with traditional preoperative hand scrub agents have decreased from 10 minutes or more to as little as 2 minutes (10,12,13,22), in this study contact time (and technique) for soap-and-water surgeon preparation were highly variable, with almost half failing to meet the minimum recommended 2-minute scrub time.

Alcohol-based surgical hand rubs have been the recommended method of choice for surgeon hand antisepsis in human medicine for some time (23). These agents have a rapid-kill effect due to their alcohol content, and typically contain another antiseptic agent such as CH that remains on the skin and provides a more prolonged antimicrobial effect. They take less time to apply, and perhaps most importantly are the least traumatic means of reducing the microbial flora of the hands, particularly with repeated use, when compared to traditional soap-and-water scrub. In two clinical trials comparing traditional hand scrub to an ASHR that measured SSIs as the primary outcome, ASHR was found to perform equally well, the ASHR protocol was better accepted by personnel (24), and in a cost analysis was 40% less expensive per application (25). The use of ASHR also reduces waste (sponges, drying towels), saves a considerable amount of water (traditional scrubs typically require approximately 20 L of water per person (10)), and negates the risk of recontamination of the hands in the case of potentially contaminated water faucets/sinks or questionable water quality.
Despite the widespread acceptance of ASHRs for preoperative hand antisepsis in human medicine, and the body of evidence available that supports their use, veterinarians have been slow to adopt this technique. A survey of board-certified veterinary surgeons in North America and Europe in 2009 found that 80% still used antiseptic soap-and-water preoperative scrub, and of these 81% used chlorhexidine-based scrub (26). This may be due to the perception that veterinarians’ hands may be more heavily soiled in the clinic environment because they handle animals and therefore need to be scrubbed (27), failure to communicate information about ASHRs to veterinarians as a result of the lack of information on this topic published in the veterinary literature, or simply resistance to change. Recently Verwilghen et al. (28) evaluated the efficacy of ASHR versus soap-and-water scrub in a veterinary context, and found the ASHR to have an equal or better immediate and sustained antiseptic effect, and concluded that ASHR could be an effective alternative for veterinary preoperative hand asepsis. In the current study, alcohol-based agents were infrequently used for surgeon preparation compared to soap-and-water, and in 50% of cases total contact time was 25 s or less (data not shown), which does not meet the recommended contact time of 1.5-2 minutes for preoperative use of such agents (12,14). Furthermore, one clinic used an AHR not labeled for preoperative use in the place of ASHR. The effectiveness of AHR intended for routine hand hygiene for preoperative hand antisepsis is unknown, and its use in this manner should be avoided given that approved ASHR products are readily available. More training and information about the use of ASHRs needs to be provided to veterinarians.

The use of sterile surgical gloves is also an important component of aseptic technique that likely contributes significantly to the prevention of SSIs by providing an effective barrier between the microbiota of the surgeon’s hands and the surgical site. Sterile gloves were used by surgeons for the majority of procedures observed in this study, although potential contamination of the outer sterile surface of gloves was seen occasionally. However, glove use does not negate the need for proper preoperative hand antisepsis. The accepted quality control limit for defects in medical gloves large enough to leak water is 1.5% (29). In one study of glove punctures in orthopedic surgery, perforations were found in 2/200 (1%) of unused control gloves (30). Furthermore, glove punctures have been reported to occur in up to 34-43% of human surgical procedures (31-33). In a study performed at two companion animal hospitals, glove punctures were found in one or both gloves in 148/382 (38.7%) glove pairs, and personnel were typically unable to predict whether or not a glove defect was present at the end of procedures (34). Proper hand antisepsis prior to gloving for surgery therefore remains critical.

Intraclass correlation coefficients are useful for estimating the correlation in outcome measures within clusters of mixed models (i.e. those including random effects)(16). In this study, the ICCs
estimate the correlation in contact times for surgeon and patient preparations within each clinic, and for surgeon preparations within each surgeon within a clinic. The ICC for clinics for contact time with soap-and-water and alcohol in patient preps were relatively low (0.35-0.36), which suggests that compliance with individual clinic protocols (assuming they exist) was also low, and is consistent with the wide range of contact times and techniques observed within each clinic. The ICC for surgeons for contact time with soap-and-water was higher (0.74), suggesting that each surgeon’s individual routine was relatively consistent. Surgeon was the only significant factor in the model for AHR contact time, but the ICC was 0.52, indicating that AHR contact time between scrubs for each surgeon was likely only moderately consistent.

Due to the limited amount of information on preoperative preparation of the patient and surgeon in the veterinary literature, veterinary surgery textbooks are one of the most likely sources of information regarding these procedures for veterinarians in private practice. Based on the results of this study, including use of agents other than CH and PI for preoperative preparation, frequently short contact times with preparation agents and relatively infrequent use of ASHR, it seems the majority of individuals observed were unaware of the guidelines in currently available companion animal surgery textbooks, or chose not to follow them during preoperative preparation for any number of reasons (e.g. personal preference, time constraints, habit, lack of perceived adverse events from alternate methods).

Any observational study is potentially subject to bias due to Hawthorne effects, whereby individuals may modify their behavior (intentionally or unintentionally) due to the knowledge that they are being observed (35). The use of video observation with discreet webcams over days to weeks was intended to help reduce or eliminate Hawthorne effects in this study, compared to direct observation with an observer present in the room, which would be considerably more intrusive and serve as a constant reminder of the ongoing study. If the presence of the cameras resulted in altered behavior among study participants with respect to the procedures observed, one might expect an initial artificial increase in contact times with preparation agents, due to increased focus on these activities, followed by a decrease over time as individuals became acclimatized to the equipment and returned to their typical routine (36). Such a pattern was not apparent here, suggesting that the cameras had little impact on participant behaviour. Based on informal verbal feedback received, the cameras seemed to be well tolerated by staff overall, and this system could be useful for future observational studies in small companion animal clinics in which direct observation of practices is not feasible.
The various limitations of this pilot study must be taken into account when interpreting the results. The sample size was small, yet covered a wide range of practice types with a variety of caseloads in terms of both type and quantity of procedures, so the power for some comparisons was quite low. Potential volunteer bias must also be considered, as clinics with more interest in improving preoperative preparation practices, or that already felt more comfortable with the quality of their practices, may have been more willing to participate. Although the use of the camera monitoring system likely provided considerably less biased and a larger quantity of data compared to direct observation, the fixed camera positions and their limited field of view resulted in incomplete data sets for many of the procedures observed. Contact time for preparation steps that were not followed by an additional preparation step (including the final preparation step) were not recorded because this information could not be captured reliably in many cases, due to the inability to determine when alcohol or alcohol-based agents had fully dried, lack of a camera in the surgical suite, or obstruction of the camera by personnel during draping and at the start of surgery that precluded determination of the time of the initial incision. In future studies, if a similar video observation system is employed, recommendations include pre-visits to all participating clinics to determine the number of cameras required in advance (to ensure an adequate number is available), and improved positioning of cameras, particularly in the surgical suite, to help reduce the risk of visual obstruction. Cameras should be placed as high up as possible or even on the ceiling (e.g. above the surgery table). Ceiling mounting of the camera system was used in this study without complications in several clinics, but was not possible in other cases due to constraints regarding power outlet locations, cable length, visual field of the cameras and concerns regarding obstruction by overhead surgical lights. Pre-visiting the clinics would also allow more time for consultation with the staff regarding optimal camera placement, and thereby increase efficiency of set up when the cameras are put in place, thus further minimizing disruption to clinic workflow.

3.5 Conclusion

This study provides an interesting glimpse of the variety of practices being employed currently in different clinics during preoperative preparation of patients and surgeons. It brings to light a number of issues, including the need for proper use of ASHR by surgeons and other skin antiseptics for patient preparation according to manufacturers’ instructions, that can potentially be addressed through education and increasing awareness. Evidence-based guidelines for patient and surgeon preoperative preparation need to be emphasized and implemented to help improve the standard of veterinary care and reduce preventable SSIs, while maintaining efficiency and cost-effectiveness. The camera system used had little detectable effect on the behavior of participants, and could be useful for performing similar field-based observational studies in the future.
Table 3.1: Agents used for routine preoperative patient preparation and surgeon preparation in 10 companion animal clinics in Ontario, as reported on-site by clinic staff, including manufacturers’ recommended contact times as per product labels

<table>
<thead>
<tr>
<th>Agent</th>
<th>Recommended contact time</th>
<th>Number of clinics using for:</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Patient prep</td>
<td>Final patient prep</td>
<td>Surgeon prep</td>
<td></td>
</tr>
<tr>
<td>70-99% isopropanol</td>
<td>-</td>
<td>8</td>
<td>3</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>70% isopropanol, 0.5% CH</td>
<td>2+ min</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>61% ethanol, 1% CH</td>
<td>1.5-2 min (12,14)</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4% CH</td>
<td>3 min twice</td>
<td>4</td>
<td>-</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>0.1% CH (prepared in house)</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2% chloroxylenol</td>
<td>2 min</td>
<td>4</td>
<td>-</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>0.6% chloroxylenol</td>
<td>Not labeled for pre-op use</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7.5% povidone iodine</td>
<td>5 min</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>10% povidone iodine</td>
<td>Paint &amp; dry, 5 min</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>0.2% ammonium chlorides</td>
<td>Not labeled for use on patients</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

CH=chlorhexidine
Table 3.2: Number of preoperative patient preparation procedures ("patient preps"), including surgical site or intended surgical procedure, in 10 companion animal clinics in Ontario recorded using video observation

<table>
<thead>
<tr>
<th>Clinic</th>
<th>Total patient preps</th>
<th>Abdominal</th>
<th>Dog neuter</th>
<th>Cat neuter</th>
<th>Limb</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
<td>8</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>14</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>13</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>15</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>36</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>148</td>
<td>58</td>
<td>19</td>
<td>25</td>
<td>30</td>
<td>16</td>
</tr>
</tbody>
</table>
Table 3.3: Contact times for soap-and-water and alcohol used in different steps\(^a\) of preoperative patient preparation in 10 companion animal clinics in Ontario recorded using video observation

<table>
<thead>
<tr>
<th>Clinic</th>
<th>Soap-and-water patient prep step</th>
<th>Alcohol patient prep step</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean contact time (s)</td>
</tr>
<tr>
<td>1</td>
<td>14</td>
<td>48</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>82</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>59</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>52</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>54</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>25</td>
<td>107</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>29</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>219</td>
</tr>
<tr>
<td>Total</td>
<td>105</td>
<td>75(^b)</td>
</tr>
</tbody>
</table>

\(^a\) Contact times were only recorded for those preparation steps which were followed by another preparation step (e.g. alcohol, antiseptic).

\(^b\) average of the means for each clinic

\(^c\) average of the medians for each clinic
Table 3.4: Number of surgeons and preoperative surgeon preparation procedures ("surgeon preps") in 10 companion animal clinics in Ontario recorded using video observation, as well as type of preparation agent used (soap-and-water or alcohol-based hand rub) and mean and range of contact time with agent.

<table>
<thead>
<tr>
<th>Clinic</th>
<th>No. of surgeons</th>
<th>Total surgeon preps</th>
<th>Soap &amp; water surgeon preps</th>
<th>Alcohol-based surgeon preps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>n</td>
<td>Mean contact time (s)</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>17a</td>
<td>8</td>
<td>41</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>30b</td>
<td>29</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>154</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>8</td>
<td>8</td>
<td>145</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>23</td>
<td>23</td>
<td>119</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>127</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>8c</td>
<td>7</td>
<td>210</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>81d</td>
<td>46</td>
<td>261</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>9</td>
<td>9</td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>7</td>
<td>7</td>
<td>88</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>190</td>
<td>144</td>
<td>121e</td>
</tr>
</tbody>
</table>

- 2 alcohol preps were started but not completed in view of the camera, surgeon gloved without prepping for one procedure (all cat neuters)
- hands rinsed with water only for 1 procedure (cat neuter)
- regloving alone performed for one procedure without additional prep
- 3 soap & water preps were started but not completed in view of the camera, regloving alone performed for one procedure without additional prep
- average of the means for each clinic
- average of the medians for each clinic
Table 3.5: Comparison of recommendations for preoperative patient and surgeon preparation from three major small animal surgery textbooks available in Ontario since 2010

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clip hair right before surgery</td>
<td>✔</td>
<td>✔</td>
<td>(✔)</td>
</tr>
<tr>
<td>Patient prep with CH or PI</td>
<td>✔</td>
<td>(✔)</td>
<td>✔</td>
</tr>
<tr>
<td>Patient prep with any other agent</td>
<td>(✔)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Contact time for patient prep (depending on agent)</td>
<td>&gt;2 min</td>
<td>2-3 min</td>
<td>0.5-2 min</td>
</tr>
<tr>
<td>Apply antiseptic in a center-to-periphery circular pattern</td>
<td>✔</td>
<td>✔</td>
<td>-</td>
</tr>
<tr>
<td>Surgeon prep with CH or PI scrub</td>
<td>✔</td>
<td>✔</td>
<td>(✔)</td>
</tr>
<tr>
<td>Surgeon prep with ASHR</td>
<td>(✔)</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Surgeon prep with any other agent</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Contact time for surgeon prep (soap &amp; water, first scrub of day)</td>
<td>5 min</td>
<td>5-7 min</td>
<td>-</td>
</tr>
<tr>
<td>Contact time for surgeon prep (soap &amp; water, any scrub)</td>
<td>2-5 min</td>
<td>2-3 min</td>
<td>-</td>
</tr>
<tr>
<td>Contact time for surgeon prep (ASHR)</td>
<td>-</td>
<td>1.5-2 min</td>
<td>-</td>
</tr>
<tr>
<td>Surgeon prep technique described</td>
<td>✔</td>
<td>✔</td>
<td>-</td>
</tr>
<tr>
<td>Wear mask during surgery</td>
<td>✔</td>
<td>✔</td>
<td>(✔)</td>
</tr>
<tr>
<td>Wear headcover during surgery</td>
<td>✔</td>
<td>✔</td>
<td>(✔)</td>
</tr>
<tr>
<td>Wear gown during surgery</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Gowning technique described</td>
<td>✔</td>
<td>✔</td>
<td>-</td>
</tr>
<tr>
<td>Gloving technique(s) described</td>
<td>✔</td>
<td>✔</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes: Formerly required ACVS reading, Current required ACVS reading, Current required ACVS reading, not available at time of study

✔ = recommended, (✔) = recommended with caveats, X = not recommended, - = no specific recommendation/not described, prep = preparation, CH = chlorhexidine, PI = povidone iodine, ASHR = alcohol-based surgical hand rub, ACVS = American College of Veterinary Surgeons

- use of chloroxylenol described, but not recommended for use in cats
- ASHR reportedly superior to CH or PI but not as commonly used
- CH or PI in alcohol preferred
- evidence is inconsistent
- follow manufacturer’s recommendation for specific product
- both agents significantly decrease bacterial load on hands, but ASHR is preferred
- mask use helps prevent direct contamination during talking, no effect on environmental bacterial load
- use of headcovers controversial, but hair carries higher bacterial load so makes sense to cover
3.6 Acknowledgements

The authors thank Dr. Jan Sargeant for consultation regarding statistical analyses, as well as all the personnel at the ten participating veterinary clinics without whose trust and willingness to be involved this study would not have been possible. There was no funding source for this study. The authors declare that they have no conflicts of interest.
3.7 References


CHAPTER 4:

Self-reported hand hygiene perceptions and barriers among companion animal veterinary clinic personnel in Ontario, Canada

Maureen EC Anderson
J Scott Weese
4.0 Abstract

Background: Hand hygiene is a critical, basic infection control measure, yet there is little information available regarding practices and perceptions of hand hygiene in veterinary clinics. The objectives of this study were to describe the perceived importance of hand hygiene at various times and as an overall infection control measure among companion animal veterinary clinic staff, as well as potential barriers to hand hygiene compliance.

Results: An anonymous, voluntary written questionnaire was provided to clinic staff following participation in a video-observation study evaluating hand hygiene behaviour. Surveys were completed by 356 of approximately 578 individuals (62%) from 49/51 clinics. On a scale of 1 (not important) to 7 (very important), the percentage of respondents who rated hand hygiene as a 5, 6 or 7 were: before handling any animal 85% (304/356), after handling a relatively healthy animal 95% (337/356), after glove removal 82% (293/356), after handling an animal with suspected gastrointestinal, respiratory or dermatological disease 99.7% (355/356), after contact with urine/feces 100% (356/356), before eating/drinking/smoking 99.7% (355/356), overall importance for preventing spread of disease in veterinary clinics 99.7% (354/355). The most frequently reported reason for not performing hand hygiene was forgetting to do so (40%, 141/353). Liquid antimicrobial soap was most frequently used for hand hygiene by 74% (239/325) of individuals. Specific discussion of hand hygiene practices at work was recalled by 32% (114/354) of respondents.

Conclusions: Although veterinary staff seem to recognize the importance of hand hygiene, it should be emphasized more in staff training in order to help ensure staff know when and how it should be performed. Incorporating hand hygiene into the clinic infection control culture may make the practice more habitual and improve compliance. Other barriers including time constraints and skin irritation should also be addressed, possibly through increased access to and use of alcohol-based hand sanitizers.
4.1 Introduction

Hand hygiene is considered a critical infection control measure for preventing hospital-associated infections (HAIs) in human medicine (1,2). The hands of healthcare workers are the primary means by which pathogens are transferred between patients and surfaces, and hand hygiene serves to break the contamination/transfer cycle in the hospital environment (1,3,4). It is difficult to clearly demonstrate the effect of improved hand hygiene on infection rates, as hand hygiene interventions are often implemented in conjunction with other infection control measures, are often studied during disease outbreaks (versus periods of endemic disease), and ethical concerns typically preclude the use of a negative control group (5-8). Nonetheless, available evidence supports the effectiveness of hand hygiene as a simple, economical and universally applicable infection control measure in human healthcare (1,4,9,10). Use of hand hygiene to decrease the spread of infection in the community has also been demonstrated (11).

There is a limited number of studies examining the use of hand hygiene for infection control in veterinary medicine. Anderson et al. (12) was the first study to show a clinically relevant effect of hand hygiene in such a context, in that equine personnel who reported always washing their hands between farms and between infectious cases were less likely to be colonized with methicillin-resistant Staphylococcus aureus (MRSA). Despite the paucity of veterinary hand hygiene studies, hand hygiene is considered equally important as an infection control measure in veterinary clinics as in human healthcare (13), based on the many comparable procedures performed and infectious disease risks in both settings, as well as basic principles of pathogen transmission.

The primary challenge to the effective use of hand hygiene is achieving adequate compliance. Reported compliance rates in human hospitals have ranged from 5-81%, with an average of 40% (4,7). Direct observation of healthcare workers is most commonly used to collect data on hand hygiene practices, therefore these rates may be artificially inflated due to Hawthorne effects and observer bias (14,15). In two studies of hand hygiene compliance in companion animal veterinary personnel, self-reported compliance (i.e. always perform hand hygiene between patients) was 42-48% (16,17), while observed compliance rates in one veterinary teaching hospital were 21-42% (18).

In order to design effective interventions to improve hand hygiene in veterinary clinics, it is critical to understand the perceived importance of and barriers to this practice among veterinary staff. Nakamura et al. (16) reported the most commonly cited reason for not performing hand hygiene among veterinary support staff was being too busy (72%). Other common barriers identified among human
healthcare workers include lack of accessibility to hand hygiene stations, and skin irritation due to frequent use of hand hygiene products (10,19,20).

The objectives of this study were to describe the perceived importance of hand hygiene at various times and as an overall infection control measure among companion animal veterinary clinic staff, as well as potential barriers and other factors that may be associated with hand hygiene compliance. Based on relatively low hand hygiene compliance among veterinary staff reported in previous studies, it was hypothesized that overall participants would place only moderate importance on hand hygiene, and that the major barriers would include lack of time and lack of conveniently located hand hygiene stations.

4.2 Materials & Methods
A convenience sample of primary care companion and mixed animal veterinary clinics from across southwestern and eastern Ontario, Canada, was recruited to participate, in conjunction with a video observation study evaluating the effectiveness of a hand hygiene poster campaign to improve hand hygiene compliance. Clinics in various regions were identified through known contacts of either of the investigators and using Google Maps (www.google.maps.ca) with the search term “veterinary”. Each clinic was then contacted directly by one of the investigators via e-mail, fax or telephone, typically obtained from individual clinic websites. If no response was received, follow-up inquiries were made by the same means 1, 3 and 5 weeks later, and then monthly thereafter until recruitment was complete. Data collection was performed from November 2010 to December 2011. Staff were informed that the focus of the observational study was routine infection control practices, but not what specific practices (including hand hygiene) were being observed. The posters used included a message regarding the importance of hand hygiene for preventing the spread of infections between animals and people, and stated that “it only takes 15 seconds to clean your hands” by either washing or using alcohol-based hand sanitizer (AHS). An anonymous, voluntary written survey was provided to up to 20 staff members at each clinic at the end of the video observation period. In each clinic, the posters had been present for approximately one week and the video cameras for approximately three weeks at the time the surveys were distributed, at which point the cameras were removed and clinics were allowed to remove the posters if desired.

Surveys were provided in a pre-addressed, postage-paid envelope, and the primary staff contact at each clinic (veterinarian, technician or office manager) was asked to distribute them to the other staff and return any completed or uncompleted questionnaires within two weeks, at which time an email or telephone reminder was sent if the envelope had not yet been received. Any staff member who worked in the clinic during the video observation period was eligible to participate, but a maximum of 20
individuals from any one clinic were allowed to fill out the survey. This number was selected \textit{a priori} so that as many staff as possible from each clinic could be included while avoiding excessive representation of clinics with very large staff numbers. Distribution and collection of the surveys was ultimately at the discretion of the clinic staff, including at clinics with over 20 staff members. The majority of the survey was presented in the form of Likert-type scale, yes/no or multiple choice questions, and a small number of fill-in-the-blank questions. The survey also included five questions regarding the poster intervention (data not shown)(see Appendix 4.1 for the full survey). The survey was piloted with several veterinarians and support staff from non-participant clinics before the study began to help improve clarity of the questions and ensure the estimated time needed to complete the survey (approximately 10 minutes) was accurate. This study was approved by the University of Guelph Research Ethics Board.

4.2.1 Statistical Analysis

Survey data were entered into a spreadsheet (Excel 2011 For Mac, Microsoft Corporation, Redmond, WA) and then imported into a statistical software package (STATA Intercooled 11, StataCorp, College Station, TX) for analysis. For quantitative analysis, data from Likert-type scale questions were dichotomized into low importance/concern (1-4) and high importance/concern (5-7). If there was a minimum of 5 responses per dichotomous category, univariable logistic regression was used to examine associations between the perceived importance of hand hygiene in each of 9 instances (before handling any animal, before handling an animal that had surgery in the last 48 hours, after handling a relatively healthy animal, after glove removal, after handling an animal with signs of gastrointestinal, respiratory or dermatological disease, after contact with urine or feces, before eating/drinking/smoking at work, after using the bathroom, overall importance for preventing spread of disease in veterinary clinics) and the six variables age, gender, role (veterinarian, technician/animal care staff, front office staff/manager), recollection of having discussed hand hygiene practices at work, concern regarding hospital associated infections in general practice, and concern regarding transmission of zoonoses from patients. A random effect for clinic was included in each model. Significance was set at \( p \leq 0.05 \). If more than one significant univariable association was found for a single outcome, then a multivariable logistic regression model was constructed using manual backward selection, and including the random effect for clinic. Variables with a \( p > 0.05 \) were removed, one at a time starting with the largest \( p \)-value. If removal of a variable changed the coefficient of any remaining variable by more than 25\%, the variable was considered a confounder and retained in the model. Descriptive statistics were examined for all other data.
4.3 Results

A total of 135 clinics were approached to participate in the study, out of approximately 1100 registered companion animal hospitals in Ontario (12%). Fifty-one clinics (38%, 51/135) participated in the video observation portion of the study and were then given the surveys. Surveys were returned from 356 individuals from 49/51 clinics, representing approximately 62% (356/578) of all eligible staff to a maximum of 20 per clinic. The estimated total number of staff per clinic ranged from 4-49 (mean 11, median 11). Individual clinic response rate ranged from approximately 25-100% (mean 66%, median 62%). One clinic returned all surveys blank, and the surveys from one other were mailed back by the clinic but were never received. All clinics were exclusively companion animal facilities, but one clinic was also licensed for mobile equine work and another shared a building with a mobile food animal practice.

The distribution of respondents by gender and role is shown in Table 4.1. The age range of respondents was 17-66 years (mean 35 years, median 32 years). Seventy-four percent (260/352) of individuals were full-time staff (i.e. working 35 hours or more per week at the clinic).

Respondents rated the importance of hand hygiene in various scenarios on a scale of 1 (not important) to 7 (very important), the results of which are shown in Table 4.2. Due to the low variability of the data, the overall importance of hand hygiene for preventing spread of disease in veterinary clinics, human hospitals and the community was also examined descriptively at the level of 7 versus 6 or less (instead of 5-7 versus 1-4 as in Table 4.2). The proportion of individuals who ranked the importance of hand hygiene as a 7 in veterinary clinics was 87% (308/355), in human hospitals 94% (336/355) and in the community 86% (306/355).

The most frequently reported barrier to (i.e. reason for not performing) hand hygiene was forgetting to do so (40%, 141/353), followed by skin damage (22%, 78/353), and being too busy (21%, 78/353). Less than 5% of respondents cited inconvenient hand hygiene stations (17), failure of others to perform hand hygiene (6), dislike of the smell or feel of available products (6), use of gloves as a substitute for hand hygiene (4) or “other” (5). When asked to indicate which barrier was the most important out of all those checked off by the individual as applicable, 44% (53/121) indicated forgetting, 24% (29/121) skin damage, 16% (19/121) being too busy, 5% (6/121) inconvenient stations, 1% (1/121) preferred use of gloves and 2% (2/121) other. Forty-six percent (162/353) of respondents felt they performed hand hygiene as often as necessary, and that there were no barriers that interfered with their ability to do so.
Availability of plain liquid soap, antimicrobial liquid soap and AHS in the clinic was indicated by 58% (170/295), 98% (328/333) and 93% (302/323) of respondents, respectively, from 47/49, 49/49 and 49/49 clinics, respectively. There was considerable disparity among respondents within each clinic regarding the availability of plain liquid soap in particular, as there were only 10/49 (20%) clinics from which all respondents gave the same response (yes or no) for this product, compared to 46/49 (94%) clinics for antimicrobial liquid soap and 41/49 (84%) clinics for AHS. Other hand hygiene products that were available included bar soap (1%, 3/283 from 3 clinics) and non-alcohol-based hand sanitizer (NAHS)(10%, 27/260 from 18 clinics). Seventy-four percent (239/325) of respondents indicated they most commonly used liquid antimicrobial soap for hand hygiene, whereas 18% (53/298) most commonly used AHS. Fifty-three percent of respondents from 96% (47/49) of clinics regularly used skin moisturizer or lotion for their hands while at work.

