AN OBSERVATIONAL STUDY MEASURING HAND WASHING BEHAVIOR IN PETTING ZOO ATTENDEES

by

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CERTIFICATE OF APPROVAL

This is to certify that the Master's thesis of

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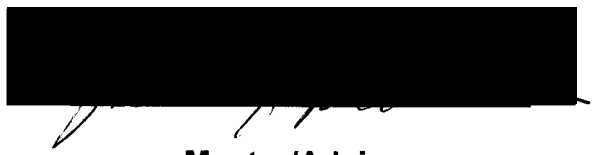
has been approved



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ABSTRACT

Each year in the US an estimated 6 million people visit petting zoos, and the number is increasing. Outbreaks in humans associated with animal pathogens are being increasingly reported. There are many published recommendations for design and maintenance for these facilities. Hand washing is recommended to prevent zoonotic pathogen transmission in these settings. The published literature lacks data on prevalence of overall hand hygiene (soap and water, water, alcohol sanitizer) and proper hand washing (using soap and water greater than 20 seconds) in petting zoos. In addition, at this time, there are no published data about demographic or environmental characteristics associated with hand hygiene in petting zoos. The following study was designed to explore these issues.

This was an observational study conducted at the Trillium Family Farm exhibit of the Oregon Zoo in Portland, OR. Subjects were systematically selected and observed by trained zoo volunteers. Data collected included demographic characteristics such as age, gender, and time spent in the exhibit, as well as environmental factors, such as availability of hygiene supplies and precipitation.

Over the course of the study, 334 subjects were observed. Of these, 218 subjects visited the petting zoo longer than one minute and touched an animal or an object on display. Of those, 49% (107/218) used any type of hand hygiene (soap, and/or water, and or alcohol-based sanitizer), and 19% (42/218) washed their hands with soap and water for greater than 20 seconds (proper hand

washing). However, this estimate is actually an upper bound for the proportion of people who properly washed. Many of those that washed properly during the first hygiene event did not rewash properly. In addition, one visitor did not wash properly the first time, but did with the second wash. Overall, 8.3% (18/218) of visitors washed their hands properly prior to leaving the exhibit after touching an animal or object.

Of all of the variables explored, age (crude odds ratios [OR] 0.57 [p=0.12], 0.31[p=0.003] and 0.47 [p=0.04] for age groups 5-10 years, 11-28 years, and 28+ years respectively, all versus the 0 – 4 year old age group), time spent in the exhibit (crude OR: 1.12, [p<0.001]) and presence of Zoo Teen volunteers in the petting zoo [crude OR: 3.3, p=0.004] were significantly associated with engaging in any hand hygiene behavior. Each of the previous associations was strengthened when entered together in a logistic regression model. Only time spent in the exhibit [crude OR: 1.10, p<0.001] was significantly associated with proper hand washing. The variable time spent was also found to be more strongly associated with the presence of Zoo Teen volunteers and age was added to the proper hand washing model for comparison.

Based on the results of our study, we designed recommendations to increase proper hand washing in petting zoo attendees. Recommendations include separating animal from non-animal areas, targeted and increased signage, and increased awareness of proper hand washing, as strategies to prevent disease transmission.

Introduction

Petting Zoos

Over six million people visit petting zoos each year in the United States (LeJeune & Davis, 2004). Petting zoos are places where people can touch, and sometimes feed, docile animals. These exhibits usually contain farm animals, such as sheep, goats, chickens, llamas, rabbits, ponies, and calves. Some exhibits contain exotic animals, such as turtles, snakes, lizards, chinchillas, ferrets, and raccoons. Many of these animals are capable of carrying pathogenic organisms and multiple serious outbreaks and potentially fatal exposures associated with these exhibits have been reported (LeJeune & Davis, 2004).

Petting zoo exhibits are designed to encourage contact with the animals. The animals are housed in a relatively small space and have close contact with each other. This allows fecal matter to collect on fur, wool, or skin despite the overall cleanliness. Disease transmission can occur when humans come into contact with fecal matter containing pathogens (Bender, Shulman, Animals in Public Contact subcommittee, National Association of State Public Health Veterinarians, 2004). The pathogens can be present on the animals themselves or transferred to inanimate objects such as toys and handrails in the exhibit by visitors that have touched these animals.