Respondents were asked to indicate the minimum amount of time they believed it was necessary to wash hands with soap and water (i.e. total contact time with soap) and to rub hands with an AHS in order to effectively disinfect them. They were given four options for soap (5 s, 15 s, 30 s, 60+s, unsure) and four options for AHS (5 s, 10 s, 20 s, 30+s, unsure). Forty-six percent (162/353) and 21% (75/351) of respondents believed it was necessary to apply soap or AHS, respectively, for 30 s or more for it to be effective. Two percent (8/353) and 11% (40/351) indicated that 5 s of contact time with soap or AHS was adequate.

Specific discussion of hand hygiene practices at work was recalled by at least one respondent from 82% (40/49) of clinics and by 32% (114/354) of respondents overall. Forty-nine percent (163/335) of respondents, representing 84% (41/49) of clinics, were aware of the existence of a written clinic infection control manual or policies.

Respondents’ rankings of their own clinic on a scale of 0 (worst) to 10 (best) in terms of good hand hygiene practices among veterinary clinics in general are shown in Figure 4.1. The mean rank for each clinic ranged from 5.1-9.3, and the overall mean of these ranks for all 49 clinics was 7.0. Eighty-three percent (285/342) of respondents indicated they felt their clinic’s hand hygiene practices could be improved (see Figure 1). Respondents also rated eight potential interventions on a scale of 1 (not effective) to 7 (very effective) in terms of how effective they felt each would be for permanently improving hand hygiene practices in their clinic, or whether the intervention was already used at their clinic, the results of which are shown in Figures 4.2 and 4.3.
On a scale of 1 (not a problem) to 7 (very big problem), 40% (141/352) and 61% (207/342) of respondents felt that the magnitude of the problem posed by HAIs in primary care veterinary clinics and referral veterinary hospitals, respectively, was a 5 or more. Eighteen percent (62/352) and 7% (24/342) ranked the problem of HAIs as a 2 or less in primary care and referral facilities, respectively.

On a scale of 1 (not concerned) to 7 (very concerned), the highest percentage of respondents indicated their concern regarding contracting an infectious disease from animals at work was a 2 (84/355, 24%), and for 67% (238/355) their concern was a 4 or less (low). Seventy-two percent (255/356) of participants completed an open-ended question querying the disease or type of disease about which they were most concerned in this regard. The most common responses were leptospirosis (40%, 101/255), ringworm/dermatophytes (24%, 61/255), non-specific parasites (18%, 47/255), internal/intestinal parasites (13%, 34/255), Giardia (11%, 27/255), rabies (9%, 24/255), Salmonella (5%, 14/255), external parasites (5%, 13/255), and antimicrobial-resistant bacterial infections including MRSA (5%, 13/255). Numerous respondents listed multiple diseases or pathogens. Other responses (all less than 4%) included toxoplasmosis (9), bite infections (5), E. coli (4), Campylobacter (3), cat scratch disease (bartonellosis)(3) and non-specific bacterial (9), dermatological (6) or fungal (5) disease. Five individuals (one animal care assistant, four front office staff) listed pathogens or diseases that are not zoonotic, including parvovirus, feline immunodeficiency virus, feline leukemia virus and immune-mediated hemolytic anemia (IMHA).

4.3.1 Quantitative analysis

Logistic regression analysis was not performed for five outcomes (importance of hand hygiene after handling an animal with signs of gastrointestinal, respiratory or dermatological disease, after contact with urine or feces, before eating/drinking/smoking at work, after using the bathroom, and overall importance for preventing spread of disease in veterinary clinics) due to lack of variation in the data. Univariable associations with a p<0.10 between each of the remaining four outcomes and the preselected variables of interest are shown in Table 4.3. Only one outcome (importance of hand hygiene after glove removal) had more than one significant (p≤0.05) univariable association (gender and role), but when both variables were included in a multivariable model, only gender remained significant and the coefficient for gender changed by less than 10%, which was not considered significant confounding.

4.4 Discussion

Although it was hypothesized that study participants would place only moderate importance on hand hygiene, overall respondents seemed to be very aware of and willing to acknowledge the importance of hand hygiene as an infection control measure in veterinary clinics. Importance of hand hygiene in all
eight clinical situations queried was rated as high (5-7 on the Likert-type scale) by over 80% of respondents, and by over 99% of respondents for four of these. Similarly, 99% or more of participants considered hand hygiene to be of high importance for preventing the spread of disease in veterinary clinics, human hospitals and the community alike. Assuming the survey respondents were representative of other veterinary staff amongst whom hand hygiene compliance has been reported to be low (16-18), these results suggest that barriers (either physical or psychological) to performing hand hygiene may be the more influential factor when it comes to poor compliance, compared to a perceived lack of importance. This is important to consider when designing hand hygiene interventions. However, survey respondents had all just participated in a video observation study regarding hand hygiene and infection control practices, which could have affected these results (see discussion of study limitations).

The situation for which the lowest percentage of individuals indicated high importance of hand hygiene was following glove removal (82%). Four respondents also indicated that use of gloves was at least one of the reasons they did not perform hand hygiene more frequently. The impression that use of gloves negates the need for hand hygiene is problematic, and has been reported as a barrier to hand hygiene compliance in human healthcare studies (10,19,20). Although gloves do provide an additional barrier between the skin of the wearer and the patient and/or objects the wearer may touch, pre-existing defects, damage/punctures that may occur during use and contamination of the hands during glove removal make gloves an imperfect barrier (4,21). Since gloves are most often used in situations when there is a need to take additional precautions to prevent contamination of a site with bacteria from the hands, or when heavy contamination of the hands or contamination with a serious infectious pathogen is expected to occur, hand hygiene before and after glove use remains necessary for infection control.

The most common self-reported barrier to hand hygiene compliance was simply forgetting to perform hand hygiene. Combating this kind of problem likely needs to go beyond reminders, be they written, verbal or in some other form, to making hand hygiene and infection control a pervasive component of the clinic culture. In this way hand hygiene becomes habitual and does not need to be consciously remembered. Almost half of respondents indicated that there were no barriers that interfered with their performance of hand hygiene. Although these individuals may actually have excellent hand hygiene compliance, based on compliance rates reported in other studies it is likely that many of them do not. This response may be at least in part due to a lack of awareness of when hand hygiene ought to be performed, but this would be inconsistent with the majority indicating hand hygiene to be of high importance in the clinical situations queried (although as previously mentioned these results may have
been affected by participation in the video observation study). Further investigation of this potential gap between perception and practice, and how to correct it, is warranted.

Other barriers commonly identified by participants were similar to those found in other studies (10,19,20). Increasing the use of AHS can help address several of these factors, as compared to soap and water, use of such products takes less time, causes less skin damage, and dispensers can be easily placed in any area or even carried in pocket for ready access at any time (22). This is also why AHS is the product primarily recommended for routine hand hygiene in hospital settings, unless involvement of an alcohol-resistant pathogen is known or suspected, or hands are visibly soiled (2,4,23). All 49 participating clinics in this study apparently had AHS available somewhere in the facility, but only 18% of individuals reported that AHS was the product they used most often for hand hygiene. Improving accessibility to AHS was also the intervention rated highest by staff for potentially improving overall clinic hand hygiene practices, and is considerably less expensive than installation of sinks or other clinic renovations to ameliorate ease of access to hand hygiene stations.

How well hand hygiene is performed when it is attempted is less commonly addressed in compliance studies, but is equally important to timing and frequency for hand hygiene to be effective. In order to effectively reduce or kill the transient microflora of the hands, it is generally recommended that soap be applied for a minimum of 10-20 s before rinsing, or for AHS that enough product be applied to cover all surfaces of the hands and then rubbed until dry (which should take approximately 10-20s as well) (4,13,24,25). A relatively small proportion of respondents indicated that only 5 s of contact time was necessary, which would result in inadequate decontamination of the hands. In contrast, a larger proportion of respondents indicated that 30 s or more of contact time was necessary. This may deter individuals from attempting hand hygiene when they are very busy, and could potentially lead to increased skin damage from excessive use, which could also become a deterrent and increases microbial carriage on the hands (4,26).

Even though 31% of respondents identified their primary role as being either front office staff or practice manager, many of these individuals likely also performed animal care staff duties (e.g. animal restraint, moving animals around the clinic) or technician duties (e.g. assisting with or performing medical procedures); this was even noted by several respondents on their surveys. Hand hygiene and basic infection control practices are nonetheless important even for staff who work solely in the front office, as they may still frequently have contact with pets before and after the animal is seen in the examination room. These personnel may also be less likely to have had any previous instruction in
infection control practices or hand hygiene, compared to veterinarians and many technicians who are institutionally trained and may pursue continuing education, which highlights the need for in-clinic education and training.

At least one respondent from 84% of clinics indicated that a written clinic infection control manual or policies were available. This is in contrast to a 2005 study in which 0/101 Ontario veterinary clinics surveyed had a recognized infection control program of any kind (27). However, only 49% of respondents were aware of the existence of such a document in their own clinic, whether one existed or not. This lack of attention to a fundamental component of an organized infection control program may be an indicator of the overall ongoing lack of infection control culture in veterinary medicine, which likely also contributes to lack of compliance with basic infection control measures such as hand hygiene.

The conflicting responses from participants within each clinic regarding the availability of plain liquid soap suggest that many individuals may not be aware of the difference between plain and antimicrobial soap. Antimicrobial soap is recommended for use under certain circumstances in healthcare settings (e.g. before and after patient contact and before invasive procedures, but use of plain soap is considered acceptable before eating or using the restroom)(24,28), and it would be reasonable to apply this recommendation to veterinary clinics as well. However, use of antimicrobial soap in the community setting has not been shown to have any benefit over plain soap, and may contribute to the development and/or selection of biocide and antimicrobial-resistant bacteria (29). Of the 18 clinics from which at least one individual reported the availability of NAHS, all but one had a greater number respondents indicate that such a product was in fact not available (data not shown), which again suggests that some individuals may not be aware of the difference between these products. There is still only limited evidence to support the use of any NAHS product in a healthcare setting (22,30), therefore routine use of AHS remains the recommendation for healthcare workers (2,4,24).

Concern regarding spread of zoonotic pathogens was significantly associated with one outcome (importance of hand hygiene before contact with any animal) and approached significance for another outcome (importance of hand hygiene after contact with a relatively healthy animal), indicating a tendency for those more concerned about zoonoses to place more importance on hand hygiene. Furthermore, two-thirds of respondents indicated that their concern regarding zoonoses at work was low (4 or less), which could reflect confidence in their clinic’s and their own individual infection control practices, or a lack of awareness of some of the zoonotic disease risks faced by veterinary staff (31,32). Education of all staff regarding such risks and means of mitigating them is important for ensuring staff
safety and for protection of the clinic from liability, and could potentially provide motivation to help improve hand hygiene compliance by highlighting the importance of this and other infection control measures to individual staff members. Only 32% of respondents could recall discussing hand hygiene practices at work, so there is a clear opportunity to improve staff education.

Although a significant association with role was only seen for one outcome (importance of hand hygiene after glove use), the finding is comparable to previous reports that hand hygiene compliance tends to be higher among nurses compared to physicians (7,33). However, the majority of male respondents were veterinarians and gender was also associated with this outcome, and when both variables were included in the same model, only gender remained significant. Gender also approached significance in the model for importance of hand hygiene after contact with a relatively healthy animal. Male gender has been identified as a factor in poor hand hygiene compliance in other studies (19), and one veterinary study found male gender was associated with a lower infection control “precaution awareness” score (17). This may indicate a tendency for women to place more importance on hygiene overall, but these results should not be over interpreted due to the limitations of the data set. Further investigation of this trend in future studies should be considered.

Dichotomization of the Likert-type scale variables and outcomes was done in order to simplify the quantitative analysis and allow for the inclusion of a random effect for clinic in each model. It was suspected that clustering by clinic could have a strong effect on the outcomes measured (due to variations in the infection control culture at each clinic), therefore non-parametric techniques such as Kruskal-Wallis analysis of variance, which do not account for clustering effects, were not used. The random effect for clinic was only significant in the six models for importance of hand hygiene before handling any animal (see Table 4.3, other data not shown). Lack of variability in the data for the other outcomes may have prevented detection of a clustering effect in some of the other models.

Due to the number of univariable associations tested (9 outcomes x 6 variables = 36 associations), it is important to consider the likelihood of a type 1 error affecting the number of significant associations found. Furthermore, the low proportion of male respondents and the lack of variability in the responses to some questions (e.g. importance of hand hygiene after contact with a sick animal or urine/feces, before eating/drinking/smoking or after using the bathroom) resulted in very low power for finding associations involving these outcomes/variable.
The limitations and potential sources of bias in this study must be considered when weighing the results. Study participants at both the clinic and individual level were selected on a voluntary basis. It is possible that clinics and staff members with a greater interest in infection control or who were more comfortable with their current practices (for better or for worse) would be more willing to participate. The hand hygiene poster campaign that took place in the week prior to survey administration, as well as providing consent for the video observation study regarding “general infection control practices,” may have influenced the responses of participants. The poster campaign was intended to emphasize the general importance of hand hygiene to clinic staff, and to help improve hand hygiene compliance by promoting its use (“it only takes 15 seconds”) and by providing strategic reminders to perform hand hygiene (via poster placement near hand hygiene stations). There was no educational campaign or discussion with clinic staff regarding the importance of hand hygiene in different scenarios and settings such as those queried in the survey; therefore, the effect of participation in the preceding study on these specific responses would likely be modest at most. The substantial proportion of responses to the question regarding required hand hygiene product contact time that were <5 s or >30 s, despite the posters clearly indicating that 15 s was needed, also indicates that the degree of influence of the posters on survey responses was not high. Despite the survey being anonymous and self-administered, the potential for bias due to the desire to give the “expected” response rather that that which truly reflects the participant’s opinion must also be considered. It would have been ideal to compare individual survey responses to actual hand hygiene practices recorded during the video observation study; however, this would have required the survey respondents and the individuals on the video recordings to be identified, and the lack of anonymity would most likely have decreased clinic and staff willingness to participate.

4.5 Conclusion

The results of this study suggest that, overall, veterinary staff consider hand hygiene to be of high importance both before and after contact with animals in various situations, although individuals’ responses may have been artificially inflated to some extent by participation in an observational study regarding infection control and hand hygiene practices prior to completing the study questionnaire. Nonetheless, discussion of hand hygiene practices with staff should be done more often, as this can help to ensure that staff know when and why hand hygiene is necessary, how to perform hand hygiene properly (including appropriate contact times) and helps to incorporate infection control into the clinic culture. Staff may have a tendency to forget to perform hand hygiene, and improving the infection control culture could also help to avoid this by making the practice more habitual. Increasing availability and emphasizing use of AHS has the potential to address other barriers to hand hygiene identified by participants in this study, as the majority of staff still primarily use soap and water hand washing and
therefore do not take advantage of the various benefits of using AHS. Hand hygiene and infection control require the active participation of every member of the clinic team in order to be effective, and therefore all staff regardless of age, gender or role need to be considered with regard to hand hygiene interventions.
Table 4.1: Distribution by gender and role of survey respondents from 49 companion animal clinics in Ontario

<table>
<thead>
<tr>
<th>Role</th>
<th>Number of personnel (%)</th>
<th>Male</th>
<th>Female</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veterinarian</td>
<td></td>
<td>26 (76)</td>
<td>56 (18)</td>
<td>1 (17)</td>
<td>83 (23)</td>
</tr>
<tr>
<td>Registered technician</td>
<td></td>
<td>1 (3)</td>
<td>86 (27)</td>
<td>1 (17)</td>
<td>88 (25)</td>
</tr>
<tr>
<td>Non-registered technician</td>
<td></td>
<td>1 (3)</td>
<td>34 (11)</td>
<td>-</td>
<td>35 (10)</td>
</tr>
<tr>
<td>Animal care assistant/kennel staff</td>
<td></td>
<td>4 (12)</td>
<td>29 (9)</td>
<td>-</td>
<td>33 (9)</td>
</tr>
<tr>
<td>Front office staff</td>
<td></td>
<td>1 (3)</td>
<td>91 (29)</td>
<td>-</td>
<td>92 (26)</td>
</tr>
<tr>
<td>Practice manager</td>
<td></td>
<td>1 (3)</td>
<td>16 (5)</td>
<td>-</td>
<td>17 (5)</td>
</tr>
<tr>
<td>Unknown</td>
<td></td>
<td>-</td>
<td>4 (1)</td>
<td>4 (67)</td>
<td>8 (2)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>34 (100)</td>
<td>316 (100)</td>
<td>6 (100)</td>
<td>356 (100)</td>
</tr>
</tbody>
</table>
Table 4.2: Ranking by staff from 49 companion animal clinics in Ontario of the perceived importance of hand hygiene in various scenarios

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Importance of hand hygiene$^1$</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (%)</td>
<td>High (%)</td>
</tr>
<tr>
<td>Before handling any animal</td>
<td>52 (14.6)</td>
<td>304 (85.4)</td>
</tr>
<tr>
<td>Before handling an animal that had surgery in the last 48 hours</td>
<td>31 (8.7)</td>
<td>325 (91.3)</td>
</tr>
<tr>
<td>After handling a relatively healthy animal</td>
<td>19 (5.3)</td>
<td>337 (94.7)</td>
</tr>
<tr>
<td>After glove removal</td>
<td>63 (17.7)</td>
<td>293 (82.3)</td>
</tr>
<tr>
<td>After handling a sick animal$^2$</td>
<td>1 (0.3)</td>
<td>355 (99.7)</td>
</tr>
<tr>
<td>After contact with urine or feces</td>
<td>0 (0)</td>
<td>356 (100)</td>
</tr>
<tr>
<td>Before eating/drinking/smoking at work</td>
<td>1 (0.3)</td>
<td>355 (99.7)</td>
</tr>
<tr>
<td>After using the bathroom</td>
<td>2 (0.6)</td>
<td>354 (99.4)</td>
</tr>
<tr>
<td>Overall importance for preventing spread of disease in:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>veterinary clinics</td>
<td>1 (0.3)</td>
<td>354 (99.7)</td>
</tr>
<tr>
<td>human hospitals</td>
<td>1 (0.3)</td>
<td>354 (99.7)</td>
</tr>
<tr>
<td>the community</td>
<td>4 (1.1)</td>
<td>351 (98.9)</td>
</tr>
</tbody>
</table>

$^1$ Low vs high importance was determined by dichotomizing survey responses (provided on a 7-point Likert-type scale) by 1-4 (low) and 5-7 (high)

$^2$ An animal with signs of gastrointestinal, respiratory or dermatological disease
Table 4.3: Univariable associations with a p-value <0.10 between each of 4 separate outcomes and 6 predetermined variables of interest\(^1\), as per the results of a survey of personnel from 49 companion animal clinics in Ontario

<table>
<thead>
<tr>
<th>Outcome(^2)</th>
<th>Variable</th>
<th>OR</th>
<th>p</th>
<th>sd(clinic)(^3)</th>
<th>LRT (clinic) p(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance of hand hygiene before handling any animal</td>
<td>Zoonoses concern(^2)</td>
<td>Low</td>
<td>Referent</td>
<td>-</td>
<td>0.918</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td></td>
<td>2.066</td>
<td>0.063</td>
</tr>
<tr>
<td>Importance of hand hygiene before handling an animal that had surgery in the last 48 hours</td>
<td>-(^4)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Importance of hand hygiene after handling a relatively healthy animal</td>
<td>Gender</td>
<td>Male</td>
<td>Referent</td>
<td>-</td>
<td>0.751</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td></td>
<td>3.021</td>
<td>0.084</td>
</tr>
<tr>
<td></td>
<td>Zoonoses concern(^2)</td>
<td>Low</td>
<td>Referent</td>
<td>-</td>
<td>0.584</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td></td>
<td>9.599</td>
<td>0.030</td>
</tr>
<tr>
<td>Importance of hand hygiene after glove removal</td>
<td>Gender</td>
<td>Male</td>
<td>Referent</td>
<td>-</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td></td>
<td>3.908</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Role</td>
<td>Veterinarian</td>
<td>Referent</td>
<td>-</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technician/animal care/kennel staff</td>
<td></td>
<td>1.984</td>
<td>0.040</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td></td>
<td>2.096</td>
<td>0.044</td>
</tr>
</tbody>
</table>

\(^1\) The 6 variables of interest were: age (continuous variable), gender (male vs female), role (veterinarian vs technician/animal care assistant/kennel staff vs other (front office staff/practice manager)), recollection of discussing hand hygiene at work (no vs yes), concern regarding hospital associated infections in primary care veterinary clinics (low vs high), and concern regarding contracting an infectious disease from animals (i.e. zoonoses) at work (low vs high)

\(^2\) Low vs high importance or concern was determined by dichotomizing survey responses (provided on a 7-point Likert-type scale) by 1-4 (low) and 5-7 (high)

\(^3\) Clinic was included as a random effect in all models, sd = standard deviation, LRT = likelihood ratio test for significance of the random effect

\(^4\) No variables associated with a p<0.10
Figure 4.1: Ranking by companion animal veterinary staff (n = 348) of their own clinic (n = 49) on a scale of 0 (worst) to 10 (best) in terms of good hand hygiene practices among veterinary clinics in general.

Data labels indicate total number of responses of each rank. Four additional respondents indicated they felt their clinic’s hand hygiene practices could be improved, but they did not provide a ranking for their clinics.
Figure 4.2: Ranking by companion animal veterinary staff of the potential effectiveness (1 = not effective, 7 = very effective) of different hand hygiene interventions for permanently improving hand hygiene practices in their respective clinics

AHS accessibility = Making alcohol-based hand sanitizer always available in each patient contact area (n = 157)
Be example = Being a good example to others by always performing hand hygiene as recommended (n = 249)
HH promotion = Having hand hygiene openly supported/promoted by owners and senior veterinarians (n = 217)
HH education = Providing education on hand hygiene to every clinic staff member (n = 295)
Feedback = Providing feedback to staff regarding their hand hygiene performance (n = 338)
HH posters = Displaying hand hygiene posters in key areas as reminders (n = 242)
HH instructions = Making instructions for hand hygiene visible to every clinic staff member (n = 277)
Owner reminders = Inviting patient owners to remind clinic staff to perform hand hygiene (n = 325)

Numbers in parentheses (n) represent the number of respondents who ranked the intervention and did not indicate that it was already used in their clinic.

Heavy black bars on graph indicate the break between low (1-4) and high (5-7) effectiveness
Figure 4.3: Proportion of companion animal clinics from which at least one survey respondent indicated that a particular hand hygiene intervention was already in use at the clinic (n=49)

See Figure 4.2 footer for abbreviations
4.6 Acknowledgements

Funding was provided by the Canadian Institutes of Health Research (CIHR) and the Ontario Veterinary College Pet Trust. The authors thank all of the personnel at the participating veterinary clinics for their trust and willingness to be involved in this study, and Ashley Frasson for assistance with data entry.
4.7 References


CHAPTER 5:

Video observation of sharps handling and infection control practices
during routine companion animal appointments

Maureen EC Anderson
J Scott Weese
5.0 Abstract

**Background:** Infection control in veterinary clinics is important for preventing pathogen spread between patients, staff and the public. There has been no direct evaluation of the use of many basic infection control practices, including sharps handling, environmental cleaning, and personal protective clothing (PPC), in companion animal clinics. The objectives of this study were to describe these and other infection control practices associated with routine companion animal appointments in veterinary clinics in Ontario.

**Results:** Video observation of practices was performed in 51 clinics for approximately 3 weeks each as part of another study evaluating the effect of a poster campaign on hand hygiene compliance. Two small wireless surveillance cameras were used: one in an exam room, one in what was considered the most likely location for hand hygiene to be performed outside the exam room following an appointment. Video footage was coded and analyzed for 47 clinics, including 2713 appointments and 4903 individual staff-animal contacts. Recapping of a needle was seen in 84% (1137/1353) of appointments in which use was observed. Only one apparent needlestick injury (NSI) was seen, during recapping. Exam tables were cleaned and floors were mopped following 76% (2015/2646) and 7% (174/2643) of appointments, respectively. Contact time with spray used to clean the exam table ranged from 0-4611 s (mean 39s, median 9s). Appropriate PPC was worn for 72% (3518/4903) of staff-animal contacts.

**Conclusions:** Although there was significant room for improvement in sharps handling behaviours in participating clinics, the number of observed NSIs was low. Contact time with environmental disinfectants and use of PPC could also be improved, as well as other basic infection control practices. Education and motivation of veterinary staff to use these simple measures more effectively could potentially have a significant impact on infection control in veterinary clinics for relatively little cost.
5.1 Introduction

Disease outbreaks within or originating from veterinary clinics involving patients, staff and even community members have been reported, and many others likely go unreported or unnoticed (1-4). Close attention to appropriate infection control measures in this setting is important for preventing direct and indirect transmission of pathogens between animals, as well as transmission of zoonotic pathogens between animals and people, in order to help protect the health of patients, staff, clients and other members of the public with whom these individuals may have contact.

There is limited published research regarding the use of certain infection control measures in veterinary facilities (5-7). Guidelines for these practices can be found in some textbooks and other publications (8-12), but their implementation has seldom been assessed. Some of these infection control measures have published research to support their effectiveness (e.g. hand hygiene, environmental cleaning) in either the human or veterinary literature (13-17), while recommendations for others are based more on known and theoretical means of pathogen transmission (e.g. use of designated clothing outside of the surgical environment that can be easily changed when contaminated)(18). Many of these infection control practices are relatively simple to perform, but they all require varying amounts of time and effort, which can make achieving adequate compliance difficult, particularly in a busy clinic setting.

Another important part of infection control and workplace safety in any medical clinic is safe handling of sharps. The avoidance of needlestick and sharps injuries (NSIs) in human healthcare is a major priority, driven in particular by the risk of transmission of serious bloodborne pathogens between patients and healthcare workers (19,20). There has been less concern regarding NSIs in veterinary medicine, likely because there are currently very few recognized bloodborne pathogens that can be transmitted between domestic animals and humans. However, reports of such transmission do exist (21,22), and the risks of other potential consequences of NSIs (e.g. trauma, local tissue infection, allergic or inflammatory reactions to drugs or biologics inoculated or injected into the tissues) are the same or potentially higher when working with animals and drugs not intended for use in humans (23-25).

The objectives of this study were to describe sharps handling practices, the occurrence of observable NSIs, the use of personal protective clothing (PPC) and environmental cleaning associated with routine (non-emergency) companion animal appointments, in addition to various clinic-level infection control-related practices, in veterinary clinics in Ontario.
5.2 Materials & Methods

A convenience sample of primary care companion and mixed animal veterinary clinics from across southwestern and eastern Ontario, Canada, was recruited to participate. Clinics in various regions were identified through known contacts of either of the investigators and using Google Maps (www.google.maps.ca) with the search term “veterinary”. Each clinic was then contacted directly by one of the investigators via e-mail, fax or telephone, typically obtained from individual clinic websites. If no response was received, follow-up inquiries were made by the same means 1, 3 and 5 weeks later, and then monthly thereafter until recruitment was complete. Data collection was performed from November 2010 to December 2011. Video observation in clinics was performed as part of another study evaluating the effectiveness of a poster campaign to improve hand hygiene compliance, which determined the target number of clinics to recruit (see Chapter 6). The posters, which were only present for the final 6-8 days of recording, did not include any information pertaining to non-hand hygiene infection control measures. Two wireless video surveillance cameras (Logitech WiLife™ Indoor Video Security System, Logitech, Newark, CA) were installed in each clinic: one in an exam room, and one in the most likely backroom location for hand hygiene to be performed outside the exam room following an appointment (excluding private offices and washrooms), as determined by clinic layout and information on clinic workflow provided by staff. The cameras were visible to staff but care was taken to position the cameras and secure their power cords to make them as discrete as possible. All indicator lights on the cameras were disabled so there were no visible signs that the cameras were on or off. Video data were recorded by powerline network on a secure, closed laptop computer kept elsewhere in the clinic in an unobtrusive location (e.g. on top of a cupboard, under a desk, on an unused shelf), using the software provided by the camera manufacturer (Logitech Command Center v2.5 (for Windows), Logitech, Newark, CA). Cameras were left in place for 14-19 working days (19-23 calendar days), and were motion-activated during the hours when routine (non-emergency) appointments were typically scheduled in each clinic, plus approximately 30 min before and after this period. The cameras did not record audio data. Written consent was obtained from all clinic personnel whose images would potentially be captured on video; they were informed that the focus of the study was general infection control practices, but not for what specific practices data would be collected.

Consent was not obtained from clients based on the following reasons: requiring consent to be collected from each client would be very time consuming and would negate the use of video cameras as an unobtrusive means of observation, because staff would be forcibly reminded of their presence for each appointment when speaking to clients about the study; the capturing of client images was purely incidental, as clients were not the subject of the study and therefore no identifying information or
information about their behavior was collected; where applicable the camera was clearly focused on the “staff side” of the exam room such that clients’ faces often did not appear on the videos. A study information sheet was provided to clinic staff, which could be given to any client who enquired about the presence of the camera, and if the client was uncomfortable staff were instructed to move the client to an unmonitored exam room, or cover the camera lens for the duration of the appointment. Clients could also request to have their image permanently deleted from the video recordings before the laptop computer was removed from the clinic. This study was approved by the University of Guelph Research Ethics Board.

A video coding scheme was developed in the form of a fillable spreadsheet (Excel 2008 for Mac, Microsoft Corporation, Redmond, WA) and tested using video recordings from two clinics that were excluded from the final analysis due to loss of data from computer malfunctions. All videos were coded by the same author (MA). The appointments coded were determined by the methods for the hand hygiene compliance study: consecutive appointments were coded from the time the hand hygiene posters were placed in the clinic for a maximum of 8 days (i.e. end of recording) or up to half of the predetermined targeted maximum number of appointments, and then an approximately equal number of appointments was coded working backward from the same point. An appointment was classified as incomplete if a segment of the video footage from the exam room was missing (e.g. if the appointment started before or ended after the cameras were scheduled to be on, or if there was a problem with the relay to the computer), in which case an additional complete appointment was coded. The targeted maximum number of complete appointments to be coded per clinic was initially set at 100, in order to maximize the amount of data that could be included from each clinic while avoiding excessive representation of very busy clinics in the data set, based on an estimate that on average 8-10 appointments would be seen per day in a single exam room over two weeks. This target was later reduced to 80 appointments per clinic due to time constraints, the number of participating clinics and the total amount of video footage collected.

Videos were generally scanned at 2-4 times normal speed, and then watched in real time or slow motion with repeated review as necessary to discern pertinent actions. The following information was coded for each appointment: patient species (cat, dog, other, multiple); appointment type (vaccination, other); use of a sharp; ready availability of an approved sharps disposal container (i.e. labeled, puncture/leak/spill proof container not kept in a cupboard or drawer, such that sharps could be directly disposed into the container after use); uncapping of a needle using the mouth; recapping of a needle using two hands (i.e. not “scoop” technique or using an instrument); bare needle left out on any surface for any length of time; all sharps placed in a disposal container (approved or unapproved) prior to the end of the
appointment; apparent NSIs; cleaning of the exam table (including contact time with spray used) and mopping of the exam room floor, respectively, within 1 h (mid-day) or 30 min (end of day) of the previous appointment; contact of a patient with the exam room floor and horizontal surface of the exam table, respectively; animal restrained by an additional staff member or client; other adverse events (e.g. scratches, bites). Contact time with table spray was measured to the second from when application of the spray began to when an individual began to wipe the table with a disposable or reusable towel. The types or brands of disinfectants used for environmental cleaning (e.g. in the table spray) were not recorded. For each staff-animal contact (coded for each unique staff member who had contact with a patient within each appointment) the use of appropriate PPC was coded, along with the individual’s gender and apparent role (veterinarian, technician, other). Appropriate PPC was defined as wearing a lab coat, scrubs or other clinic-issue uniform or clothing (i.e. bearing a clinic logo) that covered all personal clothing (i.e. street clothes) from at least the waist up other than a reasonable portion of the collar area, as well as closed-toed shoes. Lab coats worn without being buttoned or otherwise closed in the front, and scrubs or lab coats that consistently left an estimated 3-5 cm or more of the sleeve of the garment underneath exposed were not considered appropriate PPC. When observed, the type of inappropriate PPC was recorded as text in the spreadsheet. All procedures of interest captured on either the exam room or backroom video that were associated with an appointment initiated in the monitored exam room were coded. Procedures captured on video that were not related to such an appointment (e.g. procedures related to inpatients or outpatients seen in other exam rooms) were not coded. Miscellaneous noteworthy observations for each clinic pertaining to infection control were recorded separately as text.

5.2.1 Statistical analysis

Coded data were imported into a statistical software package (STATA Intercooled 11, StataCorp, College Station TX) for analysis. Logistic regression was used to examine univariable associations between ready availability of an approved sharps disposal container and recapping of a needle, a bare sharp being left out and disposal of all sharps prior to the end of the appointment, respectively, as well as between cleaning of room surfaces (table and floor) and animal contact therewith, including clinic as a random effect in all models to control for clustering. Logistic regression was also used to examine the association between appropriate PPC and gender and role, respectively, including both clinic and individual as random effects. Significance was set at $p \leq 0.05$. Descriptive statistics were examined for all other data.
5.3 Results

A total of 135 clinics were approached to participate in the study, out of approximately 1100 registered companion animal hospitals in Ontario (12%). Of these, no response of any kind was received from 26 (19%). Fifty-seven clinics (42%) declined to participate for the following reasons: staff not comfortable with the cameras (13), concern regarding clients being uncomfortable with the cameras (4), too busy and/or undergoing renovations (5), new personnel on staff (3), no reason given (32). Fifty-two clinics (39%) agreed to participate, one of which was excluded as it was determined that the caseload was primarily emergency. Of the 51 clinics in which the video monitoring was performed, four sites were excluded from the analysis: two due to loss of data from a computer malfunction during the recording period, one due to staffing issues and plumbing problems in one of the monitored areas, and one because signs were posted by clinic staff next to the cameras alerting personnel and clients to their presence, thereby altering the conditions of the study and rendering the data not comparable to the other clinics. Ultimately videos from 47 facilities were coded and included in the analysis for this study, all of which were exclusively companion animal clinics, although one clinic shared a building with a mobile large animal clinic. In 60% (28/47) of these clinics, the monitored backroom area included at least part of a treatment area, while in the remainder it was a location where animals were generally not handled (e.g. pharmacy, lab or records area in close proximity to the monitored exam room).

Data from 2713 appointments were coded, including 1053 (39%) appointments during which vaccine administration was observed and which therefore likely involved relatively healthy animals. It is possible that a number of the “other” appointments also included patient vaccination when this was performed in an unmonitored backroom area. Sixty-six (2%) appointments were classified as “incomplete” but still included pertinent data on one or more of the variables of interest, and therefore were included in the analysis. The total number of appointments (complete and incomplete) per clinic ranged from 9-104 (mean 58, median 64). A total of approximately 535 unique individuals had 4903 staff-animal contacts. The number of individuals per clinic ranged from 4-39 (mean 11, median 10), and the number of staff-animal contacts per clinic ranged from 24-251 (mean 104, median 97). The distribution of study participants by gender and role is shown in Table 5.1.

5.3.1 Sharps handling

Thirty-six percent (17/47) of clinics had an approved sharps disposal container readily available in the exam room, but in two of these it was observed that the top of the container (i.e. the portion including the needle-removal device that also prevents accidental or intentional removal of sharps from the container) was not on tight and/or the container was periodically emptied (rather than filled, sealed
and replaced). Twenty-six percent (12/47) of clinics had a sharps disposal container in a cupboard or drawer. In 30% (14/47) of clinics there was no apparent sharps disposal container anywhere in the exam room, in which case sharps were either taken elsewhere for disposal at or after the end of the appointment, or (in 4 clinics) they were temporarily placed in an open tray or cup for disposal later in the day. In at least 2 clinics sharps brought to the backroom area were placed in an open bin rather than a disposal container. Use of inappropriate sharps containers was observed in 4 clinics: 3 used empty plastic jugs with openings of various diameters, while 1 used a metal can with a modified removable plastic lid.

Use of a hypodermic needle was observed in 50% (1353/2713) of appointments, and use of a scalpel blade was observed in 0.3% (8/2713), two of which also included use of a needle. Sharps handling behaviours observed and their independent associations with ready availability of an approved sharps disposal container are shown in Table 5.2. Recapping of needles using the recommended one-handed “scoop” technique (8,11,12,24) was seen on four occasions (0.4% of 1137 appointments in which a needle was recapped); in two of these cases the individual was restraining an animal with the other hand, therefore use of a one-handed technique was the only feasible way to recap the needle. Use of an instrument to recap needles was not observed, but use of an instrument to remove needles from syringes was seen once in one clinic, and was routinely used in another clinic by two individuals. Only one NSI was observed, which was sustained by a young volunteer (subjectively appearing to be less than 18 years old) recappping a needle used to administer a vaccine that had been left out on the exam room counter.

5.3.2 Environmental cleaning

The exam table was cleaned and the exam room floor was mopped within 1 h and before the next appointment (during the day) or within 30 min (at end of day) following 76% (2015/2646) and 7% (174/2646) of appointments, respectively. In 7% (178/2646) of cases the table was cleaned more than once by either the same or different staff members. All clinics used a spray to clean the table, and the contact time allowed ranged from 0 (spray applied to cleaning towel rather than directly to table) to 76 min 51 s (spray having been applied within 1 h of the appointment and then wiped off later)(mean 39 s, median 9 s, 75th percentile 15 s). Animals had contact with the exam table, the exam room floor or both in 24% (659/2713), 28% (748/2713) and 48% (1295/2713) of appointments respectively. In 0.4% (11/2713) of appointments contact of the animal with neither the table nor floor was observed (i.e. always held by owner, remained in carrier or on gurney). Table cleaning was significantly associated with patient contact with the exam table (OR = 4.69, 95% CI 3.79-5.81, p<0.001), and floor cleaning with patient contact with the exam room floor (OR = 1.53, 95% CI 1.02-2.29, p=0.040) in separate univariable
models. The random effect for clinic was significant in both models (p for likelihood ratio test vs logistic regression without the random effect <0.001 for both).

5.3.3 Personal protective clothing (PPC)

Appropriate PPC was worn for 72% (3518/4903) of staff-animal contacts. Compliance with appropriate PPC within each clinic ranged from 21-99% (mean 69%, median 70%). Commonly observed types of inappropriate PPC are shown in Table 5.3. Appropriate PPC was significantly associated with being a veterinarian (OR = 3.26, 95% CI 1.08-9.82, p=0.036) or technician (OR = 3.94, 95%CI 1.37-11.33, p=0.011) compared to other staff, but not with gender (p=0.494). There was no significant difference between veterinarians and technicians. The random effects for clinic and individual were significant in both models (p for likelihood ratio test vs logistic regression without the random effects <0.001 for both).

5.3.4 Animal restraint

Animal restraint was recorded for 2680 appointments. In 20% (524/2680) either no restraint was required or restraint was performed by the primary staff member conducting the appointment. In 11% (290/2680) restraint was performed by an additional staff member, without help from the client. A client appearing to be over the age of 16 restrained (or helped restrain) the animal in 69% (1854/2680) of appointments, and in 0.4% (12/2680) of appointments a client appearing to be under the age of 16 helped with restraint. Restraint ranged from gentle “distraction” of the animal through physical contact to active restraint of fractious, excitable or large animals. For large dogs examined on the floor outside the field of view of the camera, it was assumed that the owner performed at least mild restraint unless there was evidence that the individual could not have done so based on position or physical limitations. Use of muzzles for both dogs and cats was observed but not coded. Only one bite was observed, which was sustained by a technician restraining a cat in the backroom. Two technicians were noted to have been scratched by cats, one while restraining and one while administering a pill. Two clients sustained scratches while restraining their own cats in the exam room; in one case the scratch was severe enough that the client was taken to the backroom to apply a bandage wrap. One other client appeared to sustain a relatively severe cat scratch (or possibly bite) immediately before entering the exam room, as evidenced by obvious bleeding and the cat’s demeanor. All observed bite and scratch injuries were to the hands.

5.3.5 Other observations

Other infection control-related observations that were made on a clinic basis are shown in Table 5.4. It is important to note that if a particular observation was not made in a specific clinic, it does not
exclude the possibility in some cases that the item/action was present/occurred elsewhere in the clinic in an unmonitored area or at an unmonitored time. These numbers therefore represent the minimum number of clinics in which the listed factors were present.

5.4 Discussion

Although hand hygiene is considered by many to be the single most important measure for controlling the spread of pathogens in the clinic environment (8,10-13), effective infection control requires diligent, every-day attention to many other practices as well. In isolation each of these practices may seem to be of limited importance, and the relative importance of most is poorly defined, but together they have the potential to help break the chain of transmission and thus reduce the incidence of infections. This study provided a unique opportunity to directly observe the use of some of these infection control practices in primary care veterinary clinics.

Attention to safe sharps handling practices is paramount to the prevention of NSIs. Sharps should be disposed immediately after use directly into an approved container (i.e. not left bare on any surface), and recapping of needles should be avoided unless no other alternative exists, as this is considered a high-risk procedure (20,23,26). If an appropriate disposal container is not readily available, recapping should be done using the one-handed “scoop” technique, or using an instrument to handle the needle cap (8,11,12,24). Recapping of needles was common in this study, but recapping in the recommended manner was only seen four times, and in two of these the technique was likely only used out of necessity because the individual only had one free hand. The risk of NSIs can also be reduced by the use of safety devices (e.g. retractable needles), which are becoming more commonly used in human healthcare (19) but have yet to be widely adopted in veterinary practice. The use of needle protective devices was not observed in any clinic in this study. Bare sharps should never be left out due to the risk of injury during subsequent handling and disposal, as well as to individuals who may not realize an exposed sharp is present. Not surprisingly, the odds of disposal of all visible sharps prior to the end of an appointment were 15-times higher when an approved sharps disposal container was readily available, although the presence of such a container was not associated with the odds of staff recapping a needle or leaving a bare sharp exposed. Veterinary staff should be trained to avoid recapping needles by disposing of them directly into an approved container, and to use the “scoop” technique or an instrument for recapping when absolutely necessary. In order to facilitate this, clinics must ensure that appropriate containers are available in all areas where sharps are used. If containers are stored in a cupboard, they should be taken out and placed in the open prior to use of any sharp. It is unknown if the volunteer who sustained the NSI observed in this study had received any training in sharps handling, which poses a potential liability issue.
for the clinic. Adequate training of such lay staff, restriction of sharps handling to trained professional staff and/or immediate disposal of the sharp (rather than leaving it bare on the counter) all could have potentially prevented the incident.

The use of temporary storage or other unapproved containers for used sharps should be discouraged, as these require additional handling of used sharps during transfer to a proper disposal container, which also increases the risk of NSI (8,11,12). Use of such containers in other clinics has been reported previously (23).

Uncapping of needles by mouth (i.e. gripping the needle cap in the teeth and unsheathing the needle using one hand) was also a relatively common occurrence in this study, typically when an individual only had one free hand. This behaviour results in higher risk of NSI to the face and potentially even the eyes, and should therefore be avoided at all times (8,11,12). It also carries the risk of transfer to the mouth of infectious pathogens that may be present on the needle cap.

Studies have indicated that 64-93% of veterinary personnel have experienced at least one NSI in their career (23,25,27-29), and in one report 74% of veterinary technicians had experienced a NSI in the last 12 months (23). As in human medicine, NSIs in veterinary medicine are likely significantly underreported (19,23). In this study only one NSI was observed among the 535 individuals whose actions were coded; however, when one considers the fraction of total activities of any one person that was captured on video and then coded, even a single NSI may represent a significant rate of occurrence given the frequency of sharps use. Furthermore, this study focused on sharps use during routine appointments, which may be lower-risk for NSIs compared to other procedures, and some NSIs may have gone undetected for various reasons, including lack of a visible physical reaction from the individual at the time.

The role of environmental contamination in the spread of pathogens in veterinary clinics is often unclear. Studies have shown that a variety of infectious agents can persist on many different surfaces within a clinic (30-33), but in the absence of epidemiological evidence linking a certain item or surface to clinical cases, the significance of such contamination is poorly understood, with the possible exception of a few well-studied pathogens (e.g. canine parvovirus)(10). Nonetheless, due to the potential for microbes in the environment, particularly on high-contact surfaces, to be picked up directly or indirectly by animals and people, attention to appropriate cleaning and disinfection protocols is highly recommended (8,9,11,12). The goal of these protocols is to reduce the environmental microbial burden to a level at
which the risk of infection for the majority of animals and people is as low as possible. Effective disinfection first requires cleaning to remove gross contamination, followed by adequate contact time with an appropriate disinfectant that is typically then wiped or rinsed off. All clinics in this study used what appeared to be a disinfectant spray for cleaning of the exam room table and other surfaces. Recommended contact times for disinfectants typically used in veterinary clinics are 5-10 min (9,10), and for some products may be as short as 1-3 min (34), yet in up to 75% of observed applications, total contact time with the spray used on the exam table was 15 s or less. In these cases the surface was being cleaned, but the presumably desired low-level disinfection was not being achieved. Disinfectants must be used according to the manufacturer’s instructions for both contact time and concentration in order to be fully effective. Due to the wide variety of patients that may be seen in a veterinary clinic, and more critically the inability to detect subclinical carriers of various pathogens that may contaminate the environment even during a routine appointment, low-level disinfection of high-contact surfaces such as exam tables between all patients is recommended (8,9,11,12).

A major difference between veterinary clinics and human hospitals is the degree of contact veterinary patients (and by extension the staff and clients working with the patients) have with the floor. In this study, animals had contact with the exam room floor in more appointments (76%) than with the exam room table (72%), yet the table was cleaned after 76% of appointments and the floor was mopped after only 7%. Floors were swept more often than mopped, and occasionally vacuumed, but still relatively infrequently (data not shown). Although sweeping helps to remove visible dirt and debris, including potentially contaminated hair and dander (making it an important step prior to application of a disinfectant), by itself sweeping does not reliably eliminate microbes from a surface, and may aerosolize contaminated dust or debris which may then settle on other surfaces. The same can be said for vacuums, unless a centralized unit is used and/or the vacuum is equipped with a HEPA filter (8,12). It is possible that this greater effort to clean exam tables over floors is for aesthetic reasons, but it is important for clinics to have a realistic view of what their current environmental cleaning practices do and do not accomplish, particularly in terms of disinfection for infection control purposes, so that protocols can be properly evaluated and adjusted if necessary.

Personal protective clothing is important for infection control within a clinic as well as for preventing spread of pathogens into the community (8,11,12). Within the clinic, additional articles of clean PPC (e.g. scrubs, lab coats) appropriate in size for each staff member must be available so that individuals can change their PPC as needed when it becomes soiled or potentially contaminated. Unlike street clothes, these items are generally made from relatively durable easy-to-clean material to facilitate
frequent laundering. Equally if not more importantly, PPC must not be worn outside the clinic, as infectious pathogens may be carried on clothing to anywhere the individual may go, including vehicles, eating establishments, other public places, and home, where the person may have close contact with household members and pets. In this study, no attempt was made to evaluate if and when staff changed their clothing, only whether they wore appropriate PPC during animal contacts. In at least 80% of contacts in which PPC was classified as inappropriate, staff wore a garment that would otherwise be considered appropriate PPC but also wore an additional piece of clothing in such a way that it was not fully covered by the PPC, thus partially negating its usefulness. It is possible that these individuals wore PPC items in order to comply with clinic policy, for comfort, convenience or other reasons, without fully understanding or appreciating the rationale behind PPC, particularly in the case of staff other than veterinarians and technicians, as these individuals were less likely to wear appropriate PPC. The importance of both wearing and changing PPC as needed throughout the day and especially removing PPC at the end of the day must be emphasized to all staff.

Appropriate restraint of animals during examinations and other procedures is crucial for the safety of the individual working on the animal, the animal itself, and the person restraining. Veterinary staff in this study often relied on clients to help restrain their own animals during appointments. Although some clients can provide security and a calming influence for their pets, they may not be familiar with effective restraint techniques, and unexpected reactions from animals can lead to injuries, including bites, scratches, falls (e.g. animal falls off table) and potentially NSIs. This is a component of infection control because such trauma can lead to wound infections and transmission of some diseases (i.e. bartonellosis (cat scratch disease), rabies). All bite and scratch injuries observed in this study were caused by cats. This may be because overall cats are more likely to cause these types or injuries, because cats are harder to restrain effectively, or because staff are more cautious with dogs and therefore take additional measures to prevent injuries (e.g. muzzle, additional personnel). Even though the absolute number of bites and scratches observed was small (6), half of these were injuries to clients. As for NSIs, when one considers the fraction of clinic activity that was observed and the frequency with which the risk of such injuries is present (essentially any time an animal is handled), this may still represent a significant rate of occurrence. Injuries to clients, and even to staff if they are inadequately trained, are potentially a serious liability issue for clinics. Any time a bite or scratch occurs, the circumstances should be recorded (8,11,12) so that the incident can be evaluated with the appropriate staff, and staff training or clinic policies adjusted if necessary in order to reduce the risk of additional injuries. Reporting can also help ensure that appropriate wound care is exercised and that the individual is directed to seek medical
attention if there is an increased risk of infection or complications (e.g. any wounds to the hands or groin, over joints or tendon sheaths, or to any individual who is immunocompromised)(12,35).

The use of paper records in veterinary clinics remains common, even in clinics in which a computer is present in the examination room. Paper records have the potential to act as a fomite for microbes (36), are often handled by multiple individuals, and may be taken to different areas including offices where food and drink may be consumed. It was observed on numerous occasions that records were placed directly on the exam table either while the patient was still on it (in which case the animal sometimes had direct contact with the record as well) or after. Records were also frequently handled during examinations without hand hygiene being performed, thus increasing the likelihood of contamination. Staff must be aware of the potential for records to indirectly transfer microbes between people and between people and animals in order to take steps to try to reduce any such risk. The use of electronic records alone in the exam room effectively eliminates this hazard; however, special attention must then be paid to appropriate cleaning of the computer keyboard, as this becomes a high-contact surface which can also harbor various infectious organisms (30,31,37).

At a clinic level, several other practices were relatively commonly noted that pose a potential increased risk to staff and/or animals from an infection control standpoint. Food and drink were seen being consumed by staff in clinical areas in 70% of clinics. Food and drink for human consumption, including dishes and utensils used there for, should not be brought to, kept or washed in any clinical area or area where clinical samples may be placed, due to the risk of contamination and subsequent oral transmission of pathogens (8,11,12). “Clinic cats” were present in over half of all clinics. The presence of (a) free-roaming animal(s) in a clinic, whether a “clinic cat” or staff-owned animal, should be strongly discouraged (12). These animals can act as vectors or become carriers of pathogens to which they may be exposed from the environment or patients. At a minimum, such animals should not be allowed to have direct contact with patients and should be restricted from areas such as exam rooms, treatment rooms and lab areas. A communal bottle of ear cleaner/medication was applied directly to the ear of patients in just under half of all clinics. This practice has the potential to result in contamination of the bottle tip (on the outside as well as the inside, which is difficult to clean) with aural pathogens, which can then potentially be transferred directly to the ears of subsequent patients. Solutions should instead be applied to disposable swabs/gauze/cotton for use on the patient, or an amount transferred to another bottle (potentially dispensed to the client) for use on a single patient. These practices should be carefully evaluated by each facility to determine if the potential benefit(s) (e.g. convenience) truly outweigh the potential increased infection risk, or if at the least an adjustment to clinic policy is warranted.
Bottles containing liquids of various kinds (e.g. soap, antiseptic, disinfectant) were seen being “topped up” in 38% of clinics in this study. Refilling bottles without prior emptying and thorough cleaning can result in perpetual contamination with pathogenic organisms, and could potentially contribute to development of resistance to the active antiseptic or antimicrobial ingredients present (8,9,11,38). In the case of products prepared from a concentrated form, improper refilling of partially empty bottles can also result in improper dilution, thus altering the products’ effectiveness. Although it has not been formally investigated, a similar risk for perpetual bacterial contamination of containers/bags of dog and/or cat treats used during appointments exists, particularly for containers that are refilled without being emptied and properly cleaned, or for large bags that are used for a long period of time before being discarded. The majority of clinics regularly or frequently made use of such containers/bags, which were often accessed after having contact with an animal (e.g. at the end of an appointment or after a procedure) without first performing hand hygiene. Refilling of these containers was noted at times but was not formally coded.

The use of video observation in this study had both advantages and disadvantages. The ability to directly observe behaviour, rather than rely on self-reported behaviour from an interview or survey, was unique compared to previously published studies in this area. The cameras allowed for discrete observation compared to the presence of a human observer, which is still the gold standard for monitoring hand hygiene compliance in human healthcare (39). However, the cameras were visible to staff, and all staff were made aware of the study in advance in order to provide consent, therefore Hawthorne effects could have resulted in altered (i.e. artificially improved) behaviour (39). Based on previous work with this system, it is suspected that this effect would be relatively small (Anderson, unpublished data 2012). Also, the appointments coded from each clinic were primarily from the latter two-thirds of the total recording period, at which point most staff would have had at least several days to become acclimatized to the presence of the cameras and resume their typical routine. The fixed camera positions, which provided a somewhat limited and at times obstructed view, and periodic problems with recording due to signal, power or computer issues likely decreased observational sensitivity, but at the same time the level of detailed video review likely increased specificity. Based on informal feedback given to the investigator at the end of the observation period, very few to no clients at each clinic queried or mentioned the presence of the exam room camera to staff, and no clients asked to be moved to an unmonitored exam room or to have their image removed from the video footage. Staff feedback at the end of the observation period regarding the cameras varied: anecdotally, most frequently staff mentioned that they forgot about the cameras over time and that in the end it was “no big deal,” but on a few occasions a single staff member expressed relief when the cameras were removed.
Other limitations of this study should also be considered. Clinics were not randomly selected, and participated on a voluntary basis. It is possible that clinic staff with a greater interest in infection control or who were more comfortable with their current practices would be more willing to participate. Univariable models included a random effect for clinic, but did not account for clustering by individual for either sharps handling or environmental cleaning.

5.5 Conclusion

Although there is significant room for improvement in sharps handling behaviours in companion animal clinics, the incidence of observed NSIs in this study was low. Better handling and disposal of sharps may become much more important if more zoonotic diseases emerge that are transmissible by blood contamination. Nonetheless, all veterinary personnel should be trained in safe sharps handling procedures in order to protect personnel, patients and animal owners from the risks of injury and infection, and appropriate policies should be included in the clinic infection control manual for reference.

This study suggests that there is room for improvement in veterinary clinics in the use of basic infection control measures such as environmental cleaning and use of PPC, as well as sharps handling. Improving many of these practices requires minimal financial investment, but may require time and effort on the part of personnel. The best means of achieving better compliance needs to be investigated. Increased staff training and education would be a reasonable starting point, but education alone does not necessarily result in behavioural changes. Ultimately the culture in veterinary clinics needs to include infection control as an integral part of everyday practices, through training, discussion, example and other means, so that compliance becomes automatic (40).
**Table 5.1**: Distribution by gender and role of study participants from 47 companion animal clinics in Ontario

<table>
<thead>
<tr>
<th>Role</th>
<th>Number of personnel (%)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Total</td>
</tr>
<tr>
<td>Veterinarian</td>
<td></td>
<td>45 (69)</td>
<td>111 (24)</td>
<td>156 (29)</td>
</tr>
<tr>
<td>Technician</td>
<td></td>
<td>10 (15)</td>
<td>266 (57)</td>
<td>276 (52)</td>
</tr>
<tr>
<td>Other support staff†</td>
<td></td>
<td>10 (15)</td>
<td>93 (20)</td>
<td>103 (19)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>65 (100)</td>
<td>470 (100)</td>
<td>535 (100)</td>
</tr>
</tbody>
</table>

† including receptionists, students, volunteers
Table 5.2: Selected sharps handling behaviours observed during 1359 routine companion animal appointments in 47 veterinary clinics in Ontario, and their independent associations with ready availability of an approved sharps disposal container

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Number of appointments (%)</th>
<th>Number of clinics (%)</th>
<th>OR</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncapping of needle using the mouth</td>
<td>350/1353 (26)</td>
<td>41/47 (87)</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Recapping of needle</td>
<td>1137/1353 (84)</td>
<td>47/47 (100)</td>
<td>0.46</td>
<td>0.15-1.38</td>
<td>0.167</td>
</tr>
<tr>
<td>Bare sharp left out</td>
<td>237/1359 (17)</td>
<td>38/47 (81)</td>
<td>0.78</td>
<td>0.43-1.43</td>
<td>0.431</td>
</tr>
<tr>
<td>All visible sharps placed in disposal container</td>
<td>513/1359 (38)</td>
<td>39/47 (83)</td>
<td>15.00</td>
<td>6.67-33.73</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

ND=not determined as availability of a disposal container would not be expected to affect uncapping behaviour

1 A random effect for clinic was included in each model, and in all three models the effect was significant (p for likelihood ratio test vs logistic regression without the random effect <0.001 for all).
Table 5.3: Commonly observed types of inappropriate personal protective clothing (PPC) observed during 4903 staff-animal contacts during 2713 routine appointments in 47 companion animal clinics in Ontario

<table>
<thead>
<tr>
<th>Inappropriate PPC</th>
<th>N (% of total staff-animal contacts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long sleeves worn under short-sleeved scrubs, smock or lab coat</td>
<td>553 (11)</td>
</tr>
<tr>
<td>Sweater that was not clinic-issue or part of a clinic uniform worn over scrubs</td>
<td>316 (6)</td>
</tr>
<tr>
<td>Open lab coat over street clothes</td>
<td>170 (3)</td>
</tr>
<tr>
<td>Sleeves sticking out 3-5 cm or more past the cuffs of a lab coat or scrub shirt</td>
<td>73 (1)</td>
</tr>
<tr>
<td>Open-toed shoes</td>
<td>43 (1)</td>
</tr>
<tr>
<td>Street clothes alone (no PPC)</td>
<td>107 (2)</td>
</tr>
<tr>
<td>Other/not recorded</td>
<td>123 (3)</td>
</tr>
</tbody>
</table>
Table 5.4: Additional observations of factors relating to infection control made during video monitoring of 47 companion animal clinics in Ontario

<table>
<thead>
<tr>
<th>Factor</th>
<th>Number of clinics (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper records regularly used in exam room</td>
<td>37 (79)</td>
</tr>
<tr>
<td>Computer present in exam room</td>
<td>18 (38)</td>
</tr>
<tr>
<td>Food and/or drink consumed in clinical areas</td>
<td>33 (70)</td>
</tr>
<tr>
<td>Human food dishes/utensils cleaned in clinical area sink</td>
<td>7 (15)</td>
</tr>
<tr>
<td>Free-roaming cat(s) in clinic</td>
<td>25 (53)</td>
</tr>
<tr>
<td>Clinic or staff animals allowed to have contact with patients in exam room</td>
<td>4 (9)</td>
</tr>
<tr>
<td>Communal ear cleaner/medication bottle applied directly to ears of patients</td>
<td>22 (47)</td>
</tr>
<tr>
<td>Bottles of liquids (e.g. soap, antiseptic, disinfectant) “topped up”</td>
<td>18 (38)</td>
</tr>
<tr>
<td>Communal container or bag of treats kept/used in exam room</td>
<td>42 (89)</td>
</tr>
<tr>
<td>Disposable thermometer covers used</td>
<td>12 (26)</td>
</tr>
</tbody>
</table>
5.6 Acknowledgements

Funding was provided by the Canadian Institutes of Health Research (CIHR) and the Ontario Veterinary College Pet Trust. The authors thank all of the personnel at the participating veterinary clinics for their trust and willingness to be involved in this study.
5.7 References


CHAPTER 6:

Video observation of hand hygiene practices during routine companion animal appointments
and the effect of a poster intervention on hand hygiene compliance

Maureen EC Anderson
Jan M Sargeant
J Scott Weese
6.0 Abstract

Background: Hand hygiene is considered one of the single-most important infection control measures in human medicine, but there is little information available regarding hand hygiene frequency and technique used in veterinary clinics. The objectives of this study were to describe hand hygiene practices associated with routine appointments in companion animal clinics in Ontario, and the effectiveness of a poster campaign to improve hand hygiene compliance.

Results: Observation of hand hygiene practices was performed in 51 clinics for approximately 3 weeks each using 2 small wireless surveillance cameras: one in an exam room, and one in the most likely location for hand hygiene to be performed outside the exam room following an appointment. Data from 38 clinics were included in the final analysis, including 449 individuals, 1139 appointments before and after the poster intervention, and 10894 hand hygiene opportunities. Overall hand hygiene compliance was 14% (1473/10894), while before and after patient contact compliance was 3% (123/4377) and 26% (1145/4377), respectively. Soap and water was used for 87% (1182/1353) of observed hand hygiene attempts with a mean contact time of 4 s (median 2 s, range 1-49 s), while alcohol-based hand sanitizer (AHS) was used for 7% (98/1353) of attempts with a mean contact time of 8 s (median 7 s, range 1-30 s). The presence of the posters had no significant effect on compliance, although some staff reported that they felt the posters did increase their personal awareness of the need to perform hand hygiene, and the posters had some effect on product contact times.

Conclusions: Overall hand hygiene compliance in veterinary clinics in this study was low, and contact time with hand hygiene products was frequently below the recommended 15 s. Use of AHS was low despite its advantages over hand washing and availability in the majority of clinics. The poster campaign had a limited effect on its own, but could still be used as a component of a multimodal hand hygiene campaign. Improving the infection control culture in veterinary medicine would facilitate future campaigns and studies in this area.
6.1 Introduction

Hand hygiene is a critical infection control measure for the prevention of hospital-associated infections (HAIs) in human medicine (1,2). In various jurisdictions, hospitals are now required to collect and report hand hygiene compliance data as part of programs to help improve patient safety and quality of care, as well as ensure facility accountability (3-5). In veterinary medicine, infection control guidelines also recommend proper hand hygiene practices as one of the most important measures for reducing the spread of pathogens in clinics (6-8). However, hand hygiene compliance in veterinary clinics has received little attention, and only recently have a small number of studies begun to investigate the actual use of this simple yet essential infection control practice amongst veterinary staff, reporting compliance of 21-48% in companion animal personnel (9-11).

The gold standard for measuring hand hygiene compliance in human healthcare facilities remains direct observation, typically performed by an observer on the clinic floor (2,12-14). This is not a feasible method for use in most primary care veterinary clinics where there is typically a relatively small number of staff and a substantial amount of animal contact takes place during outpatient appointments done in small, private exam rooms. In these scenarios the presence of a designated observer for the purpose of collecting hand hygiene compliance data would likely be considered unacceptably cumbersome and intrusive. The use of video cameras for direct observation can be considerably more discrete, and even in fixed positions cameras can capture a substantial amount of raw data when strategically used in a relatively limited environment, such as an exam room or treatment area. Video observation of hand hygiene practices is not frequently used in healthcare settings (15), but has been used successfully in food handling studies (16,17).

Based on the low staff hand hygiene compliance reported in recent veterinary studies, the effectiveness of measures to improve compliance warrants investigation. Posters are a commonly used type of intervention for promoting a wide variety of ideas and behaviours in many settings, and they are often incorporated into broader multimodal interventions for improving hand hygiene compliance in healthcare facilities (18-20). The impact of hand hygiene poster campaigns is variable and may be short-term, and often cannot be separated from the effect of concurrent interventions (21,22). Careful attention to the design of the campaign message and the poster(s) is critical, but thereafter implementation of a basic poster campaign is fairly simple and requires little to no effort on the part of the targeted individuals. This makes a hand hygiene poster intervention a reasonable “first step” in facilities that may be resistant to more involved, active interventions due to lack of a strong infection control culture or other reasons.
The objectives of this study were to use remote video observation to describe hand hygiene compliance in terms of timing and technique associated with routine appointments in companion animal clinics in Ontario, as well as to evaluate the effectiveness of a basic poster campaign to improve hand hygiene compliance, and to identify factors that could potentially help guide the design and implementation of future interventions to improve hand hygiene practices in veterinary clinics.

6.2 Materials & Methods

6.2.1 Clinic recruitment

A convenience sample of primary care companion and mixed animal veterinary clinics from across southwestern and eastern Ontario, Canada, was recruited to participate. Clinics in various regions were identified through known contacts of either of the investigators and using Google Maps (maps.google.ca) with the search term “veterinary”. Each clinic was then contacted directly by one of the investigators via e-mail, fax or telephone, typically obtained from individual clinic websites. If no response was received, follow-up inquiries were made by the same means 1, 3 and 5 weeks later, and then monthly thereafter until recruitment was complete. Data collection was performed from November 2010 to December 2011. A required sample size of 40 clinics was estimated based on a baseline hand hygiene compliance of 30%, a minimum effect to detect of 30% (i.e. increase in compliance to 60%), rho=0.1 (i.e. cluster coefficient for individuals within a clinic), a minimum of 3 individuals per clinic, power=0.80 and alpha=0.05.

6.2.2 Video observation

Two wireless video surveillance cameras (Logitech WiLife™ Indoor Video Security System, Logitech, Newark, CA) were installed in each clinic: one in an exam room, and one in the most likely backroom location for hand hygiene to be performed outside the exam room following an appointment (excluding private offices and washrooms), as determined by clinic layout and information on clinic workflow provided by staff. The cameras were visible to staff, but care was taken to position the cameras and secure their power cords to make them as discrete as possible. All indicator lights on the cameras were disabled so there were no visible signs that the cameras were on or off. Video data were recorded by powerline network on a secure, closed laptop computer kept elsewhere in the clinic in an unobtrusive location (e.g. on top of a cupboard, under a desk, or on an unused shelf), using the software provided by the camera manufacturer (Logitech Command Center v2.5 (for Windows), Logitech, Newark, CA). Cameras were left in place for 14-19 working days (19-23 calendar days), and were motion-activated during the hours when routine (non-emergency) appointments were typically scheduled in each clinic, plus approximately 30 min before and after this period. The cameras did not record audio data.
6.2.3 Poster intervention

Two different poster designs were used in each clinic (Appendix 6.1). The justification for the key elements of both posters is shown in Appendix 6.2. Poster B contained slightly more text than Poster A, as it was intended for use in staff-only areas where personnel would potentially have more opportunity to read the additional information if they were so inclined. Heavy lamination was used for all posters to protect against water damage and wear-and-tear so they maintained a well-kept, professional appearance and remained legible for the duration of the study. A copy of Poster A was displayed in every exam room (monitored and unmonitored) in a location intended to be highly visible to staff during the appointment, such as over the sink or close to the computer work station (if present). In exam rooms where no sink was present, the poster was typically placed at the door where it was most likely to be seen as a staff member entered or exited. Poster B was displayed near up to 3 hand hygiene stations (most often sinks) in the backroom area, particularly those closest to the monitored exam room and most likely to be used by staff for hand hygiene between appointments. All posters were mounted by one investigator (MA) between 9-13 working days after the cameras were installed. The posters did not include any information pertaining to non-hand hygiene infection control measures.

6.2.4 Participant consent

Written consent was obtained from all clinic personnel whose images would potentially be captured on video; they were informed that the focus of the study was general infection control practices, but not for what specific practices data would be collected (including hand hygiene).

Consent was not obtained from clients based on the following reasons: requiring consent to be collected from each client would be very time consuming and would negate the use of video cameras as an unobtrusive means of observation, because staff would be forcibly reminded of their presence for each appointment when speaking to clients about the study; the capturing of client images was purely incidental, as clients were not the subject of the study and therefore no identifying information or information about their behavior was collected; and where applicable the camera was clearly focused on the “staff side” of the exam room such that clients’ faces often did not even appear on the videos. A study information sheet was provided to clinic staff which could be given to any client who enquired about the presence of the camera, and if the client was uncomfortable staff were instructed to move the client to an unmonitored exam room, or cover the camera lens for the duration of the appointment. Clients could also request to have their image permanently deleted from the video recordings before the laptop computer was removed from the clinic. This study was approved by the University of Guelph Research Ethics Board.
6.2.5 Follow-up survey

At the end of the study, during the final site visit, an anonymous, voluntary written survey was provided to up to 20 staff members at each clinic. Surveys were provided in a pre-addressed, postage-paid envelope, and the primary staff contact at each clinic (veterinarian, technician or office manager) was asked to distribute them to the other staff and return any completed or uncompleted questionnaires within two weeks, at which time an email or telephone reminder was sent if the envelope had not yet been received. Any staff member who worked in the clinic during the video observation period was eligible to participate, but a maximum of 20 individuals from any one clinic were allowed to fill out the survey. Distribution and collection of the surveys was ultimately at the discretion of the clinic staff, including at clinics with over 20 staff members. The first five questions on the survey queried individual perception of and response to the poster intervention, in the form of yes/no and Likert-type scale questions. The remainder of the survey consisted of questions regarding hand hygiene practices and perceptions in general (see Chapter 4). The estimated time needed to complete the entire survey was 10 minutes. For the full survey, see Appendix 4.1.

6.2.6 Video coding - Scheme

A video coding scheme was developed in the form of a fillable spreadsheet (Excel 2008 for Mac, Microsoft Corporation, Redmond, WA) and tested using video recordings from two clinics that were excluded from the final analysis due to loss of data from computer malfunctions. The scheme was modified from the World Health Organization’s (WHO) “5 moments for hand hygiene” (13,23). The five types of hand hygiene opportunity used in this study were: (1) before animal contact, (2) before a “clean” procedure (with or without gloves), (3) after a “dirty” procedure without gloves, (4) after glove removal, (5) after animal contact. Table 6.1 lists common procedures that were considered “clean” or “dirty” for the purposes of this scheme, warranting hand hygiene before or after being performed, respectively. Rather than merely classifying hand hygiene as “attempted” or “not attempted” for every opportunity, the following six classifications were used for hand hygiene timing: (0) unobserved, (1) not performed prior to (next) “clean” procedure, contact with a “cleaner” part of the same animal, or contact with an unrelated animal, (2) outside of room having touched other objects/surfaces, (3) outside of room without having touched other objects/surfaces, (4) in room having touched other objects/surfaces not in direct contact with animal, (5) in room without having touched other objects/surfaces not in direct contact with animal. Table 6.2 shows the information that was coded at the clinic, appointment, individual and hand hygiene opportunity level, respectively.
The availability of AHS in each clinic was determined by observation of AHS dispensers in high-traffic areas during site visits (camera set up, poster mounting, camera take-down), particularly in the monitored areas (exam room, backroom). Availability of AHS in other areas of the clinic was not directly assessed, but if it was sufficiently limited that AHS was not observed during any site visit or recording, it was considered unlikely to have a significant impact on hand hygiene compliance associated with routine appointments. Hand hygiene product contact time was measured in seconds from the moment the product came into contact with both hands (i.e. start of scrubbing/rubbing) to the moment when contact with running water ceased (if water only used) or when contact with running water for rinsing began (if soap and water used) or when rubbing ceased (if AHS used). If an individual applied AHS but left the field of view before ceasing hand rubbing, the attempt was coded without a product contact time and without a hand drying technique. A technique score from 0 to 4 was produced for each hand hygiene attempt for which contact time was > 1 s and all four technique variables (i.e. deliberate effort to scrub/rub back of hands, between fingers, thumbs, and wrists) were coded as either yes or no, with one point given for each component when scrubbing/rubbing was observed. Additional details of the video coding scheme are described in Appendix 6.3.

6.2.7 Video coding - Process

All videos were coded by the same author (MA). Consecutive appointments were coded from the time the hand hygiene posters were placed in the clinic for a maximum of 8 days (i.e. end of recording) or up to 40 appointments, and then an equal number of appointments was coded working backward from the same point, for a maximum of 80 appointments per clinic, not including incomplete appointments. An appointment was classified as incomplete if a segment of the video footage from the exam room was missing (e.g. if the appointment started before or ended after the cameras were scheduled to be on, or if there was a problem with the relay to the computer) which potentially included a hand hygiene attempt prior to an individual’s first contact with the patient or following an individual’s final contact with the patient. For each incomplete appointment an additional complete consecutive appointment was coded. Incomplete appointments were excluded from the analysis. The maximum number of appointments to be coded per clinic was initially set at 100, in order to maximize the amount of data that could be included from each clinic while avoiding excessive representation of very busy clinics in the data set, based on an estimate that on average 8-10 appointments would be seen per day in a single exam room over two weeks. This maximum was later reduced to 80 appointments per clinic due to time constraints, the number of participating clinics and the total amount of video footage collected. Appointments already coded in excess of this number for any single clinic were discarded, so that the appointments included for each
clinic were all determined by the same scheme. The minimum data set required for inclusion of a clinic was 10 appointments pre- and post-intervention, respectively.

Videos were generally scanned at 2-4 times normal speed, and then watched in real time or slow motion with repeated review as necessary to discern pertinent actions. All procedures of interest, including related hand hygiene opportunities, captured on either the exam room or backroom video, that were associated with an appointment initiated in the monitored exam room were coded. Procedures captured on video that were not related to such an appointment (e.g. procedures related to inpatients or outpatients seen in other exam rooms) were not coded.

6.2.8 Statistical analysis

Coded data were imported into a statistical software package (SAS 9.3, SAS Institute Inc., Cary, NC) for analysis. Descriptive statistics were examined for all dependent and independent variables. Data for contact time with hand hygiene product were not normally distributed; therefore, a log transformation of contact time was used for modeling. Two separate multivariable statistical models were constructed: one for observation of a hand hygiene attempt in either monitored area (exam room or backroom, i.e. hand hygiene timing classified as a 2, 3, 4, or 5 vs 0 or 1) using mixed logistic regression via the Proc GLIMMIX procedure (hand hygiene compliance model), and one for the log of hand hygiene product contact time using mixed linear regression via the Proc Mixed procedure (contact time model). Variables of interest tested in both models, which were determined a priori, were: role, gender, sink in exam room, AHS readily available in clinic, presence of posters, recording day (as a continuous variable), appointment type, room, species, and hand hygiene opportunity type. Hand hygiene product used was also tested in the contact time model. Random effect terms for clinic, appointment (grouped by clinic) and individual (grouped by clinic and appointment) were initially added to both models to account for the potential impact of clustering by each of these variables.

A backward stepwise selection approach was used for model construction. Significance was set at p≤0.05. All variables of interest were initially included in the model, then variables with a p>0.05 were removed, one at a time starting with the largest p-value, noting the effect of removal on the coefficients for the remaining variables. If at least 1 of the coefficients for the remaining variables changed by more than 20%, the eliminated variable was deemed to be a confounder and restored to the model. Presence of posters was forced into the final models, as this was a primary variable of interest. This process generated the “main effects model.” Biologically plausible 2-way interactions between variables in the main effects model were assessed by creating 2-way interaction terms and adding them to the model, one at a time, to
test for their significance. All interaction terms with a \( p \leq 0.05 \) were then added to the main effects model, and if the \( p \)-value remained \( \leq 0.05 \) the term was retained in the model. If multiple significant two-way interactions shared one or more terms, then 3-way and 4-way interaction terms were also tested in the model and retained if \( p \leq 0.05 \). Variables that were part of a significant interaction term were retained in the final model regardless of their individual significance. The 95% confidence intervals (CI) and \( p \)-values reported were not adjusted for multiple comparisons.

For the contact time model, residuals for observations at the hand hygiene opportunity level were examined graphically using scatter plots, histograms and normal quantile plots to assess normality, and to identify potential outlier observations and variables with unequal variance. Outliers were further examined to ensure they were not the result of errors in data entry. Normality of residuals was also assessed using the Anderson-Darling and Shapiro-Wilk tests.

### 6.3 Results

A total of 135 clinics were approached to participate in the study, out of approximately 1100 registered companion animal hospitals in Ontario (12%). Of these, no response of any kind was received from 26 (19%). Fifty-seven clinics (42%) declined to participate for the following reasons: staff not comfortable with the cameras (13), concern regarding clients being uncomfortable with the cameras (4), too busy and/or undergoing renovations (5), new personnel on staff (3), and no reason given (32). Fifty-two clinics (39%) agreed to participate, one of which was excluded as it was determined that the caseload was primarily emergency. Of the 51 clinics in which the video monitoring was performed, one was excluded due to staffing issues and plumbing problems in one of the monitored areas, and one because signs were posted by clinic staff next to the cameras alerting personnel and clients to their presence (thereby altering the conditions of the study and rendering the data not comparable to the other clinics). Another clinic was excluded due to loss of all baseline data secondary to a computer memory error. Power failures of sufficient duration to drain the recording laptop’s battery occurred at 7 clinics during the study period, resulting in loss of all subsequent data until the next site visit. Two of these resulted in loss of all data from the second baseline week (just prior to the intervention), therefore these clinics were also excluded. In 5 clinics the power failure occurred during the intervention week, but in 3 of these sufficient footage was still recorded to complete a minimum data set for inclusion. A technical issue with the programming of the camera schedule resulted in reduction of the total recording time by approximately one-half to two-thirds in 8 other clinics, but in 5 of these sufficient footage was still recorded to complete a minimum data set. In one clinic recording times were limited based on the work schedule of a single technician who did not wish to participate in the study. This clinic and 2 others (for which there were no
recording issues) were excluded due to lack of sufficient footage to complete a minimum data set. Ultimately videos from 38 facilities were coded and included in the analysis for this study, all of which were exclusively companion animal clinics. In 58% (22/38) of these clinics, the monitored backroom area included at least part of a clinical procedures area, while in the remainder it was a location where animals were generally not handled (e.g. pharmacy, lab or records area in close proximity to the monitored exam room).

Table 6.3 shows selected descriptive data for each of the 38 clinics included in the analysis. Data from 2278 appointments were coded, including 887 (39%) appointments during which vaccine administration was observed. Sixty-seven percent (1532/2278) of appointments involved a single dog, 24% (542/2278) involved a single cat, 8% (190/2278) involved multiple dogs and/or cats, and 0.6% (14/2278) involved an animal of another species (e.g. rabbit, bird, rodent). Sixty-six (3%) appointments were classified as “incomplete,” with a maximum of 7 or up to 9% of appointments in any single clinic. The number of complete appointments coded per clinic ranged from 20-80 (mean 60, median 67). A total of 10894 hand hygiene opportunities were observed, involving approximately 449 unique individuals. The number of individuals coded per clinic ranged from 4-39 (mean 12, median 11), and the number of hand hygiene opportunities per clinic ranged from 70-631 (mean 287, median 285). Thirteen percent (58/449) of participants were male, of which 67% (39/58) were veterinarians, 17% (10/58) were technicians and 16% (9/58) were other support staff (e.g. receptionists, students, volunteers). Of 391 female participants, 22% (86/391) were veterinarians, 59% (229/391) were technicians, and 19% (76/391) were other support staff.

Table 6.4 shows the distribution of hand hygiene opportunities by type and whether a hand hygiene attempt was observed, not performed or not observed. Overall hand hygiene compliance (calculated as total number of opportunities for which a hand hygiene attempt was observed divided by total number of opportunities observed) was 14% (1473/10894), and was highest after glove removal (39%, 60/153) followed by after patient contact (26%, 1145/4377), after a “dirty” procedure without gloves (26%, 120/463), before patient contact (3%, 123/4377) and was lowest before a “clean” procedure (2%, 25/1524). Of the 3201 opportunities after which the individual left the room/area where the contact/procedure took place and a hand hygiene attempt was not observed, in 48% (1545/3201) the individual left the field of view without touching any objects/surfaces, in 37% (1181/3201) the individual left the field of view within 2 minutes and after touching objects/surfaces, and in 15% (475/3201) the individual remained on camera for a minimum of 2 min (or 5 min if the person was only completing medical records) without attempting hand hygiene. For 1% (97/10894) of opportunities, an off-camera
hand hygiene station was available in the immediate area (in the exam room in one clinic (86 opportunities) and in the backroom in another clinic (11 opportunities)) and it could not be determined from the footage if hand hygiene was attempted in the room/area or not.

Timing of glove removal was observed in 152 instances (in one case timing of removal could not be determined due to camera angle). Of these, in 62% (94/152) gloves were removed in the room before having contact with a “cleaner” part of the animal or other objects/surfaces not in direct contact with the animal, in 29% (44/152) gloves were removed in the room but after having contact with other objects/surfaces not in direct contact with the animal, in 4% (6/152) gloves were removed after leaving the room before contact with objects/surfaces in the next room, and in 5% (8/152) the individual left the room and returned still wearing the same pair of used/dirty gloves. Anecdotally, gloves were most commonly worn to perform digital rectal exams and/or to express anal glands of patients, and it was common for individuals to don only one glove for such a procedure.

A sink was present in the exam room in 66% (25/38) of clinics, and AHS was readily available in 68% (26/38) of clinics. Eleven percent (4/38) of clinics had neither a sink in the exam room nor AHS readily available (Table 6.3). The presence of a sink in the exam room was unconditionally associated with performance of hand hygiene within the room (odds ratio (OR) 12.7, p<0.001) and in either monitored area (OR 1.5, p<0.001). A total of 1353 hand hygiene attempts were observed, accounting for 1246 unique hand hygiene opportunities, 227 coincident hand hygiene opportunities (in which a single attempt fulfilled more than one hand hygiene indication/opportunity), and 14% (1473/10894) of all hand hygiene opportunities. Soap and water was used for 87% (1182/1353) of all attempts, water alone for 5% (63/1353), and for 1% (10/1353) water was used but it was not possible to determine if soap was used as well. Use of bar soap was not observed, only liquid soap. Alcohol-based hand sanitizer was used in 7% (98/1353) of all hand hygiene attempts, and in 1% (98/8078) of opportunities and 10% (98/990) of attempts that occurred in clinics where AHS was readily available. Descriptive statistics for hand hygiene product contact times are shown in Table 6.5.

Observation of hand hygiene technique in terms of deliberate effort to scrub/rub various parts of the hands (i.e. backs, between fingers, thumbs, wrists) was often difficult based on camera angle, visual obstructions and in some cases video resolution (when the camera was positioned relatively far from the hand hygiene station, e.g. in some backroom areas). For 38% (509/1353) of hand hygiene attempts, contact time with the product used was 1 s, which was considered inadequate to deliberately scrub/rub any part of the hands. Of the remaining 844 attempts observed, coding for all four technique variables
was complete (i.e. no variable was coded as “not visible”) in 45% (379/844), representing 92% (35/38) of clinics. Scrubbing/rubbing between fingers was most commonly observed in 30% (113/379) of attempts, followed by back of hands in 27% (101/379), thumbs in 13% (49/379) and wrists in 4% (15/379). The technique scores produced for these hand hygiene attempts using water alone, soap and AHS are shown in Table 6.6. The mean product contact time for hand hygiene attempts with a complete score and contact time > 1 s was 5.6 s (median 4 s, range 2-30 s), whereas the mean product contact time for all hand hygiene attempts with a contact time > 1 s was 6.4 s (median 5 s, range 2-49 s).

Hand drying techniques observed are shown in Table 6.7. Single-use towels (e.g. paper towel) were the most common means of hand drying in 82% (31/38) of clinics. Use of reusable towels was seen in 34% (13/38) clinics and was the most common means of hand drying in 18% (7/38). Direct hand contact with the water faucet after hand hygiene occurred in 99% (1223/1237) of attempts in which running water was used, including 19 instances of 3 different individuals in 2 separate clinics in which AHS was used at a sink in place of soap. Use of paper towel to protect the hands when turning off the faucet was seen in 1% (9/1237) of attempts, and for all other attempts there was either no subsequent contact with the faucet (4) or part of the arm was used to turn the faucet off (1). In one clinic one of the monitored sinks had a touchless water faucet (either motion-activated or foot-operated), and in another clinic one of the faucets could be turned on and off by tapping it, but staff still generally used their hands (instead of the forearm or elbow) to operate the faucet. Hand drying technique and faucet contact following use of running water could not be determined for 10 and 18 attempts, respectively. For 11% (11/98) of attempts using AHS, the individual walked off camera while still rubbing, therefore neither total contact time nor drying technique were coded.

Approximately 74% (194/263) of personnel who were observed performing hand hygiene were seen wearing a ring, watch, bracelet (including any type of band or elastic worn around the wrist) or multiples of these items during patient contact. Of the 1353 hand hygiene attempts observed, a watch was worn for 13% (178/1353), one or more rings for 16% (221/1353), one or more bracelets for 4% (51/1353), a combination of more than one of these different items (most commonly a watch and ring) for 48% (643/1353) and no visible jewelry for 19% (260/1353). Removal of any jewelry prior to a hand hygiene attempt was noted on one occasion.

Direct face-to-animal contact or indirect facial contact via an individual’s own hands occurred prior to hand hygiene in 60% (277/463) of opportunities after a dirty procedure, 49% (75/153) of opportunities after degloving, and of 69% (3003/4377) of opportunities after regular contact with an
animal during 96% (2191/2278) of all appointments. Although the following were not specifically coded for each “after animal contact” hand hygiene opportunity, direct face-to-animal contact was noted in at least 236 (5% of 4377) instances, in addition to kissing the animal or being licked on the face by the animal in 59 (1%) and 51 (1%) instances, respectively.

All exam room posters remained in place for the duration of the intervention period. All but 2 backroom posters remained in place: one was moved by a staff member from a cupboard door by a sink to a small space of wall immediately over the sink, where it was somewhat less apparent but still visible, and one which was placed on a door leading to the treatment room area either fell off or was removed at an unknown point in time. At the end of the study clinics were able to choose whether the posters were removed by the investigator at the same time as the cameras, or whether they were left in place for ongoing use. At least one poster was left in place in 76% (29/38) of clinics. There was no additional follow-up to determine how long the posters may have been used in each clinic after the final site visit.

6.3.1 Quantitative analysis - Hand hygiene compliance

The final model for hand hygiene compliance included terms for presence of posters (not significant, but forced in), recording day, room, role, gender, and opportunity type, and interaction terms for room*role, gender*opportunity type, and room*opportunity type. Use of an interaction term for hand hygiene opportunity type and role resulted in the model failing to converge. The model also failed to converge when 3-way and 4-way interaction terms for room, role, gender and opportunity type were included, but when these terms were entered into the model without the random effects they were not significant. Therefore, only the three significant 2-way interaction terms were retained in the final model. The p-values for each of the fixed and random effects in the final hand hygiene compliance model are shown in Table 6.8.

Due to the complexity of the model, for ease of interpretation adjusted probabilities of an observed hand hygiene attempt for each variable and combination of variables (for interactions) are shown in Figure 6.1. To see all significant differences refer to Appendix 6.4, which shows the OR, 95% CIs and p-values for all possible contrasts of associations between variables in the final model. The effect of posters was not significant (p=0.5347). The odds of an observed hand hygiene attempt increased by 1.04 for each recording day (95% CI 1.002-1.087, p=0.0408). The effects of the other significant variables were all affected by interactions. In general, the odds of an observed hand hygiene attempt were higher for veterinarians and technicians compared to other staff, for opportunities after a procedure, glove
removal or patient contact compared to before a procedure or patient contact, for females compared to males, and for opportunities observed in the backroom compared to the exam room.

6.3.2 Quantitative analysis - Hand hygiene product contact time

Based on descriptive statistics, data for hand hygiene product contact time were not normally distributed; therefore, a log transformation of contact time was used for modeling. Furthermore, the 10 observations for which it was unknown if soap and water or water alone was used were excluded from the contact time model.

The final contact time model included terms for role, gender, AHS readily available in clinic, presence of posters, species, hand hygiene product, and opportunity type, and interaction terms for role*AHS readily available in clinic, presence of posters*AHS readily available in clinic, and presence of posters*opportunity type. Three-way and 4-way interaction terms for role, posters, opportunity type and AHS in clinic were tested but were not significant, therefore only the three significant 2-way interaction terms were retained in the final model. The estimated effect of clustering by appointment was consistently zero throughout the model-building process; therefore, this term was dropped from the final model. The p-values for each of the fixed and random effects in the final contact time model are shown in Table 6.9. Tests for normality (Anderson-Darling=7.07, p<0.005; Shapiro Wilk=0.99, p<0.0001) indicated that the residuals were not normally distributed; however, based on visual assessment of the histogram and normal quantile plot of the residuals, the distribution was considered adequate in terms of normality (see Appendix 6.5).

Due to the complexity of the model, for ease of interpretation adjusted median values (geometric mean) for contact time for each variable and combination of variables (for interactions) are shown in Figure 6.2. To see all significant differences refer to Appendix 6.6, which shows the ratios of contact times, 95% CIs and p-values for all possible contrasts of associations between variables in the final model. Contact time for males was 1.20 times that for females (p=0.0120, 95% CI 1.04-1.38). The contact time ratio was 1.18 for hand hygiene attempts associated with contact with individual cats compared to individual dogs (p=0.0074, 95% CI 1.05-1.33), and 1.22 for individual cats compared to multiple animals (dogs and/or cats) in the same appointment (p=0.0368, 95% CI 1.01-1.46). No other species comparisons reached statistical significance. The contact time ratio was 1.69 for AHS compared to soap (p<0.0001, 95% CI 1.38-2.08), 2.28 for AHS compared to water alone (p<0.0001, 95% CI 1.70-3.05), and 1.34 for soap compared to water alone (p<0.0001, 95% CI 1.09-1.66). The effects of the other significant variables were all affected by interactions. In general, contact time was shorter for
veterinarians compared to technicians and other staff in clinics where AHS was readily available, and contact times were longer for hand hygiene attempts before patient contact or procedures when posters were present compared to attempts after procedures, glove removal or patient contact. Contact times were also longer in clinics where AHS was readily available (independent of product used) but the difference was not significant for veterinarians. The presence of posters had a statistically significant effect on contact times in clinics where AHS was not readily available (ratio of 1.50, p=0.0043, 95% CI 1.14-1.99).

6.3.3 Follow-up survey

Surveys were returned from 289 individuals (approximately 62% (289/465) of all staff to a maximum of 20 per clinic) from 37/38 clinics. The surveys from one clinic were mailed to the investigator but never received. The estimated total number of staff per clinic ranged from 4-49 (mean 13, median 12), based on a combination of staff numbers provided by clinic contacts, number of surveys returned, and total number of individuals coded per clinic (whether or not they were included in the final data set). Individual clinic response rate ranged from approximately 25-100% (mean 63%, median 60%).

Survey respondents included 66 (23%) veterinarians, 71 (25%) registered veterinary technicians, 26 (9%) non-registered veterinary technicians, 25 (9%) animal care assistants/kennel staff, 80 (28%) front office staff, 15 (5%) practice managers, and 6 (2%) individuals who did not identify their primary role. The age range of respondents was 17-66 years (mean 35 years, median 32 years). Seventy-seven percent (221/286) of individuals were full-time staff (i.e. working 35 hours or more per week at the clinic). Ten percent (27/284) of respondents were male, of which 78% (21/27) were veterinarians, 2 were technicians, 2 animal care assistants, 1 front office staff and 1 practice manager.

Ninety-four percent (272/289) of respondents indicated that they noticed the hand hygiene posters that had been put up for the last week of the study. The self-perceived impacts of the posters on individual hand hygiene practices, ranked on a scale of 1 (not at all) to 7 (very much) are shown in Figure 6.3. One percent (3/270) of respondents recalled a client asking them a question regarding hand hygiene after seeing the posters. Using the same Likert-type scale as above, one of these respondents indicated that these owner inquiries had no impact at all (rank 1) on how or how often they performed hand hygiene, while one indicated they had a moderate impact (rank 5), and one did not answer this portion of the question.
6.4 Discussion

Observed hand hygiene compliance in this study (14%) was low compared to self-reported compliance among veterinary staff in other studies (42-48%)(10,11) and average reported compliance rates in human hospitals (40%)(12), but was comparable to (though still lower than) directly observed baseline hand hygiene compliance in a companion animal teaching hospital (21%), as recorded by live observers (9). The lowest compliance by opportunity type was for before “clean” procedures, including all types of injections (e.g. vaccinations), which were a common occurrence. However, there are no existing recommendations to perform hand hygiene prior to vaccine administration in veterinary patients, even though hand hygiene has been recommended before administering injections in human medicine (23). Hand hygiene prior to patient contact was 3%, compared to after patient contact and after “dirty” procedures at 26%, which was a significant difference in all contrasts in the multivariable model. This same finding, whereby healthcare workers tend to have better hand hygiene compliance after patient contact/procedures than before, has been reported in several other studies (24-27). Potential reasons for this phenomenon include increased incentive to perform hand hygiene if hands are visibly or palpably soiled after handling an animal, and the fact that while hand hygiene after animal contact helps prevent cross-contamination and spread of pathogens to other individuals and patients, it is also in part a self-motivated behaviour that first of all protects oneself from potential infection by transient microbes on the hands. In contrast, hand hygiene prior to patient contact is primarily for the benefit of the patient, and as such motivation to perform it may be more likely to come from an individual’s sense of professional responsibility and altruism, which is typically a less powerful force than self-preservation (21) and requires an understanding of HAI risks. It was interesting to note that several individuals in different clinics had a habit of wiping their hands on dry paper towel or tissue after some “dirty” procedures, rather than performing proper hand hygiene. This behaviour indicates some level of awareness of the potential for hand contamination, but the response is inappropriate, for although dry wiping may help to remove gross contamination from the hands, it would do little in terms of effectively decontaminating the hands in a situation when they have evidently been soiled.

Based on the multivariable model, compliance was also better in the backroom compared to the exam room for both veterinarians and technicians, and for after dirty procedures. This could potentially be because staff feel they have more time or opportunity to perform hand hygiene when a client is not present; however, hand hygiene in the exam room has the added benefit of demonstrating commitment to infection control and providing a good example to pet owners, and therefore should be emphasized. The finding that veterinarians were significantly more likely to perform hand hygiene compared to technicians in the exam room is in contrast to studies in human medicine that have reported that nurses have better
compliance than physicians (28,29). Compliance among all staff who have contact with animals is important, but it appears to require the most improvement among other support staff, who consistently had the lowest compliance according to the model. The most statistically significant effect of gender was female staff were 1.75 times as likely to perform hand hygiene after patient contact than male staff. This is consistent with other studies that have identified male gender as a risk factor for decreased hand hygiene compliance and lower infection control “precaution awareness” (10,30).

The large number of opportunities for which a hand hygiene attempt was not observed needs to be carefully considered. The likelihood that an individual could have or may have performed hand hygiene in an unmonitored area varied considerably based on each clinic layout and the availability of AHS (as dispensers can be easily moved from place to place). Nonetheless, in each facility the monitored backroom area was considered the most likely station to be used during or between appointments based on location, convenience and staff routine; therefore, if hand hygiene was unobserved the individual would have had to bypass the two most likely stations to be used (assuming a hand hygiene station was present in the exam room), making it less likely that hand hygiene in relation to the appointment would be performed elsewhere. Furthermore, if less convenient stations were used, or the longer an individual delayed performing hand hygiene (i.e. beyond the 2-5 min for which they were followed on the video after leaving the room/area), the more likely the individual would be to cross-contaminate other surfaces, animals or people, thus decreasing the benefits of performing hand hygiene in the first place. Similarly, hand hygiene outside of the room/area prior to patient contact or a “clean” procedure was not considered compliant, as in this scenario hands may become recontaminated via common-touch surfaces (e.g. doors) prior to the contact/procedure taking place. Such attempts, which were not frequently noted, were also excluded because of the difficulty in discerning whether they were performed due to a previous patient contact/procedure, due to the impending contact/procedure for the next patient, or both, whereas hand hygiene performed within the room with the animal in question was more clearly for the benefit of that patient.

The most commonly used product for hand hygiene in this study was liquid soap and water, including in clinics where AHS was available. Although use of soap and water is recommended when hands are visibly soiled, or when an alcohol-resistant pathogen may be present (e.g. some non-enveloped viruses such as canine parvovirus, spore-forming bacteria such as Clostridium spp), use of AHS is the primary recommendation for routine hand hygiene (2,8,12,31,32) as it is takes less time, causes less skin damage (12,33), can easily be used at the point-of-care even when a sink is not available, saves water, and generates less waste because disposable towels are not required for hand drying. Interestingly, even
though AHS was only apparent on site visits in 68% of clinics, at least one individual from each of the other 12 clinics indicated on the follow-up survey that there was AHS available somewhere in the facility (data not shown, see Chapter 4), suggesting that AHS dispensers are not always placed in some of the areas where they could be of most use. Hand hygiene using water alone was seen in a small percentage of attempts. Although simply rinsing hands with water can remove some superficial skin cells and loosely-adherent bacteria through mechanical flushing action (33), in the clinical setting the use of soap (either antimicrobial or non-antimicrobial depending on the specific situation) and water is recommended (8,12,32). The detergent action of the soap helps to increase the removal of transient microbes and oily contaminants, and antimicrobial soaps provide killing or inhibitory action, and may also provide some residual effect (12,33). If hands are rinsed very quickly with water, as was observed in this study (median contact time of 2 s), this is unlikely to have any significant effect on reducing contamination of the hands, and if hands are not adequately dried afterward the procedure may even increase the risk of pathogen transmission (34,35).

The presence of a sink in the exam room was not associated with observation of a hand hygiene attempt in the multivariable model when attempts in both the exam room and backroom were considered; however, it did have a strong unconditional association with performance of hand hygiene within the same room as the animal contact/procedure, which is the preferred location. It is very important to have sinks available in exam rooms and other patient care areas (e.g. treatment room, wards) in order to promote and facilitate hand hygiene, and to avoid the potential spread of microbes that may occur if an individual is forced to move to another area to find a hand hygiene station. Thirty-four percent of participating clinics in this study did not have a sink in the exam room. The installation of a sink in a pre-existing space can be difficult and expensive, if it is feasible at all, but in these cases an AHS dispenser can be placed in the room instead, and ideally procedures that are likely to result in gross contamination of the hands (and therefore require hand washing instead of AHS) should be performed in another area where there is a sink. In 4 clinics there was neither a sink in the exam room nor AHS seemingly available in the clinic, thus making compliance with recommended hand hygiene practices during appointments virtually impossible, unless staff carry their own AHS dispensers. In new or renovated clinics, exam rooms should always include a sink of adequate size and design that staff can easily wash their hands (8). Notably in this study, even in clinics in which a sink was available in the exam room, staff who performed hand hygiene often chose to use the sink in the backroom area instead. The reasons for this were typically unclear, but potentially may have included preference for the soap product/dispenser present at the backroom sink, that the sink in the exam room was too small and had a lower faucet making it more difficult to perform hand hygiene properly, or that the individual wanted to leave the exam room.
quickly while the client was still preparing to leave. Identification of such factors could aid in the design of more effective hand hygiene interventions. Effort should be made to facilitate use of the exam room sink as much as possible (e.g. by providing the desired soap product), and, as previously mentioned, staff should be encouraged to perform hand hygiene in the presence of clients.

In order to effectively reduce or kill the transient microbiota of the hands, it is generally recommended that soap be applied for a minimum of 10-20 s before rinsing, or for AHS that enough product be applied to cover all surfaces of the hands and then rubbed until dry (which should take approximately 10-20s as well) (6,12,31,36-38). Product contact time was well below this range for the majority of hand hygiene attempts observed in this study (Table 6.5). Average duration of hand washing (i.e. the entire process, not just product contact time) by human healthcare workers in previous studies ranges from 5-24 s (12). The differences in median contact times between genders and species were likely biologically inconsequential, even though they were statistically significant (e.g. a contact time ratio of 1.20 when the referent median contact time is 2.7 s is an absolute difference of only 0.5 s). Contact times with AHS were significantly longer than with soap; this may be in part due to the additional steps required to complete a hand wash (rinsing and drying) resulting in individuals abbreviating the scrubbing/contact time component of the process. With AHS, more of this same time period can be devoted to the rubbing stage, which can also be done while moving to another area instead of standing at a sink. Improved contact times could be yet another reason to promote the use of AHS in veterinary clinics.

Unfortunately, misuse of AHS was also seen. On several occasions various individuals were noted to use AHS immediately after hand washing, which is not recommended (2,32). Similarly, the use of AHS in the place of soap prior to rinsing the hands with running water, as observed in two clinics, is contrary to standard recommendations (2,6,8,12). Alcohol-based hand sanitizers do not have the same detergent effect as soap to help the water remove contaminants from the hands; therefore, the effect of this process in terms of hand hygiene would likely be the equivalent of the AHS alone (for the contact time elapsed) followed by a water-only rinse. If AHS is applied correctly for the appropriate contact time prior to rinsing (at which point hands should already be dry), the individual’s hands should be effectively decontaminated; however, the rinsing step then potentially requires contact with the contaminated faucet, and if hands remain wet afterwards the risk of transmission of bacteria to and from the skin increases (34,35). The use of disposable or reusable towels to dry the hands after using AHS, which was seen in 26% of attempts using AHS, should also not be necessary and may be counterproductive. If hands are still wet with AHS after rubbing all surfaces as directed, then it is likely that too much product was
applied initially and reducing the amount used will resolve the issue. If paper towel is being used to dry the hands less than 15 s after applying the product (as observed here), then hands may not be adequately decontaminated due to inadequate rubbing and contact time. Performance of rinsing or towel-drying after AHS use should be discouraged, as should the concurrent use of AHS and hand washing, as these unnecessary steps have the potential to cause additional damage to the skin, which can lead to increased carriage of pathogens on the hands and reluctance to perform hand hygiene subsequently due to discomfort (12,39).

Use of appropriate technique during hand hygiene is crucial to ensuring all parts of the hands come in contact with the product used and are adequately decontaminated. The areas most likely to be missed include the base of the thumbs, backs of the hands, between the fingers and beneath the fingernails (8,36,40). In this study, attention to scrubbing/rubbing of the wrists was also considered an indicator of a more thorough hand wash (38), although in many cases training charts and descriptions of recommended technique do not specifically mention wrists in regard to routine hand hygiene (only pre-operative hand hygiene) (2,8,20,31). Scrubbing/rubbing of wrists, which was observed the least often of the four selected technique components, could potentially be hindered by watches, bracelets or long sleeves, although this was not reported by another study (41). It was noted that many individuals using soap and water scrubbed more areas of their hands only after starting to rinse, which is likely to be ineffective because soap itself does not have adequate contact with all surfaces. Hand hygiene attempts with longer contact times would be more likely to achieve a higher technique score based on the four components, which may explain in part why scores tended to be higher for attempts using AHS. However, obstruction of the view of the individuals hands would also be more likely to occur at some point during the attempt if the contact time was longer, therefore those attempts with a complete score would be more likely to have shorter contact times, and therefore lower scores. Nonetheless, the mean and median contact times for hand hygiene attempts with and without a complete score (excluding attempts with a contact time of ≤ 1 s) were within 1 s of each other, indicating that attempts with a complete score may still be relatively representative of the entire set of observations. It is unknown if or how much training veterinary personnel receive on hand hygiene technique. Given that it is such a routine practice both inside and outside the clinic environment, it may be assumed that individuals know how to do it properly, but these results suggest otherwise. Some training, including emphasis on parts of the hands most often missed during hand hygiene, may be beneficial for improving technique. Improved technique would likely also result in increased product contact time.
Hand drying is a very important component of hand hygiene, as bacteria are transferred from hands to surfaces much more readily when hands remain wet (34,35). Single-use disposable paper towels are typically recommended for hand drying after hand washing in both the veterinary and human healthcare setting (2,6-8,12), and should be used to turn off manual water faucets in order to protect hands from immediate recontamination from the faucet handle(s) or knob(s). In this study, use of paper towel in this manner was seen after only 1% of hand hygiene attempts, and in some of these cases it was noted that the individual continued to use the same paper towel to finish hand drying after turning off the faucet, thus negating the potential benefits of this practice. Reusable cloth towels are not recommended for use in the healthcare setting (2,12,35,36) due to their potential to act as a fomite between individual users, and because they cannot be used in the same manner as disposable towels to avoid recontamination of the hands when turning off the water faucet without becoming contaminated themselves. Nonetheless, reusable towels were used for hand drying in 23% of observed hand hygiene attempts in participating veterinary clinics, including after 20% of attempts using AHS. Information on appropriate drying techniques and protecting hands from recontamination via the water faucet should be emphasized to veterinary personnel in training and educational campaigns.

Hand jewelry (e.g. watches, rings, bracelets) has been shown to increase the number of microbes harbored on the hands (42). The majority of veterinary personnel seen performing hand hygiene in this study (74%) wore at least one such item, and removal of hand jewelry prior to hand hygiene was rarely observed. While some studies have shown that jewelry such as rings can interfere with effective hand washing (43-45), no studies have shown an effect of rings on pathogen transmission via hands in the clinical setting (12). One study showed rings did not have a significant effect on bacterial counts on hands following use of a pre-surgical alcohol-based hand rub versus traditional antimicrobial soap-and-water scrub (46), but it should not be assumed that this necessarily holds true for routine hand hygiene using AHS which may be less thorough and takes less time. The issue of whether or not the wearing of rings by healthcare workers should be allowed therefore remains unresolved (12). Nonetheless, it stands to reason that rings of elaborate design or with settings that are difficult to clean themselves should be avoided. There are very few studies examining the effect of wearing watches or bracelets on hand hygiene, with varying results (41,47). While these items may or may not interfere with washing or sanitizing the hands and fingers, they have potential to interfere with these processes at the level of the wrist, and since they have been shown to increase bacterial load on the hands (42), some infection control guidelines recommend that these items be removed prior to patient contact or hand hygiene (7,8,31). Although watches can be useful for clinical duties (e.g. measuring patient heart rate), alternatives to wrist watches exist (e.g. easily visible wall clocks that count seconds, timers/clocks that clip on to a
stethoscope). At a minimum, similar to rings, watches and bracelets should be avoided if they are elaborate in design, or made from materials that absorb liquid or cannot be adequately cleaned if contaminated.

Gloves worn to perform “dirty” procedures should be removed immediately afterwards, using an appropriate technique to avoid further contamination of the hands, and then hand hygiene should be performed (2,6,8,12). In this study, gloves were removed in the same room/area in which they were used in 91% of cases, but in 29% of cases other objects or surfaces in the room were touched prior to glove removal, which has the potential to lead to environmental contamination and indirect transmission of pathogens to other people or animals. Failure to remove gloves prior to leaving the room/area (9% of cases) could lead to even wider-spread contamination, including common-touch surfaces such as doors. Hand hygiene compliance was actually highest after glove removal of all the hand hygiene opportunity types, and of the three “after” opportunity types hand hygiene was most frequently attempted in the same room (compared to the other room/area) after glove removal. One potential explanation for this is that gloves are often used for procedures that are more likely to lead to gross contamination of the hands, often with unpleasant-smelling substances such as feces or wound discharge, thus making individuals more inclined to perform hand hygiene due to the “ick factor.” Even so, observed hand hygiene compliance after glove removal was still only 39%. Glove use may be misconstrued as a substitute for hand hygiene, and has been reported as a barrier to hand hygiene in other studies (30,48,49). Pre-existing defects or damage to gloves during use, as well as the potential for contamination of the hands during glove removal make gloves an imperfect barrier (6,12,50), and the nature of the “dirty” procedures for which gloves are often worn makes hand hygiene following glove removal very important.

Direct face-to-patient contact or indirect facial contact with an animal via an individual’s own hands should be considered a relatively high risk behaviour based on the fecal-oral transmission route of zoonotic enteric bacteria and parasites, as well as the risk of transmission of methicillin-resistant Staphylococcus aureus (MRSA) either to or from the patient, as this pathogen is typically harboured in the nose of human carriers (51,52). Direct face-to-patient contact, especially kissing and licking, is likely even higher risk than indirect hand-to-face contact, and anecdotally may occur more often with young puppies and kittens, which are also at higher risk of shedding various pathogens (37). However, in some situations it may be very difficult to entirely avoid this kind of contact (e.g. very excitable dogs that persistently jump up and attempt to lick the handler’s face). Face touching is often a subconscious behaviour in humans (53), but should be avoided in clinical settings particularly after patient contact, as hands are the primary mode of fecal-oral pathogen transmission (54). It was incidentally observed that
numerous female personnel in this study, particularly those with medium-length or long hair that was inadequately or not at all tied back, would often brush their hair away from their faces by hand, and in doing so made frequent hand-to-face contact, and also theoretically could have transferred transient microbes from their hands to their hair. The recommendation to tie back long hair may be included in specific facility guidelines or dress codes, as in some situations it is also a safety measure, but there are no studies regarding the risk of pathogen transmission to self or others due to loose long hair. Direct and indirect facial contact were commonly seen in this study following both “dirty” procedures (with or without gloves) and regular patient contact. However, observation of this behaviour was highly dependent on how long an individual was on-camera following the contact or procedure, and was not coded in cases when the “after patient contact” hand hygiene opportunity was not observed (e.g. the individual left the monitored area(s) while still in contact with the animal). Hand-to-face contact prior to performing hand hygiene was therefore likely more common than observed, but quantitative associations with other variables could not be reliably estimated.

The coding scheme for hand hygiene opportunities used in this study was based largely on the WHO’s “5 moments for hand hygiene” (13,23). However, there are clearly many differences in how animal patients and human patients are handled, and the scheme had to be adapted for use in a veterinary outpatient setting rather than a human inpatient setting. For example, hand hygiene attempts were noted as being within or outside the room where the animal contact/procedure took place, with or without contact with other objects or surfaces, rather than attempting to define a “patient zone.” Certain factors were retained in the scheme in order to maintain some degree of comparability to the system used in human hospitals, such as considering an injection of any kind, including subcutaneous vaccine administration, a “clean” procedure resulting in a hand hygiene opportunity in each case. Although there is no evidence that hand hygiene prior to use of a hypodermic needle for a simple injection or aspirate is beneficial in veterinary patients, in each case the skin is broken and the opportunity for microbes to invade the tissues exists. Perhaps at a minimum, procedural changes to avoid performing “dirty” procedures before injections could be considered. Similar procedural changes could also potentially alleviate some of the need for additional hand hygiene attempts. For example, by performing “dirty” procedures at the end of an appointment instead of in the middle, hand hygiene for after the procedure and after patient contact can be accomplished with the same attempt. Ensuring as much as possible that all necessary items needed for a given appointment are readily accessible in the room avoids the need to perform hand hygiene before leaving the room to retrieve an item, or the potential contamination of surfaces that occurs if hand hygiene is not done before leaving. There were many instances in which unnecessary or miss-timed contact with an animal resulted in additional failed hand hygiene opportunities.
that could have been avoided, such as petting a patient at the end of an appointment after having just performed hand hygiene and then failing to do so again. An example of a typical appointment in which the patient is received first by a technician, and then examined by a veterinarian who also administers a vaccine would include 5 hand hygiene opportunities: before and after patient contact for each individual, as well as before the “clean” procedure for the veterinarian. In this study, the two appointments with the highest number of observed hand hygiene opportunities included 29 and 32 opportunities, respectively, largely due to unnecessary contact by multiple individuals not directly involved with the appointment, or from an animal being repeatedly passed off to other staff members. Anecdotally, young puppies and kittens frequently had unnecessary contact with a number of staff, likely because they are considered very “cute.” However, as mentioned above, young animals of this kind may be more likely to shed various fecal pathogens than their healthy adult equivalents, and are potentially more susceptible to pathogens that may be transmitted on hands in a veterinary clinic (37), making hand hygiene before and after contact with them even more important. Although the additional social contact can be beneficial for the animal and is appealing to staff, if individuals are not prepared to perform appropriate hand hygiene then this sort of unnecessary contact should be avoided. Perfect hand hygiene compliance in any veterinary clinic based on this scheme would not be a realistic goal at this time, but by “aiming high” it may be possible to reach what may be a critical threshold for compliance at which the transmission cycle is consistently broken at at least one point (if not several) in every case, so that preventable HAIs do not occur.

The presence of posters only had a significant effect on contact times in clinics where AHS was not readily available, and for hand hygiene attempts before patient contact or “clean” procedures. As this suggests, a poster campaign of this kind may be more effective in a particular subset of clinics compared to others. Overall the availability of AHS resulted in longer contact times, independent of whether AHS or another product was used. It is possible that clinics without AHS may have a poorer infection control culture, such that the posters were more likely to have an impact on practices. However, neither posters nor availability of AHS had a detectable effect on compliance. Although the posters were only in place for a short time, this type of intervention is most likely to have a short-term effect (21), therefore the likelihood of a longer monitoring period detecting any greater effect is low. One unavoidable issue that may have decreased the impact of the posters was their placement was not uniform in all clinics due to the wide variety of facility layouts (e.g. cupboards and shelving over skins, other items posted in the area causing “clutter,” periodic obstruction by opened doors), resulting in the posters being more prominent in some clinics than others. Nonetheless, based on the follow-up survey responses it is clear that the majority of staff noticed the posters, and many reported a self-perceived impact of the posters on their awareness and practices, even though this was not objectively detected. The posters were not intended to
be training charts, therefore it was not surprising that the self-perceived impact on hand hygiene frequency and technique appeared to be slightly lower than the impact on overall awareness, even though the statistically significant effects of the posters were all on contact time. Posters of this kind can contribute to improved infection control culture within a clinic and could potentially be a useful component of a multimodal intervention in conjunction with other items. Over the longer-term, the effectiveness of poster campaigns may be increased by regularly changing the posters so they are more noticeable, or using an “infosheet” format to help generate staff interest and discussion (16,21). Recommendations for improving hand hygiene compliance in human healthcare call for multimodal interventions that address the issue in multiple ways, and critically include the involvement and visible support of upper management (1,2,12,22,30,55,56). Convincing clinics to implement such an intervention with the current lack of infection control culture in veterinary medicine may be difficult. Shea and Shaw (9) reported a 21% increase in hand hygiene compliance at a companion animal teaching hospital following a multimodal educational campaign emphasizing use of a foaming AHS product. Although it was not possible to discern the effect of the campaign from that of improved availability of AHS (most of the increase in hand hygiene was due to use of the foam), or from the potential impact of the presence of live observers, given the low use of AHS in the current study, such a campaign could potentially be effective in other veterinary clinics as well.

The use of video observation in this study had both advantages and disadvantages. Staff behaviours were directly observed, rather than relying on self-reported behaviour from an interview or survey. The cameras allowed for discrete observation of staff compared to direct “live” observation; however, the cameras were visible to staff, and all staff were made aware of the study in advance in order to provide consent, therefore Hawthorne effects still could have resulted in altered (i.e. artificially improved) behaviour (57). Recording day was found to have a small but significant positive effect on hand hygiene compliance. It was initially hypothesized that if the recording day had any effect it would be negative, as a result of progressive desensitization to the presence of the cameras (i.e. decreased Hawthorne effect). The appointments coded from each clinic were primarily from the latter two-thirds of the total recording period, at which point it was hoped that most staff would have had at least several days to become acclimatized to the presence of the cameras and resume their typical routine. The cause of this slight positive effect is unclear, but it could potentially be the result of increased discussion regarding hand hygiene practices among clinic staff over the course of the study, resulting in improved awareness and compliance. No effect of time was seen in a previous study of preoperative preparation practices in veterinary clinics using the same camera system (Anderson 2012, unpublished data). A constant static effect of the presence of the cameras also cannot be ruled out. The fixed camera positions, which
provided a somewhat limited and at times obstructed view, and periodic problems with recording due to signal, power or computer issues likely decreased observational sensitivity. As the cameras were motion-activated, it is possible that pertinent time segments could have occasionally been missed entirely if the camera signal was interrupted before and restored after action in the field of view took place (e.g. between appointments in the exam room), but it is considered unlikely that such events (if they occurred) would have a significant impact on the observations that were made. At the same time, the level of detailed video review, facilitated by the ability to watch and re-watch video segments in real time or slow motion as needed, likely increased observational specificity.

The video coding scheme used was quite complex. A simpler scheme would have been desirable, but the complexity was necessary to account for the wide variety of procedures and comings and goings that may occur over the course of an appointment. The goal was to capture as much information as possible from the video available, making reasonable assumptions based on knowledge of general and specific clinic operations, while still providing the benefit of the doubt for off-camera activities. Due to the complexity of the coding scheme and the time required to code such a large volume of video footage, all videos were ultimately coded by the primary investigator only. Although verification of all coding by a second observer could have been beneficial to help ensure accuracy, having a single coder who was fully dedicated to the project and who had seen the physical layout of each clinic during site visits likely provided the most consistent and accurate application of the coding scheme across all clinics. The volume of data coded would also help to lessen the impact of any non-systematic data entry errors that were not corrected during data cleaning. Even though effort was taken to make the coding scheme as objective as possible, there is always potential for some level of observer bias, but the level of detail included in the scheme hopefully helped to minimize this. Ideally the observer would have also been blinded with regard to whether or not the posters were in place at the time of each appointment, but this was not possible as the posters were often within the field of view, and to put them elsewhere would have potentially decreased their effectiveness, while to use an alternate camera angle would have potentially resulted in loss of pertinent data (and in many cases would not have been possible due to the physical layout of the room and location of power outlets).

Other limitations of this study should also be considered. Clinics were not randomly selected, and participated on a voluntary basis. It is possible that clinic staff with a greater interest in infection control or who were more comfortable with their current practices would be more willing to participate. This would be expected to bias the results toward increased hand hygiene compliance, which is concerning given the low compliance observed. The inclusion of appointments in which vaccination was
unobserved (e.g. done in an unmonitored backroom area) in the “other” category would decrease the power to find any significant associations associated with this variable. Similarly, there was potential for misclassification of technicians and receptionists, as in some clinics individuals in either of these roles may perform similar duties within an appointment, and video footage from the backroom area did not always show additional activities that would help differentiate the two. Also, despite the ability to repeatedly review and compare video segments, in some clinics, particularly those with a larger number of staff, it was difficult to differentiate certain individuals in the same role who had very similar physical features, likely resulting in a low degree of misidentification, but unlikely to have a significant effect on the overall analysis. The large number of observations, particularly in the compliance model, increased the likelihood of identifying biologically insignificant effects and interactions as statistically significant. Also, because overall contact times were fairly short, even some of the larger ratios between variables in the contact time model may represent an absolute difference of only a few seconds. Therefore, the statistical models should be viewed as a relevant overview of some of the factors involved and their relative effects, without overemphasizing small differences between categories, even if they are statistically significant.

6.5 Conclusion

This study provided a unique opportunity for detailed observation of hand hygiene practices of staff in companion animal veterinary clinics in Ontario. Overall hand hygiene compliance at participating clinics was low, but not altogether dissimilar from previous reports of hand hygiene compliance in human healthcare facilities. In particular, hand hygiene prior to patient contact needs to be emphasized, as well as attention to performing hand hygiene prior to leaving the patient contact room/area in order to reduce the risk of more distant cross-contamination. Many of the same barriers to hand hygiene likely exist in both the human and veterinary professions, and veterinary clinics may be able to apply some of the lessons learned in human healthcare to improve hand hygiene compliance. The results of this study suggest that, as has been found in human medicine, promoting the use of AHS in veterinary clinics could potentially improve hand hygiene compliance in terms of timing and technique, as AHS can easily be made available in any area and in this study was associated with longer product contact time (though still shorter than recommended) compared to soap and water. Many clinics already have AHS available in some areas, but veterinary personnel need to take more advantage of the benefits and convenience such products offer. The poster campaign had a very limited effect on hand hygiene product contact time, with no detectable effect on compliance, but did “connect” with some staff and could potentially be a useful component of a multimodal campaign to improve hand hygiene practices. However, improving the infection control culture in veterinary medicine will likely be required before, or at least concurrent to,
any such initiative, so that clinics will be willing to put in the required time and effort to execute a successful campaign.
Table 6.1: Common procedures considered “clean” or “dirty,” warranting hand hygiene before or after being performed, respectively, for the purposes of a video coding scheme used to measure hand hygiene compliance in companion animal veterinary clinics

<table>
<thead>
<tr>
<th>Clean procedures</th>
<th>Dirty procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Injections (including but not limited to subcutaneous, intramuscular, intravenous)(^1)</td>
<td>- Ear swabs and/or ear cleaning(^2)</td>
</tr>
<tr>
<td>- Venipuncture (any vein)</td>
<td>- Digital rectal exam and/or expression of anal glands(^3)</td>
</tr>
<tr>
<td>- Fine needle aspirate (including but not limited to cystocentesis, arthrocentesis, abdominocentesis, aspiration of masses, aspiration of lymph nodes)</td>
<td>- Removal of an old/dirty bandage from over a skin lesion/wound/incision</td>
</tr>
<tr>
<td>- Direct contact with a surgical incision (including suture removal)</td>
<td>- Cleaning and/or debridement of a skin lesion/wound/incision</td>
</tr>
<tr>
<td>- Application of a new/clean bandage over a skin lesion/wound/incision</td>
<td>- Abscess drainage or other contact with pus</td>
</tr>
<tr>
<td>- Application of solution or ointment to the eye (including fluorescein stain)</td>
<td>- Any contact with feces</td>
</tr>
<tr>
<td>- Placement (but not removal) of acupuncture needles</td>
<td>- Manipulation inside an animal’s mouth(^4)</td>
</tr>
</tbody>
</table>

\(^1\) injection of any substance into an animal to facilitate or carry out euthanasia was not considered a clean procedure

\(^2\) direct application of ear medication/drops was not considered a dirty procedure if no material/fluid was subsequently removed from the ear canal

\(^3\) use of a rectal thermometer was not considered a dirty procedure

\(^4\) manipulation inside an animal’s mouth included direct administration of pills (i.e. not using a pilling wand, syringe or any means by which the animal consumed the medication voluntarily (e.g. hidden in food)); examination of the buccal gingiva if the fingers were not placed in the buccal sulcus or further into the mouth was not considered a dirty procedure
Table 6.2: Information coded at the clinic, appointment, individual and hand hygiene opportunity level from video monitoring footage collected at 38 companion animal veterinary clinics in Ontario

<table>
<thead>
<tr>
<th>Clinic level variables</th>
<th>Appointment level variables</th>
<th>Individual level variables</th>
<th>HH opportunity level variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Clinic number</td>
<td>-Appointment number</td>
<td>-Individual number</td>
<td>-Opportunity number</td>
</tr>
<tr>
<td>-Sink present in exam room</td>
<td>-Appointment type vaccine only/other clean or dirty</td>
<td>-Role veterinarian/technician/other</td>
<td>-Room¹ (exam room/backroom)</td>
</tr>
<tr>
<td>-AHS readily available in clinic</td>
<td>-Patient species dog/cat/other/multiple</td>
<td>-Gender male/female</td>
<td>-Opportunity type (1-5)²</td>
</tr>
<tr>
<td>-Posters present (yes/no)</td>
<td>-Recording day (measured as the number of working days before or after the posters were placed in the clinic (= day 0))</td>
<td>-Facial contact prior to HH³ (yes/no)</td>
<td>-Unique vs coincident opportunity (yes/no)</td>
</tr>
<tr>
<td>-Hand hygiene opportunities after exposure/procedure/contact; this included indirect facial contact with the animal via an individual touching (with a hand) any part of his/her own face forward of the ears as well as touching hair that was likely to have contact with the same area, and direct face-to-animal contact (e.g. kissing, licking, snuggling, contact with the face during restraint)</td>
<td>-Timing of glove removal (if applicable) (0-5)⁴</td>
<td>-HH product used (water/soap-&amp;-water/AHS)</td>
<td>-HH product contact time (in seconds)</td>
</tr>
<tr>
<td>-Hand drying technique (none/disposable towel/hand/arm or elbow)</td>
<td>-Contact with water faucet after HH (none/disposable towel/hand/arm or elbow)</td>
<td>-Visitable deliberate effort to scrub/rub (yes/no/not visible):</td>
<td>-Hand drying technique (none/disposable towel/reusable towel/clothes/shaking hands)</td>
</tr>
</tbody>
</table>

HH = hand hygiene, AHS = alcohol-based hand sanitizer

¹ the room in which the animal contact occurred, resulting in a hand hygiene opportunity, not necessarily the room in which hand hygiene was attempted

² 1: before animal contact, 2: before a “clean” procedure (without or without gloves), 3: after a “dirty” procedure without gloves, 4: after glove removal, 5: after animal contact

³ for hand hygiene opportunities after exposure/procedure/contact; this included indirect facial contact with the animal via an individual touching (with a hand) any part of his/her own face forward of the ears as well as touching hair that was likely to have contact with the same area, and direct face-to-animal contact (e.g. kissing, licking, snuggling, contact with the face during restraint)

⁴ 0: unobserved, 1: not performed prior to next “clean” procedure, contact with a “cleaner” part of the same animal, or contact with an unrelated animal, 2: outside of room having touched other objects/surfaces, 3: outside of room without having touched other objects/surfaces, 4: in room having touched other objects/surfaces not in direct contact with animal, 5: in room without having touched other objects/surfaces not in direct contact with animal
Table 6.3: Selected descriptive data for 38 companion animal veterinary clinics in Ontario included in the analysis for the video observation hand hygiene intervention trial

<table>
<thead>
<tr>
<th>Clinic</th>
<th>Estimated number of staff coded</th>
<th>Number of staff coded</th>
<th>Number of staff</th>
<th>Total appts per day</th>
<th>Mean HH opps per day</th>
<th>Mean HH opps coded</th>
<th>% HH compl (^1)</th>
<th>Backroom camera in clinical area</th>
<th>Sink in exam room</th>
<th>AHS readily available in clinic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>8</td>
<td>20</td>
<td>7</td>
<td>70</td>
<td>4</td>
<td>9</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>7</td>
<td>20</td>
<td>2</td>
<td>100</td>
<td>5</td>
<td>12</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>4</td>
<td>22</td>
<td>2</td>
<td>104</td>
<td>5</td>
<td>17</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>7</td>
<td>26</td>
<td>3</td>
<td>144</td>
<td>6</td>
<td>10</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>16</td>
<td>16</td>
<td>30</td>
<td>3</td>
<td>244</td>
<td>8</td>
<td>14</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>13</td>
<td>11</td>
<td>30</td>
<td>5</td>
<td>149</td>
<td>5</td>
<td>7</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
<td>11</td>
<td>32</td>
<td>3</td>
<td>163</td>
<td>5</td>
<td>8</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
<td>7</td>
<td>34</td>
<td>2</td>
<td>157</td>
<td>5</td>
<td>7</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>6</td>
<td>34</td>
<td>4</td>
<td>268</td>
<td>8</td>
<td>7</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>4</td>
<td>40</td>
<td>3</td>
<td>282</td>
<td>7</td>
<td>24</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
<td>11</td>
<td>42</td>
<td>3</td>
<td>271</td>
<td>6</td>
<td>12</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
<td>5</td>
<td>44</td>
<td>4</td>
<td>142</td>
<td>3</td>
<td>12</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>13</td>
<td>18</td>
<td>15</td>
<td>54</td>
<td>4</td>
<td>275</td>
<td>5</td>
<td>17</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>11</td>
<td>11</td>
<td>54</td>
<td>4</td>
<td>281</td>
<td>5</td>
<td>17</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>15</td>
<td>12</td>
<td>10</td>
<td>56</td>
<td>4</td>
<td>299</td>
<td>5</td>
<td>11</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>16</td>
<td>9</td>
<td>9</td>
<td>60</td>
<td>6</td>
<td>234</td>
<td>4</td>
<td>11</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>17</td>
<td>13</td>
<td>11</td>
<td>62</td>
<td>4</td>
<td>207</td>
<td>3</td>
<td>26</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>18</td>
<td>5</td>
<td>5</td>
<td>66</td>
<td>4</td>
<td>221</td>
<td>3</td>
<td>24</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>19</td>
<td>49</td>
<td>39</td>
<td>66</td>
<td>6</td>
<td>365</td>
<td>6</td>
<td>14</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>20</td>
<td>12</td>
<td>11</td>
<td>68</td>
<td>5</td>
<td>250</td>
<td>4</td>
<td>7</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>21</td>
<td>7</td>
<td>6</td>
<td>72</td>
<td>6</td>
<td>204</td>
<td>3</td>
<td>17</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>22</td>
<td>12</td>
<td>8</td>
<td>74</td>
<td>6</td>
<td>351</td>
<td>5</td>
<td>9</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>23</td>
<td>14</td>
<td>14</td>
<td>74</td>
<td>6</td>
<td>287</td>
<td>4</td>
<td>18</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>24</td>
<td>21</td>
<td>20</td>
<td>78</td>
<td>8</td>
<td>402</td>
<td>5</td>
<td>10</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>25</td>
<td>12</td>
<td>10</td>
<td>80</td>
<td>9</td>
<td>289</td>
<td>4</td>
<td>17</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>26</td>
<td>23</td>
<td>20</td>
<td>80</td>
<td>9</td>
<td>631</td>
<td>8</td>
<td>22</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>27</td>
<td>18</td>
<td>10</td>
<td>80</td>
<td>7</td>
<td>369</td>
<td>5</td>
<td>19</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>28</td>
<td>9</td>
<td>9</td>
<td>80</td>
<td>8</td>
<td>342</td>
<td>4</td>
<td>9</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>29</td>
<td>9</td>
<td>9</td>
<td>80</td>
<td>9</td>
<td>441</td>
<td>6</td>
<td>10</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>30</td>
<td>15</td>
<td>15</td>
<td>80</td>
<td>10</td>
<td>304</td>
<td>4</td>
<td>13</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>31</td>
<td>15</td>
<td>12</td>
<td>80</td>
<td>7</td>
<td>370</td>
<td>5</td>
<td>28</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>32</td>
<td>15</td>
<td>13</td>
<td>80</td>
<td>8</td>
<td>337</td>
<td>4</td>
<td>16</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>33</td>
<td>22</td>
<td>16</td>
<td>80</td>
<td>7</td>
<td>379</td>
<td>5</td>
<td>4</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>34</td>
<td>11</td>
<td>10</td>
<td>80</td>
<td>7</td>
<td>424</td>
<td>5</td>
<td>10</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>35</td>
<td>11</td>
<td>11</td>
<td>80</td>
<td>6</td>
<td>320</td>
<td>4</td>
<td>10</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>36</td>
<td>15</td>
<td>14</td>
<td>80</td>
<td>11</td>
<td>377</td>
<td>5</td>
<td>16</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>37</td>
<td>22</td>
<td>21</td>
<td>80</td>
<td>20</td>
<td>539</td>
<td>7</td>
<td>6</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>38</td>
<td>24</td>
<td>23</td>
<td>80</td>
<td>8</td>
<td>302</td>
<td>4</td>
<td>11</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Total | 504                             | 449                   | 2278            | -                   | 10894               | -                   | -               | -                               | -               | -                           |
Mean   | 13                             | 12                    | 60              | 6                   | 287                 | 5                   | 13              | -                               | -               | -                           |
Median | 12                             | 11                    | 67              | 6                   | 285                 | 5                   | 12              | -                               | -               | -                           |
Range  | 4-49                           | 4-39                  | 20-80           | 2-20                | 70-631              | 3-8                 | 1-28            | -                               | -               | -                           |

appts=appointments, HH opps=hand hygiene opportunities, AHS=alcohol-based hand sanitizer

\(^1\) % HH compl = hand hygiene compliance = HH opps with observed attempt / total HH opps \times 100
<table>
<thead>
<tr>
<th>Hand hygiene opportunity type</th>
<th>n</th>
<th>In same room/area (%)</th>
<th>In other room/area (%)</th>
<th>Not performed (%)</th>
<th>Not observed in other room/area&lt;sup&gt;f&lt;/sup&gt; (%)</th>
<th>Not observed&lt;sup&gt;g&lt;/sup&gt; (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before patient contact</td>
<td>4377</td>
<td>114 (3)</td>
<td>9 (0.2)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4220 (96)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0</td>
<td>34 (1)</td>
</tr>
<tr>
<td>Before a “clean” procedure&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1524</td>
<td>24 (2)</td>
<td>1 (0.1)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1497 (98)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0</td>
<td>2 (0.1)</td>
</tr>
<tr>
<td>After a “dirty” procedure without gloves&lt;sup&gt;a&lt;/sup&gt;</td>
<td>463</td>
<td>69 (15)</td>
<td>51 (11)</td>
<td>235 (51)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>101 (22)</td>
<td>7 (2)</td>
</tr>
<tr>
<td>After glove removal</td>
<td>153</td>
<td>46 (30)</td>
<td>14 (9)</td>
<td>59 (39)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>31 (20)</td>
<td>3 (2)</td>
</tr>
<tr>
<td>After patient contact</td>
<td>4377</td>
<td>350 (8)</td>
<td>795 (18)</td>
<td>112 (3)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>3069 (70)</td>
<td>51 (1)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>10894</td>
<td>603 (6)</td>
<td>870 (8)</td>
<td>6123 (56)</td>
<td>3201 (29)</td>
<td>97 (1)</td>
</tr>
</tbody>
</table>

<sup>a</sup> see Table 6.1 for list of procedures considered “clean” vs “dirty”

<sup>b</sup> in these cases, the individual performed hand hygiene in the exam room at the start of the appointment, but then left the room briefly (< 2 min) and returned prior to touching the animal for the first time (4) or performing an injection (1), or the individual performed hand hygiene in the exam room and then exited to front office and returned with a client and animal in < 60 s to start the appointment (5)

<sup>c</sup> no hand hygiene attempt was made within the same room prior to contact/procedure

<sup>d</sup> no hand hygiene attempt was observed prior to a “clean” procedure, contact with a “clean” part of the same animal, or contact with an unrelated animal, and the individual was not off-camera for a sufficient duration (20-30s) to have the opportunity to perform hand hygiene in an unmonitored area

<sup>e</sup> no hand hygiene attempt was observed prior to contact with an unrelated animal and the individual was not off-camera for a sufficient duration (20-30s) to have the opportunity to perform hand hygiene in an unmonitored area

<sup>f</sup> no hand hygiene attempt was made in the room where the contact/procedure took place, and no attempt was made in the other room/area within 2 min of leaving the original room/area or before the individual went off-camera for a sufficient duration (20-30s) to have the opportunity to perform hand hygiene in an unmonitored area

<sup>g</sup> in these cases, an off-camera hand hygiene station was present in the room, and the hand hygiene attempt was coded as not observed if the individual was off-camera for a sufficient duration prior to touching the animal for the first time/performing a “clean” procedure or after final contact with the animal/performing a “dirty” procedure/degloving that use of this station could not be ruled out (occurrences were limited to 2 separate clinics)
Table 6.5: Contact times with water alone, soap, and alcohol-based hand sanitizer observed during 1343 hand hygiene attempts associated with routine companion animal appointments at 38 veterinary clinics in Ontario

<table>
<thead>
<tr>
<th>HH product</th>
<th>Number of HH attempts observed (%)</th>
<th>n</th>
<th>Mean</th>
<th>50th percentile</th>
<th>90th percentile</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water alone</td>
<td>63 (5)</td>
<td>63</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1-11</td>
</tr>
<tr>
<td>Soap</td>
<td>1182 (88)</td>
<td>1180</td>
<td>4</td>
<td>2</td>
<td>10</td>
<td>1-49</td>
</tr>
<tr>
<td>AHS</td>
<td>98 (7)</td>
<td>87</td>
<td>8</td>
<td>7</td>
<td>17</td>
<td>1-30</td>
</tr>
</tbody>
</table>

HH=hand hygiene, AHS=alcohol-based hand sanitizer
Table 6.6: Hand hygiene technique scores\(^1\) for 379 hand hygiene attempts with product contact times >1s observed in 35 companion animal veterinary clinics in Ontario

<table>
<thead>
<tr>
<th>HH product</th>
<th>n</th>
<th>0 (%)</th>
<th>1 (%)</th>
<th>2 (%)</th>
<th>3 (%)</th>
<th>4 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water alone</td>
<td>27</td>
<td>25 (93)</td>
<td>2 (7)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Soap</td>
<td>300</td>
<td>158 (53)</td>
<td>100 (33)</td>
<td>32 (11)</td>
<td>8 (3)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>AHS</td>
<td>52</td>
<td>7 (13)</td>
<td>17 (33)</td>
<td>21 (40)</td>
<td>7 (13)</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>379</td>
<td>190 (50)</td>
<td>119 (31)</td>
<td>53 (14)</td>
<td>15 (4)</td>
<td>2 (1)</td>
</tr>
</tbody>
</table>

HH=hand hygiene, AHS=alcohol-based hand sanitizer

\(^1\) score was based on observation of deliberate effort to scrub/rub each of four separate parts of the hands (backs, between fingers, thumbs, wrists), with one point given for each component, resulting in a score from 0-4
Table 6.7: Hand drying techniques observed for 1332 hand hygiene attempts associated with routine companion animal appointments at 38 veterinary clinics in Ontario

<table>
<thead>
<tr>
<th>Hand hygiene product used</th>
<th>n</th>
<th>None (%)</th>
<th>Single-use/paper towel (%)</th>
<th>Reusable/cloth towel (%)</th>
<th>Wipe on clothes (%)</th>
<th>Shake hands in air (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water alone</td>
<td>63</td>
<td>-</td>
<td>57 (90)</td>
<td>6 (10)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Water +/- soap&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10</td>
<td>-</td>
<td>8 (80)</td>
<td>2 (20)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Soap</td>
<td>1172</td>
<td>1 (0.1)</td>
<td>885 (76)</td>
<td>283 (24)</td>
<td>1 (0.1)</td>
<td>2 (0.2)</td>
</tr>
<tr>
<td>AHS</td>
<td>87</td>
<td>61 (70)</td>
<td>5 (6)</td>
<td>17 (20)</td>
<td>1 (1)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Total</td>
<td>1332</td>
<td>62 (5)</td>
<td>955 (72)</td>
<td>308 (23)</td>
<td>2 (0.2)</td>
<td>5 (0.4)</td>
</tr>
</tbody>
</table>

AHS=alcohol-based hand sanitizer

<sup>a</sup>Hand hygiene was performed at sink with running water, but could not determine whether or not soap was used.
**Table 6.8**: p-values for each of the fixed and random effects in the final multivariable mixed logistic regression model for observed hand hygiene compliance for opportunities associated with routine companion animal appointments at 38 veterinary clinics in Ontario (n = 10894)

<table>
<thead>
<tr>
<th>Term</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed effects</strong></td>
<td></td>
</tr>
<tr>
<td>Role</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Gender</td>
<td>0.0003</td>
</tr>
<tr>
<td>Presence of posters</td>
<td>0.5347</td>
</tr>
<tr>
<td>Recording day</td>
<td>0.0408</td>
</tr>
<tr>
<td>Room</td>
<td>0.0103</td>
</tr>
<tr>
<td>HH opportunity type</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Role*room</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Gender*HH opportunity type</td>
<td>0.0045</td>
</tr>
<tr>
<td>Room*HH opportunity type</td>
<td>0.0007</td>
</tr>
<tr>
<td><strong>Random effects</strong></td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td>0.0002</td>
</tr>
<tr>
<td>Appointment (by clinic)</td>
<td>0.0152</td>
</tr>
<tr>
<td>Individual (by clinic and appointment)</td>
<td>0.0764</td>
</tr>
</tbody>
</table>

HH=hand hygiene
Table 6.9: p-values for each of the fixed and random effects in the final multivariable mixed linear regression model for product contact time for hand hygiene attempts associated with routine companion animal appointments at 38 veterinary clinics in Ontario (n = 1330)

<table>
<thead>
<tr>
<th>Term</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed effects</strong></td>
<td></td>
</tr>
<tr>
<td>Role</td>
<td>0.0017</td>
</tr>
<tr>
<td>Gender</td>
<td>0.0120</td>
</tr>
<tr>
<td>AHS readily available in clinic</td>
<td>0.0004</td>
</tr>
<tr>
<td>Presence of posters</td>
<td>0.0170</td>
</tr>
<tr>
<td>Species</td>
<td>0.0348</td>
</tr>
<tr>
<td>HH product</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>HH opportunity type</td>
<td>0.0136</td>
</tr>
<tr>
<td>Role*AHS readily available in clinic</td>
<td>0.0002</td>
</tr>
<tr>
<td>AHS readily available in clinic*presence of posters</td>
<td>0.0211</td>
</tr>
<tr>
<td>Presence of posters*HH opportunity type</td>
<td>0.0400</td>
</tr>
<tr>
<td><strong>Random effects</strong></td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td>0.0003</td>
</tr>
<tr>
<td>Individual (by clinic and appointment)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

HH = hand hygiene
Figure 6.1: Probabilities for each variable and interaction included in the final multivariable random effects logistic regression model for observed hand hygiene compliance for opportunities associated with routine companion animal appointments at 38 veterinary clinics in Ontario (n = 10894)
Figure 6.2: Median values (geometric means) for each variable and interaction included in the final multivariable random effects linear regression model for product contact time for hand hygiene attempts associated with routine companion animal appointments at 38 veterinary clinics in Ontario (n = 1330)
Figure 6.3: Self-perceived impacts of a hand hygiene poster intervention on individual hand hygiene awareness and practices, ranked on a scale of 1 (not at all) to 7 (very much), as reported by 271 staff members from 37 companion animal veterinary clinics in Ontario

HH awareness = Posters increased awareness of need to perform hand hygiene and/or infection control in general (n = 270)

HH frequency = Posters increased how often hand hygiene was performed (n = 271)

HH technique = Posters increased how hand hygiene was performed (e.g. more thorough washing/rubbing) (n = 271)
6.6 Acknowledgements

Funding for this study was provided by the Canadian Institutes of Health Research (CIHR) and the Ontario Veterinary College Pet Trust. Infrastructure that assisted this research within the Centre for Public Health and Zoonoses Research Laboratories was funded by the Canada Foundation for Innovation and the Ministry of Economic Development and Innovation. The authors thank William Sears for consultation regarding statistical analyses, as well as all of the personnel at the participating veterinary clinics for their trust and willingness to be involved in this study.
6.7 References


CHAPTER 7:

Discussion & Conclusion
7.0 Discussion

Overall, each of the individual studies met its objectives, and each provided new, and sometimes unexpected, information regarding infection control practices used in the public and veterinary clinic settings.

It was clearly demonstrated that active interventions to increase hand hygiene compliance at a petting zoo were the most effective. The lack of a significant effect of the increased signage alone (a passive intervention) in this setting was reflected in the veterinary clinic hand hygiene study, where the poster campaign had no effect on compliance, and only a small significant effect on product contact times during hand hygiene attempts in clinics where alcohol-based hand sanitizer (AHS) was not available, and prior to animal contacts and procedures. This should not be interpreted as signage and posters being of little to no use as hand hygiene interventions, only that they should not be used by themselves. Sensitizing individuals, be they petting zoo visitors or veterinary clinic staff, through the use of other active interventions to the messages conveyed by passive media may improve their effect, but this was not specifically evaluated in these studies. Just as it is important to validate diagnostic tests for use in different species, so it is that specific interventions ultimately need to be tested in different settings, as their efficacy may vary significantly depending on the target population and scenario. Although evaluation of a more active intervention in the clinic setting would have been preferred, it was anticipated that clinic recruitment would already be a challenge based on the nature of the study and initial sensitivity of staff to the use of cameras. A passive intervention was therefore selected, as it was more likely to be acceptable to clinic management and would permit recruitment of a broader cross-section of clinics for evaluation of baseline hand hygiene compliance and overall infection control practices.

Another interesting contrast was the ready use of AHS by visitors to the petting zoo compared to the low self-reported and observed use of AHS by veterinary personnel. A critical contributing factor to this phenomenon at the petting zoo was the presence of only one sink versus multiple AHS dispensers (including event staff actively offering AHS to visitors at times), but even in veterinary clinics where sinks were not available in exam rooms, AHS use was infrequent. The probability of hands becoming grossly soiled, thereby warranting hand washing over AHS use, is likely higher at a petting zoo exhibiting farm animals than in a companion animal clinic in most cases, and yet veterinary staff used AHS far less than petting zoo visitors. Interestingly, hand hygiene compliance by hand washing after visiting the petting zoo (22%) was comparable to compliance after animal contact in veterinary clinics (26%), with the difference in overall compliance being made up by AHS use. Even in the study of preoperative preparation practices, bearing in mind that the number of clinics sampled was small and they were not
randomly selected, use of alcohol-based products for surgeon hand preparation was low. In human healthcare, promotion of the use of alcohol-based products has been a major factor in facilitating improved hand hygiene compliance, and it stands to reason that veterinary medicine will also need to make better use of these products in order to achieve the same goal. In conjunction with this, additional education of veterinary staff may be required to ensure they are aware of the advantages of AHS use, and that misuse of AHS, as was seen in several clinics during this research, is avoided. Investigation of misuse of AHS among members of the public would be an interesting comparison, but this was not performed in the petting zoo study reported here.

While studies of hand hygiene compliance and other infection control measures typically focus on when or how often practices are used, this research also examined how well they were performed, which is less commonly done. Short product contact times, most often well below specific manufacturers’ and general recommendations, were a recurrent issue in several areas, including preoperative patient and surgeon preparation, routine hand hygiene and disinfection of exam room tables. It is unknown if these shortened times were due to lack of awareness of the importance of observing recommended contact times, lack of awareness of what the recommended contact times actually are, or lack of the ability to adhere to these times due to individual workload. Based on the results of the veterinary staff survey, the majority of individuals knew that contact time with soap or AHS should be 10-20 s, and being too busy was a commonly reported barrier to hand hygiene compliance in this and a previous study, suggesting lack of time due to workload may be a contributing factor to short contact times for routine hand hygiene as well. However, 46% of survey respondents felt that there were no barriers that interfered with their ability to perform hand hygiene, in which case lack of awareness of the importance of observing recommended contact times may be a more significant issue. Performing hand hygiene, patient preparation or environmental disinfection without observing proper contact times may lead to a false sense of security that the desired level of antisepsis or disinfection has been achieved. Education of personnel regarding recommended contact times is one component of rectifying this issue, but it is equally important that clinic workflow and procedures be adjusted to ensure that staff have adequate time to perform these procedures properly, without feeling rushed and thereby tempted to cut corners.

The survey results indicated that veterinary staff likely do place high importance on hand hygiene as an infection control measure, both within and outside the clinic, but based on the observed low compliance it does not appear to be a priority compared to other duties and activities. For example, when hand hygiene was performed after animal contact it was common for individuals to first complete other tasks such as writing records or filling prescriptions rather than vice versa, which increases the risk of
cross-contamination of other objects or environmental surfaces via hands. In these cases, the individuals are already prepared to make the effort to perform hand hygiene, but an adjustment to the prioritization of the tasks in question needs to be made, which can actually make the same hand hygiene attempt more effective in terms of preventing cross-contamination. This lack of priority on infection control practices may be another reflection of the overall lack of infection control culture in veterinary clinics. Other indications of this may include the common observance of inappropriate personal protective clothing (PPC), particularly in cases when scrubs or lab coats were worn with other items in such a way that otherwise appropriate PPC was rendered ineffective. This practice could be addressed by establishing a simple clinic policy that could easily be enforced, and yet it is not. Another example may be the commonly observed consumption of food and drink in clinical areas, including exam rooms, and in some cases even providing beverages to clients in the exam room during appointments. This is not a practice that developed due to heavy clinic workload or lack of training, but rather a practice of convenience that has not been adequately discouraged due to poor infection control culture, when available guidelines (and common sense) clearly indicate it should be avoided.

The wireless video recording system proved to be a very useful tool. The use of a powerline network for recording permitted the use of small cameras with minimal wiring that were able to run with no user intervention for days to weeks with the use of a laptop computer. One of the biggest advantages of this system was the speed and ease of set up and removal of the cameras. The cameras (and power cords, when necessary) were securely mounted to almost any wall surface using adhesive strips, and were even safely mounted on the ceiling in some cases. When used properly, these strips could be removed without causing any damage to the surface finishing (e.g. paint); thus no residual marks or holes from the cameras were left at the end of the study. The camera system used in the two clinic studies, and other similar systems, can be readily purchased from commercial retailers for a small but not excessive investment (generally starting at a few hundred dollars depending on how many cameras are desired). As the technology continues to develop, additional options for systems of this kind will likely also become available in a variety of price ranges. Use of the powerline technology was less reliable in some clinics compared to others, likely depending on the age and complexity of the building’s electrical wiring, as well as the connection of other electrical devices to the same circuit, which resulted in periodic interruption of the signal from one or multiple cameras. However, the trade-off was that no additional wiring or network cables were required other than those connecting the cameras and computer to a power outlet. The use of laptop computers allowed the system to stay active during short power interruptions and therefore continue recording once power was restored to the cameras. It would have been ideal to have the computers checked more frequently in order to reset them following longer power interruptions.
that drained the laptop batteries, resulting in the system shutting down, as occurred on a few occasions. However, it was not permissible to allow any clinic staff to have access to the video data due to confidentiality concerns, and in most cases the clinic staff were unaware that there had been a power interruption and thus the investigator was not informed prior to the next site visit.

The only significant effect on study participants that could potentially be attributed to the presence of the cameras was a small increase in the odds of hand hygiene compliance over time. It was hypothesized that if the cameras had any effect on behaviour, it would be strongest when the cameras were first put in place and participants were most likely to aware of them, and then gradually diminish, resulting in a slight decrease in compliance over time. Anecdotally, although there were several staff members who initially expressed some apprehension about having the cameras in the clinic, most seemed to be nervous about inadvertently being recorded doing something “embarrassing” (e.g. changing clothes, dancing or generally being “silly”), not about having their professional practices scrutinized. It is doubtful, though not impossible, that clinic staff became increasingly sensitized to the cameras as the study progressed. It is more likely that some other unmeasured factor was responsible for this effect, such as increasing discussion and awareness of hand hygiene practices, which may have been initiated prior to or following the initial site visit and continued over the course of the study. Regardless, even if this effect was due to the presence of the cameras, it was not considered sufficiently large to invalidate the use of the camera system for this kind of monitoring, and was not detected at all in the preoperative preparation study. At the petting zoo, no visitors approached event staff regarding the cameras, and based on their location it is unlikely that a significant number of visitors even realized they were present. Given that security cameras in public areas and commercial businesses are becoming increasingly common, as well as the ubiquitous presence of camera phones in public, use of video recording in busy public settings like petting zoos is probably the least intrusive means of direct monitoring available, even more so than in veterinary clinics, and it provides substantially more and likely less biased data that live observation.

The video coding was extremely labour-intensive, requiring almost 16 months to complete for the final hand hygiene intervention study. This was in part due to the amount and detail of the coded data collected, including multiple variables related to hand hygiene timing and technique, as well as variables for the numerous other infection control practices and appointment elements examined. While this provided a great deal of excellent information for these research projects, the scheme could be shortened significantly for use in routine monitoring if desired. Focusing on behaviours that could be recorded using a single camera (e.g. hand hygiene within the exam room or backroom only), recording only dichotomous outcomes (e.g. hand hygiene performed or not, contact time greater than 15 s or not), and
aided by the use of motion capture recording and the ability to screen videos at high speed, coding could likely be made quite efficient. This is potentially a feasible means of periodically collecting data on hand hygiene and other infection control practices in veterinary clinics for the purposes of gauging compliance and possibly measuring responses to interventions.
7.1 Conclusion

This research has demonstrated that there is clearly room for improvement with regard to many frequently used infection control practices in veterinary clinics in Ontario. Veterinary staff are dedicated to promoting the health of their patients and providing quality service to their clients, which includes an ethical obligation to protect the animals under their care from infectious diseases. This research was never intended to be a “slap on the wrist” for veterinary personnel; rather, the goal was to provide a baseline point from which to move forward, and, as it turns out, a wake-up call with regard to some specific points which can and should be addressed. These include increasing use of alcohol-based hand sanitizer products, observing appropriate contact times for antiseptic and disinfectant products, and improving overall hand hygiene compliance, particularly prior to patient contact. The passive use of posters was generally ineffective for improving hand hygiene practices in both veterinary clinics and at a public petting zoo, but active interventions at the petting zoo were effective, and the use of more active multimodal interventions should be investigated in veterinary clinics as well. The video monitoring system used in this research may be a useful tool for conducting these and similar studies in the future.

The most critical factor that must be addressed in order to improve infection control practices in veterinary clinics is the overall lack of infection control culture in veterinary medicine. There are already signs that this culture is improving, such as increased attention on infection control topics at continuing education events, and the very fact that over 50 clinics were willing to participate in the studies reported here. However, for a true infection control culture to be established, it is crucial that it permeate all groups and levels of clinic staff. This must start with ensuring an infection control mentality is adequately incorporated into formal education and training of veterinarians and technicians. In clinics, while components such as a detailed infection control manual and policies are essential to an effective infection control program, their existence is not sufficient to establish a culture, with the drive coming only from the top down. Everyone from administration and senior veterinarians to volunteers and kennel staff, and even patient owners, must do their part to make routine infection control practices like hand hygiene as effective as possible.
Appendix 4.1

Survey distributed to veterinary clinic staff following a video observation study evaluating the effectiveness of a hand hygiene poster campaign to improve hand hygiene compliance
(survey results reported in Chapter 4 and Chapter 6)
HAND HYGIENE PRACTICES & PERCEPTIONS IN COMPANION ANIMAL VETERINARY CLINICS

• This survey is designed to collect information regarding your opinion of the recent hand hygiene intervention study in which you participated, as well as information about hand hygiene practices and opinions in general. It will NOT be used to critique your practices.
• It will take approximately 10 minutes to complete.
• The survey is completely voluntary. You may skip any questions you do not wish to answer.
• All responses will be kept strictly confidential. The completed surveys will only be seen by Drs. Scott Weese and Maureen Anderson, who are conducting the study.
• When you are done, please place your survey in the pre-addressed envelope provided to the clinic.
When all surveys have been collected, they will be mailed directly to Dr. Anderson.

If you have any questions, please contact Dr. Weese (519-824-4120 Ext. 54064 or jsweese@uoguelph.ca) or Dr. Anderson (mander01@uoguelph.ca), Department of Pathobiology, University of Guelph, at any time. If you have any questions about your rights as a research participant, please contact Sandy Auld, Research Ethics Coordinator at 519-824-4120 Ext 56606 or sauld@uoguelph.ca.

1. Hand Hygiene Intervention

1. Over the last 7-10 days, did you notice the hand hygiene posters that were put up in the clinic?
   □ Yes (continue to question 2)
   □ No (skip to question 6 (next page))

2. Did the hand hygiene posters increase your awareness of the need to perform hand hygiene (either hand washing or using an alcohol-based hand sanitizer) and/or infection control in general?
   For all scale questions, please tick the box that best reflects your opinion.
   Not at all □ · □ · □ · □ · □ · □ · □ · □ · □ Very much

3. Do you feel the hand hygiene posters increased how often you performed hand hygiene?
   Not at all □ · □ · □ · □ · □ · □ · □ · □ · □ Very much

4. Do you feel the hand hygiene posters change how you performed hand hygiene (e.g. more thorough washing/rubbing)?
   Not at all □ · □ · □ · □ · □ · □ · □ · □ · □ Very much

5a. Do you recall any pet owners asking you questions about hand hygiene after seeing the posters?
   □ Yes (continue to question 5b)
   □ No (skip to question 6 (next page))

5b. If yes, do you feel that having owners ask you questions about hand hygiene increased how often or changed how you performed hand hygiene?
   Not at all □ · □ · □ · □ · □ · □ · □ · □ · □ Very much
6a. How do you feel your clinic ranks in terms of good hand hygiene practices among veterinary clinics in general?
   Worst (0) □ □ □ □ □ □ □ □ □ (10) Best
   Average (5)

6b. Do you think hand hygiene practices in your clinic could be improved?
   □ Yes
   □ No

7. In your opinion, how effective would each of the following actions be to improve hand hygiene practices permanently in your clinic? If it is something that is already being done in your clinic, please check the “Done” column on the right.
   a  Having clinic owners and senior veterinarians at your clinic support and openly promote hand hygiene.
      Done
      Not effective □ □ □ □ □ □ □ □ □ Very effective  □

   b  Making alcohol-based hand sanitizer always available in each patient contact area.
      Not effective □ □ □ □ □ □ □ □ □ Very effective  □

   c  Displaying hand hygiene posters in key areas as reminders.
      Not effective □ □ □ □ □ □ □ □ □ Very effective  □

   d  Providing education on hand hygiene to every clinic staff member.
      Not effective □ □ □ □ □ □ □ □ □ Very effective  □

   e  Making clear and simple instructions for hand hygiene visible to every staff member.
      Not effective □ □ □ □ □ □ □ □ □ Very effective  □

   f  Giving feedback to staff about their hand hygiene performance.
      Not effective □ □ □ □ □ □ □ □ □ Very effective  □

   g  Personally always performing hand hygiene as recommended (i.e. being a good example for your colleagues).
      Not effective □ □ □ □ □ □ □ □ □ Very effective  □

   h  Inviting owners to remind clinic staff to perform hand hygiene.
      Not effective □ □ □ □ □ □ □ □ □ Very effective  □
II. Hand Hygiene Practices & Perceptions

8. How important do you think it is to perform hand hygiene (either washing your hands or using hand sanitizer) in each of the following situations?

a. Before handling an animal that comes in for an appointment of any kind
   Not important □ □ □ □ □ □ □ □ Very important

b. After handling a relatively healthy animal that comes in for a routine exam/procedure
   Not important □ □ □ □ □ □ □ □ Very important

c. Before handling an animal that has had surgery in the last 48 hours
   Not important □ □ □ □ □ □ □ □ Very important

d. After removing disposable gloves used for any procedure
   Not important □ □ □ □ □ □ □ □ Very important

e. After handling an animal with diarrhea of unknown cause
   Not important □ □ □ □ □ □ □ □ Very important

f. After handling an animal with coughing/sneezing of unknown cause
   Not important □ □ □ □ □ □ □ □ Very important

g. After handling an animal with a potentially infected wound/incision/skin lesion
   Not important □ □ □ □ □ □ □ □ Very important

h. After contact with feces or urine (e.g. samples, used litterboxes, "stoop & scoop")
   Not important □ □ □ □ □ □ □ □ Very important

i. Before eating, drinking or smoking at work
   Not important □ □ □ □ □ □ □ □ Very important

j. After using the bathroom at work
   Not important □ □ □ □ □ □ □ □ Very important
9. Which of the following factors stop you from performing hand hygiene more frequently at work? Check all that apply AND indicate the most significant factor with a star ★.

☐ I forget
☐ Other staff don’t perform hand hygiene that often, so I don’t
☐ Takes too much time/I’m too busy
☐ Sinks/soap/sanitizers are not conveniently located
☐ Soap/sanitizers are too damaging/drying for the skin on my hands
☐ I dislike the smell or feeling of the soap/handrub that is available at work
☐ I prefer to wear gloves instead so I don’t need to wash my hands or use handrub

☐ Other (please specify: ________________________________)

☐ None. I perform hand hygiene as often as is necessary and there are no factors that make me less likely to perform hand hygiene when I believe it is needed.

10. Indicate which of the following hand hygiene products are readily available for staff use on a daily basis at your clinic. Also, rank the products that are available according to how often you use each one when you perform hand hygiene at work (1 = used most often, 6 = used least often).

<table>
<thead>
<tr>
<th>Product</th>
<th>Available</th>
<th>Rank (1-6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar soap</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Liquid soap (plain)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Liquid antibacterial soap</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Alcohol-based hand sanitizer</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Non-alcohol-based hand sanitizer</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Other (specify: __________)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

11. What do you believe is the minimum amount of time for which hands should be washed with soap and water (i.e. total contact time with soap) in order to effectively disinfect them?

☐ 5 seconds
☐ 15 seconds
☐ 30 seconds
☐ 60 seconds or more
☐ Unsure

12. What do you believe is the minimum amount of time for which hands should be rubbed with an alcohol-based hand sanitizer in order to effectively disinfect them?

☐ 5 seconds
☐ 10 seconds
☐ 20 seconds
☐ 30 seconds or more
☐ Unsure
13. Do you regularly use skin moisturizer/lotion for your hands when at work?
   □ Yes
   □ No

14. Do you recall hand hygiene practices ever being specifically discussed with you at work, either individually or during a group meeting?
   □ Yes
   □ No

15. To your knowledge, does your current clinic have a written infection control manual/policy?
   □ Yes
   □ No

16. How important do you feel hand hygiene is for preventing spread of diseases:
   a in the community? (e.g. at home or in public places)
      Not important □ · □ · □ · □ · □ · □ · □ Very important
   b in human hospitals?
      Not important □ · □ · □ · □ · □ · □ · □ Very important
   c in veterinary clinics?
      Not important □ · □ · □ · □ · □ · □ · □ Very important

17. Hospital-associated infections in animals are defined as infections from pathogens that animals pick up while visiting or staying at a veterinary clinic. These infections may become apparent while the animal is still at the clinic or after it goes home.
   How much of a problem do you feel hospital-associated infections in animals are:
   a in general practice/primary care veterinary clinics?
      Not a problem □ · □ · □ · □ · □ · □ · □ Very big problem
   b in large referral veterinary hospitals?
      Not a problem □ · □ · □ · □ · □ · □ · □ Very big problem

18. In general, how concerned are you about contracting any infectious diseases from the animals with which you work?
   Not concerned □ · □ · □ · □ · □ · □ · □ Very concerned
19. What disease (or type of disease), if any, are you most concerned about contracting from the animals with which you work?

Disease: ________________________________

III. General Information

20. Please select the option that BEST describes your PRIMARY role/position in the clinic:
   - Veterinarian
   - Technician (RVT)
   - Technician (non-registered)
   - Animal care assistant (do not perform medical procedures such as injections, bandage changes etc. but may assist with restraint, nail trims, grooming etc.)
   - Kennel staff (generally don’t assist with procedures, but may walk/feed animals)
   - Front office staff
   - Practice manager

21. How many hours do you typically work per week at this clinic?
   - <35 (part time)
   - ≥35 (full time)

22. Age: __________

23. Sex
   - Male
   - Female

24. If you have any additional comments or feedback about the intervention or this study in general, please enter them here:

THANK YOU FOR YOUR PARTICIPATION!

ALL RESPONSES ARE STRICTLY CONFIDENTIAL
Appendix 6.1

Images of posters used as an intervention to help improve hand hygiene compliance among staff in companion animal veterinary clinics in Ontario. A: Poster A, which was mounted in exam rooms (actual size 22 cm x 28 cm); B: Poster B, which was mounted in backroom areas (actual size 28 cm x 22 cm)
Pets can carry infections too!

Protect pets, their owners and yourself:

**PAUSE TO CLEAN YOUR PAWS!**

Hands are the #1 way infections are spread.

It only takes 15 seconds to clean your hands.
Wash your hands or use an alcohol-based hand sanitizer to help stop the spread of infections to pets, to their owners, and to you!

Clean Hands =
Healthier Pets + Healthier People
Protect pets and people:
PAUSE TO CLEAN YOUR PAWS!

Pets can carry a large number of bacteria, viruses and parasites in their mouths, noses, skin and fur—often with no signs of illness or infection.

Many can be transmitted to other animals, and some even to people.

Hands are the #1 way infections spread. It only takes 15 seconds to clean your hands properly by washing or using an alcohol-based hand sanitizer. It can help stop the spread of infections to pets, to their owners, and to you!

Clean Hands = Healthier Pets + Healthier People
**Appendix 6.2:** Justification for the key elements included on Posters A and B (see Appendix 6.1) designed to help improve hand hygiene compliance among staff in companion animal veterinary clinics in Ontario.

<table>
<thead>
<tr>
<th>Poster theory</th>
<th>Element of hand hygiene posters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid making the poster a “training chart,” as knowledge does not necessarily affect behavioural change in a positive direction.</td>
<td>Posters do NOT show how to wash hands, but rather focus on why to wash hands.</td>
</tr>
<tr>
<td>Most health professionals (which may include veterinary staff in this case) know/believe/are aware that hand hygiene can prevent cross contamination, however, based on poor compliance it is thought that there is low “personal acceptance” of this fact, meaning that many health professionals do not believe it is applicable specifically to themselves. To motivate individuals to perform hand hygiene they need to believe it is effective (i.e. for preventing cross contamination) and that they themselves are at risk.</td>
<td>Emphasis that “hands are the #1 way infections are spread” and picture showing multiple pathogens that can be carried on the hands reinforces the utility of hand hygiene for preventing pathogen spread. Include reminders of personal benefits (“protect...yourself,” “stop spread of infections...to you”)</td>
</tr>
<tr>
<td>In the case of health professionals, who themselves may be relatively fit and healthy and at reasonably low risk of infection, it also important to appeal to their sense of obligation to protect others (i.e. patients and clients).</td>
<td>“Protect pets, their owners...” “Protect pets and people” “stop spread of infections to pets, to their owners...”</td>
</tr>
<tr>
<td>It is useful to emphasize minimization of losses/barriers (such as time) so individuals realize that they not only should perform hand hygiene but that they can.</td>
<td>“It only takes 15 seconds to clean your hands...” in bold.</td>
</tr>
<tr>
<td>Gain-framing (versus loss-framing) has been shown to be more effective for promoting prevention behaviors.</td>
<td>Emphasis on “stop spread of infection” by using hand hygiene, rather than “infections may occur” if hand hygiene is not used.</td>
</tr>
<tr>
<td>Emphasis on “protect.” “Clean hands = Healthier pets + Healthier people” emphasizes gains of hand hygiene.</td>
<td></td>
</tr>
<tr>
<td>Fear-appeals can backfire (especially if moderate to severe) and must be related to personal concern to be effective (e.g. self-infection).</td>
<td>Fear appeals avoided except on Poster B, where they are limited to pointing out that infections “can be transmitted to other animals, and some even to people” which is related to personal (self) concern.</td>
</tr>
<tr>
<td>One size does not fit all.</td>
<td>Two slightly different posters used (Poster A in exam rooms, Poster B in backroom areas).</td>
</tr>
</tbody>
</table>

Appendix 6.3: Additional details of video coding scheme used to measure hand hygiene compliance in companion animal veterinary clinics

A complete “contact cycle” was considered observation of an individual’s initial contact and final contact with a patient, before being off camera for over 2 min or having visible contact with an unrelated animal. For hand hygiene opportunities before patient contact, or before “clean” procedures, only hand hygiene attempts made within the same room/area as the applicable contact were coded (i.e. hand hygiene timing was only coded as 1, 4, or 5, see Table 6.2, Chapter 6). If an individual left the room/area where the last animal contact took place, but did not leave the field of view for more than 2 min or have visible contact with another animal before returning, this was considered part of the same contact cycle, but any subsequent hand hygiene attempt for “after contact” was coded as “outside of room having touched other objects/surfaces,” even if it was performed in the room upon the person’s return. If an individual left the room/area where the last animal contact took place, and then left the field of view for more than 2 min without first attempting hand hygiene, hand hygiene timing for “after contact” was coded as “unobserved” and a new contact cycle was coded if the individual returned and had further contact with the animal, beginning with an additional “before contact” hand hygiene opportunity. This 2-minute interval was based on the possibility of the individual having contact with either another animal or a sufficient number/type of objects/surfaces while off-camera over a period of 2 min or more to warrant an additional hand hygiene attempt prior to subsequent patient contact. If the person was off-camera for less than 2 min then the likelihood of such contact was lower, and the benefit of the doubt was given that additional hand hygiene prior to subsequent patient contact would not be as useful.

If hand hygiene was not observed for an after contact/procedure/degloving opportunity (i.e. hand hygiene opportunity type 3, 4, or 5, see Table 6.2, Chapter 6), additional information coded included whether the individual was seen to touch any other objects/surfaces outside of the patient contact room/area before leaving the field of view. Individuals were followed for up to 2 min after leaving an appointment or last having contact with the patient in the backroom, if the person remained in the field of view for this long. If the person left the field of view in less than 2 min and was off-camera for more than 20 s (in clinics with AHS available) or more than 30s (in clinics without AHS available), then hand hygiene was coded as “unobserved, left view.” If the individual was in view for at least 2 min without going off-camera for more than 20-30 s (depending on the clinic), then hand hygiene was coded as “unobserved, stayed in view.” This 2-minute interval was selected to increase the likelihood that any hand hygiene attempt coded was related primarily to the appointment/relevant animal contact rather than other tasks performed subsequently. An exception to this interval was made for staff who remained in the field of view and were clearly completing medical records, without engaging in any other tasks, in which case
they were followed for up to 5 min to observe a hand hygiene attempt. The 20 s interval was the estimated minimum amount of time that would be required to reach, use and return from an AHS station located in another area of the clinic, while the 30 s interval was the same for a hand washing station (i.e. sink with soap and water). If an individual performed a “dirty” procedure or removed gloves prior to leaving the field of view, and was then off camera for less than 2 min but for at least 20-30 s (depending on the clinic), hand hygiene timing for that opportunity was coded as unobserved, because a hand hygiene attempt could not be excluded if the individual was off-camera for this interval (and otherwise subsequent contact with a “clean” part of the patient (without performing hand hygiene) would be considered a “failure” (i.e. hand hygiene timing = 1, not performed)).

If a person entered or left the field of view in direct contact with a patient (including leading a dog on leash, but not including carrying a cat in a closed carrier) and was off-camera for at least 20-30 s (depending on the clinic, i.e. long enough to potentially perform hand hygiene in an unmonitored area) prior to or after being seen with the animal, then no hand hygiene opportunity was coded. Contact with multiple animals brought in by the same client in the same appointment was treated as contact with a single animal, but if the same procedure (e.g. vaccination) was performed on more than one of these animals consecutively, these were considered different procedures and a hand hygiene opportunity was coded for each, if applicable.
**Appendix 6.4:** All contrasts of associations for variables included in the final multivariable random effects logistic regression model for observed hand hygiene compliance for opportunities associated with routine companion animal appointments at 38 veterinary clinics in Ontario (n = 10894)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Interaction</th>
<th>Comparison</th>
<th>OR</th>
<th>95% CI</th>
<th>p-value Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posters</td>
<td>-</td>
<td>Absent vs present</td>
<td>1.04</td>
<td>0.91</td>
<td>1.19</td>
<td>0.5347</td>
</tr>
<tr>
<td><strong>Recording day</strong></td>
<td>-</td>
<td>Per 1 day increase</td>
<td>1.04</td>
<td>1.002</td>
<td>1.087</td>
<td>0.0408</td>
</tr>
<tr>
<td>Room*role</td>
<td>Exam room</td>
<td>Other vs veterinarian</td>
<td>0.27</td>
<td>0.19</td>
<td>0.39</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other vs technician</td>
<td>0.58</td>
<td>0.40</td>
<td>0.85</td>
<td>0.0053</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Veterinarian vs technician</td>
<td>2.15</td>
<td>1.80</td>
<td>2.56</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Backroom</td>
<td>Other vs veterinarian</td>
<td>0.21</td>
<td>0.05</td>
<td>0.94</td>
<td>0.0408</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other vs technician</td>
<td>0.19</td>
<td>0.04</td>
<td>0.83</td>
<td>0.0271</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Veterinarian vs technician</td>
<td>0.90</td>
<td>0.63</td>
<td>1.28</td>
<td>0.5522</td>
</tr>
<tr>
<td>Exam room vs backroom</td>
<td>Other</td>
<td></td>
<td>0.72</td>
<td>0.15</td>
<td>3.34</td>
<td>0.6723</td>
</tr>
<tr>
<td></td>
<td>Veterinarian</td>
<td></td>
<td>0.56</td>
<td>0.38</td>
<td>0.83</td>
<td>0.0036</td>
</tr>
<tr>
<td></td>
<td>Technician</td>
<td></td>
<td>0.23</td>
<td>0.15</td>
<td>0.35</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Gender*HH opp type</td>
<td>Male</td>
<td>Before patient contact vs before “clean” procedure</td>
<td>9.16</td>
<td>2.02</td>
<td>41.56</td>
<td>0.0041</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs after “dirty” procedure</td>
<td>0.10</td>
<td>0.05</td>
<td>0.19</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs after glove removal</td>
<td>0.10</td>
<td>0.04</td>
<td>0.24</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs after patient contact</td>
<td>0.14</td>
<td>0.09</td>
<td>0.22</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs after “dirty” procedure</td>
<td>0.01</td>
<td>0.002</td>
<td>0.05</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs after glove removal</td>
<td>0.01</td>
<td>0.002</td>
<td>0.06</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs after patient contact</td>
<td>0.02</td>
<td>0.004</td>
<td>0.07</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After “dirty” procedure vs after glove removal</td>
<td>1.08</td>
<td>0.43</td>
<td>2.68</td>
<td>0.8761</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After “dirty” procedure vs after patient contact</td>
<td>1.51</td>
<td>0.85</td>
<td>2.69</td>
<td>0.1575</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After glove removal vs after patient contact</td>
<td>1.41</td>
<td>0.65</td>
<td>3.03</td>
<td>0.3824</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs before “clean” procedure</td>
<td>1.40</td>
<td>0.81</td>
<td>2.42</td>
<td>0.2263</td>
</tr>
<tr>
<td>Variable*HH opp type</td>
<td>Interaction</td>
<td>Comparison</td>
<td>OR</td>
<td>95% CI</td>
<td>p-value</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------</td>
<td>------------</td>
<td>-----</td>
<td>--------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Before patient contact vs after “dirty” procedure</td>
<td>0.05</td>
<td>0.03</td>
<td>0.08</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs after glove removal</td>
<td>0.03</td>
<td>0.02</td>
<td>0.06</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs after patient contact</td>
<td>0.07</td>
<td>0.05</td>
<td>0.09</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs after “dirty” procedure</td>
<td>0.04</td>
<td>0.02</td>
<td>0.07</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs after glove removal</td>
<td>0.02</td>
<td>0.01</td>
<td>0.05</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs after patient contact</td>
<td>0.05</td>
<td>0.03</td>
<td>0.08</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After “dirty” procedure vs after glove removal</td>
<td>0.68</td>
<td>0.37</td>
<td>1.26</td>
<td>0.2172</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After “dirty” procedure vs after patient contact</td>
<td>1.40</td>
<td>0.93</td>
<td>2.09</td>
<td>0.1052</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After glove removal vs after patient contact</td>
<td>2.06</td>
<td>1.23</td>
<td>3.43</td>
<td>0.0057</td>
</tr>
<tr>
<td></td>
<td>Male vs female</td>
<td>Before patient contact</td>
<td>1.21</td>
<td>0.79</td>
<td>1.83</td>
<td>0.3784</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure</td>
<td>0.18</td>
<td>0.04</td>
<td>0.80</td>
<td>0.0244</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After “dirty” procedure</td>
<td>0.62</td>
<td>0.37</td>
<td>1.05</td>
<td>0.0749</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After glove removal</td>
<td>0.39</td>
<td>0.18</td>
<td>0.88</td>
<td>0.0224</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After patient contact</td>
<td>0.57</td>
<td>0.46</td>
<td>0.71</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Room*HH opp type</td>
<td>Exam room</td>
<td>Before patient contact vs before “clean” procedure</td>
<td>4.12</td>
<td>1.91</td>
<td>8.90</td>
<td>0.0003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs after “dirty” procedure</td>
<td>0.12</td>
<td>0.09</td>
<td>0.17</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs after glove removal</td>
<td>0.08</td>
<td>0.05</td>
<td>0.13</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs after patient contact</td>
<td>0.08</td>
<td>0.07</td>
<td>0.10</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs after “dirty” procedure</td>
<td>0.03</td>
<td>0.01</td>
<td>0.07</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs after glove removal</td>
<td>0.02</td>
<td>0.008</td>
<td>0.04</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs after patient contact</td>
<td>0.02</td>
<td>0.01</td>
<td>0.04</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After “dirty” procedure vs after glove removal</td>
<td>0.63</td>
<td>0.38</td>
<td>1.03</td>
<td>0.0669</td>
</tr>
<tr>
<td>Variable</td>
<td>Interaction</td>
<td>Comparison</td>
<td>OR</td>
<td>95% CI</td>
<td>p-value</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
<td>--------------------------------</td>
<td>------</td>
<td>--------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td></td>
</tr>
<tr>
<td>Room*HH opp type</td>
<td>Exam room</td>
<td>After “dirty” procedure vs after patient contact</td>
<td>0.67</td>
<td>0.51</td>
<td>0.89</td>
<td>0.0054</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After glove removal vs after patient contact</td>
<td>1.07</td>
<td>0.69</td>
<td>1.66</td>
<td>0.7631</td>
</tr>
<tr>
<td>Backroom</td>
<td>Before patient contact vs before “clean” procedure</td>
<td>3.11</td>
<td>0.95</td>
<td>10.21</td>
<td>0.0614</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Before patient contact vs after “dirty” procedure</td>
<td>0.04</td>
<td>0.02</td>
<td>0.09</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Before patient contact vs after glove removal</td>
<td>0.04</td>
<td>0.02</td>
<td>0.12</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Before patient contact vs after patient contact</td>
<td>0.12</td>
<td>0.07</td>
<td>0.20</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Before “clean” procedure vs after “dirty” procedure</td>
<td>0.01</td>
<td>0.003</td>
<td>0.05</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Before “clean” procedure vs after glove removal</td>
<td>0.01</td>
<td>0.004</td>
<td>0.06</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Before “clean” procedure vs after patient contact</td>
<td>0.04</td>
<td>0.01</td>
<td>0.12</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>After “dirty” procedure vs after glove removal</td>
<td>1.17</td>
<td>0.39</td>
<td>3.45</td>
<td>0.07818</td>
<td></td>
</tr>
<tr>
<td></td>
<td>After “dirty” procedure vs after patient contact</td>
<td>3.15</td>
<td>1.49</td>
<td>6.70</td>
<td>0.0028</td>
<td></td>
</tr>
<tr>
<td></td>
<td>After glove removal vs after patient contact</td>
<td>2.71</td>
<td>1.13</td>
<td>6.50</td>
<td>0.0261</td>
<td></td>
</tr>
<tr>
<td>Exam room vs backroom</td>
<td>Before patient contact</td>
<td>0.64</td>
<td>0.31</td>
<td>1.29</td>
<td>0.2119</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Before “clean” procedure</td>
<td>0.48</td>
<td>0.16</td>
<td>1.42</td>
<td>0.1863</td>
<td></td>
</tr>
<tr>
<td></td>
<td>After “dirty” procedure</td>
<td>0.19</td>
<td>0.08</td>
<td>0.48</td>
<td>0.0004</td>
<td></td>
</tr>
<tr>
<td></td>
<td>After glove removal</td>
<td>0.36</td>
<td>0.13</td>
<td>1.03</td>
<td>0.0574</td>
<td></td>
</tr>
<tr>
<td></td>
<td>After patient contact</td>
<td>0.91</td>
<td>0.54</td>
<td>1.54</td>
<td>0.7278</td>
<td></td>
</tr>
</tbody>
</table>

OR=odds ratio, CI=confidence interval, HH opp=hand hygiene opportunity
Statistically significant contrasts (p<0.05) are in **boldface**
Appendix 6.5: Histogram and normal quantile plot for residuals of the final multivariable random effects linear regression model for product contact time at the sample level (hand hygiene attempt) after log transformation of the outcome.
Appendix 6.6: All contrasts of associations for variables included in the final multivariable random effects linear regression model for product contact time for hand hygiene attempts associated with routine companion animal appointments at 38 veterinary clinics in Ontario (n = 1330)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Interaction term</th>
<th>Comparison</th>
<th>Ratio</th>
<th>Lower 95% CI</th>
<th>Upper 95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>-</td>
<td>Male vs female</td>
<td>1.20</td>
<td>1.04</td>
<td>1.38</td>
<td>0.0120</td>
</tr>
<tr>
<td>Species</td>
<td>-</td>
<td>Other vs dog</td>
<td>1.34</td>
<td>0.75</td>
<td>2.39</td>
<td>0.3242</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other vs cat</td>
<td>1.13</td>
<td>0.63</td>
<td>2.03</td>
<td>0.6725</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other vs multiple</td>
<td>1.38</td>
<td>0.76</td>
<td>2.51</td>
<td>0.2893</td>
</tr>
<tr>
<td></td>
<td>Dog vs cat</td>
<td></td>
<td>0.85</td>
<td>0.75</td>
<td>0.96</td>
<td>0.0074</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dog vs multiple</td>
<td>1.03</td>
<td>0.88</td>
<td>1.21</td>
<td>0.7019</td>
</tr>
<tr>
<td></td>
<td>Cat vs multiple</td>
<td></td>
<td>1.22</td>
<td>1.01</td>
<td>1.46</td>
<td>0.0368</td>
</tr>
<tr>
<td>HH product</td>
<td>-</td>
<td>Water vs soap</td>
<td>0.74</td>
<td>0.60</td>
<td>0.92</td>
<td>0.0066</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water vs AHS</td>
<td>0.44</td>
<td>0.33</td>
<td>0.59</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soap vs AHS</td>
<td>0.59</td>
<td>0.48</td>
<td>0.72</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>AHS in clinic*role</td>
<td>AHS in clinic</td>
<td>Other vs veterinarian</td>
<td>1.82</td>
<td>1.37</td>
<td>2.44</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other vs technician</td>
<td>1.19</td>
<td>0.87</td>
<td>1.61</td>
<td>0.2757</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Veterinarian vs technician</td>
<td>0.65</td>
<td>0.57</td>
<td>0.75</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>AHS not in clinic</td>
<td>Other vs veterinarian</td>
<td>0.76</td>
<td>0.51</td>
<td>1.12</td>
<td>0.1665</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other vs technician</td>
<td>0.71</td>
<td>0.46</td>
<td>1.09</td>
<td>0.1162</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Veterinarian vs technician</td>
<td>0.93</td>
<td>0.73</td>
<td>1.18</td>
<td>0.5409</td>
</tr>
<tr>
<td></td>
<td>AHS not in clinic</td>
<td>Veterinarian</td>
<td>0.85</td>
<td>0.64</td>
<td>1.14</td>
<td>0.2852</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technician</td>
<td>0.60</td>
<td>0.42</td>
<td>0.85</td>
<td>0.0043</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>0.36</td>
<td>0.21</td>
<td>0.61</td>
<td>0.0002</td>
</tr>
<tr>
<td>Posters*HH opp type</td>
<td>Posters present</td>
<td>Before patient contact vs</td>
<td>1.23</td>
<td>0.65</td>
<td>2.33</td>
<td>0.5145</td>
</tr>
<tr>
<td></td>
<td></td>
<td>before “clean” procedure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs</td>
<td>1.63</td>
<td>1.16</td>
<td>2.29</td>
<td>0.0054</td>
</tr>
<tr>
<td></td>
<td></td>
<td>after “dirty” procedure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs</td>
<td>1.83</td>
<td>1.14</td>
<td>2.95</td>
<td>0.0128</td>
</tr>
<tr>
<td></td>
<td></td>
<td>after glove removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs</td>
<td>1.46</td>
<td>1.15</td>
<td>1.86</td>
<td>0.0021</td>
</tr>
<tr>
<td></td>
<td></td>
<td>after patient contact</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs</td>
<td>1.32</td>
<td>0.69</td>
<td>2.53</td>
<td>0.3981</td>
</tr>
<tr>
<td></td>
<td></td>
<td>after “dirty” procedure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs</td>
<td>1.49</td>
<td>0.73</td>
<td>3.04</td>
<td>0.2758</td>
</tr>
<tr>
<td></td>
<td></td>
<td>after glove removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs</td>
<td>1.19</td>
<td>0.65</td>
<td>2.16</td>
<td>0.5749</td>
</tr>
<tr>
<td></td>
<td></td>
<td>after patient contact</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>After “dirty” procedure vs</td>
<td>1.12</td>
<td>0.68</td>
<td>1.86</td>
<td>0.6428</td>
</tr>
<tr>
<td></td>
<td></td>
<td>after glove removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>Interaction term</td>
<td>Comparison</td>
<td>Ratio</td>
<td>95% CI</td>
<td>p-value</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------</td>
<td>-----------------------------------------------------------</td>
<td>--------</td>
<td>--------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td></td>
</tr>
<tr>
<td>Posters*HH opp type</td>
<td>Posters present</td>
<td>After “dirty” procedure vs after patient contact</td>
<td>0.90</td>
<td>0.69</td>
<td>1.17</td>
<td>0.4169</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After glove removal vs after patient contact</td>
<td>0.80</td>
<td>0.52</td>
<td>1.23</td>
<td>0.3073</td>
</tr>
<tr>
<td></td>
<td>Posters absent</td>
<td>Before patient contact vs before “clean” procedure</td>
<td>2.32</td>
<td>1.36</td>
<td>3.97</td>
<td><strong>0.0023</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs after “dirty” procedure</td>
<td>1.25</td>
<td>0.87</td>
<td>1.77</td>
<td>0.2222</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs after glove removal</td>
<td>1.04</td>
<td>0.68</td>
<td>1.59</td>
<td>0.8511</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before patient contact vs after patient contact</td>
<td>1.09</td>
<td>0.89</td>
<td>1.34</td>
<td>0.09051</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs after “dirty” procedure</td>
<td>0.54</td>
<td>0.30</td>
<td>0.96</td>
<td>0.6223</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs after glove removal</td>
<td>0.45</td>
<td>0.25</td>
<td>0.80</td>
<td><strong>0.0068</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure vs after patient contact</td>
<td>0.47</td>
<td>0.28</td>
<td>0.78</td>
<td><strong>0.0041</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>After “dirty” procedure vs after glove removal</td>
<td>0.84</td>
<td>0.52</td>
<td>1.34</td>
<td>0.4567</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After “dirty” procedure vs after patient contact</td>
<td>0.88</td>
<td>0.65</td>
<td>1.19</td>
<td>0.4010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After glove removal vs after patient contact</td>
<td>1.05</td>
<td>0.72</td>
<td>1.54</td>
<td>0.7930</td>
</tr>
<tr>
<td></td>
<td>Posters absent</td>
<td>Before patient contact</td>
<td>0.68</td>
<td>0.50</td>
<td>0.92</td>
<td><strong>0.0132</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Before “clean” procedure</td>
<td>0.36</td>
<td>0.17</td>
<td>0.79</td>
<td><strong>0.0109</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>After “dirty” procedure</td>
<td>0.89</td>
<td>0.60</td>
<td>1.32</td>
<td>0.5691</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After glove removal</td>
<td>1.20</td>
<td>0.68</td>
<td>2.11</td>
<td>0.5210</td>
</tr>
<tr>
<td></td>
<td></td>
<td>After patient contact</td>
<td>0.91</td>
<td>0.82</td>
<td>1.02</td>
<td>0.1007</td>
</tr>
<tr>
<td></td>
<td>Posters absent</td>
<td>AHS not in clinic vs AHS in clinic</td>
<td>0.64</td>
<td>0.46</td>
<td>0.89</td>
<td><strong>0.0086</strong></td>
</tr>
<tr>
<td></td>
<td>Posters present</td>
<td>AHS not in clinic vs AHS in clinic</td>
<td>0.50</td>
<td>0.36</td>
<td>0.70</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td></td>
<td>Posters absent</td>
<td>AHS not in clinic vs AHS in clinic</td>
<td>0.85</td>
<td>0.68</td>
<td>1.07</td>
<td>0.1716</td>
</tr>
<tr>
<td></td>
<td>Posters absent</td>
<td>AHS not in clinic</td>
<td>0.66</td>
<td>0.50</td>
<td>0.88</td>
<td><strong>0.0043</strong></td>
</tr>
<tr>
<td></td>
<td>Posters absent</td>
<td>AHS not in clinic</td>
<td>0.85</td>
<td>0.68</td>
<td>1.07</td>
<td>0.1716</td>
</tr>
<tr>
<td></td>
<td>Posters absent</td>
<td>AHS not in clinic</td>
<td>0.66</td>
<td>0.50</td>
<td>0.88</td>
<td><strong>0.0043</strong></td>
</tr>
</tbody>
</table>

CI=confidence interval; multiple=more than 1 dog and/or cat; HH=hand hygiene; AHS=alcohol-based hand sanitizer; HH opp=hand hygiene opportunity
Statistically significant contrasts (p<0.05) are in boldface