Children in particular may be at increased risk of pathogen exposure in petting zoos. Petting zoos are generally designed to allow children to have the experience of interacting with and touching animals. However, young children

often do not understand the implications of putting their hands in their mouths directly after touching an animal, other object, or even soil. If parents and guardians are aware of this as a potential problem, they may be more motivated to prevent hand-to-mouth contact in the exhibit.

Zoonotic Disease Potential

Animal contact has long been recognized as a risk factor for a variety of enteric and other zoonotic infections. In recent years animal contact at fairs, petting zoos, and similar venues has been increasingly identified as a source of outbreaks and sporadic infections (Bender et al., 2004; Mantia, 2003). In a recently published study, investigators reported that 14% of beef cattle, 4% of sheep, and 2% of goats sampled from agricultural fairs tested positive for *E. coli* O157:H7 (Keen, Wittum, Dunn, Bono, Durso, 2006)

A few examples of outbreaks and exposures include *E. coli* O157:H7, dermatophytosis, Cryptosporidium, Q fever, Tuberculosis, and rabies (Warshawsky, et. al, 2002; Lejeune & Davis, 2004; Bender, et. al, 2004; National Association of Public Health Veterinarians, 2004). Some recent examples include:

- In 2000, 56 children became ill with *E. coli* O157:H7 after visiting farms in Washington and Pennsylvania. Of these, 16 were hospitalized, and 8 developed hemolytic uremic syndrome, a serious complication that can be fatal (Centers for Disease Control and Prevention [CDC], 2001).
- In an outbreak in England, 54 people contracted the parasite *Cryptosporidium* after visiting a farm (LeJeune & Davis, 2004).

- Over 400 people were potentially exposed to a rabid goat at a New York county fair and were given rabies prophylaxis (Bender et al., 2004). The median cost of rabies prophylaxis was estimated to be $1500 per person exposed (CDC, 1997). If all 400 people were given prophylaxis following this exposure, the cost would be well over $600,000.

Prevention

Thorough hand washing with soap and water has been shown to significantly reduce the risk of disease transmission (American Society of Microbiology, 2003; LeJeune & Davis, 2004). Efforts to increase proper hand washing in visitors after exposure at petting zoos could result in a decreased chance of fecal–oral exposure to pathogens, and a resulting decreased incidence of associated illness. Many factors must be taken into account when determining the optimal length of hand washing including the degree to which hands are soiled and type of soap available, as well as external or site-specific factors, such as a long line at a sink or hand washing station. However, there is not consensus on exactly how long a person should wash in each situation. To date, this author has found no solid evidence supporting one optimal length of hand washing to prevent pathogen transmission. However, a commonly used guideline from the Food Handlers Association defines proper hand washing as 20 seconds of running water (Oregon Department of Agriculture, 1999). This definition has been promoted by Centers for Disease Control and Prevention (2006). We adopted this same definition for this study as it was felt to be a

feasible length of time for visitors to the petting zoo, in addition to being a fairly commonly recommended length of time.

People do not always wash their hands as recommended. For example, a study utilizing phone surveys and direct subject observation showed that 95% of people claimed to have washed their hands after using the restroom, while only 68% of people were observed to have actually washed (American Society for Microbiology, 2003). Even populations expected to have good hygiene, in fact, do not. One study showed that fewer then 10% of health care workers in an intensive care unit washed their hands after having contact with patients (Bischoff, Reynolds, Sessler, Edmond, Wenzel, 2000). An ICU is a setting where there is ample education on the merits of proper hand washing and the risks of improper hand washing. Visitors to a zoo are less likely to have formal education on the topic, and may be less aware of the importance of proper hand washing. In addition, many people ignore explicit signs by continuing to eat and drink to these areas, introducing greater potential for exposure to pathogens via the fecal–oral route.

A CDC article on hand washing behavior among healthcare personnel identified inaccessible supplies, insufficient time, lack of knowledge, and lack of risk awareness as the main factors affecting adherence to adequate hand washing (CDC, 2002a). Many of these same factors likely affect petting zoo attendees. Visitors may not be aware of risks, or, if they are, the hand washing facilities may be difficult to access on more crowded days. Alternatively, visitors

may not wash hands because they are simply in a hurry, or because supplies, such as soap and/or paper towels are missing.

An alternative hand hygiene strategy is to use alcohol based hand sanitizers, which have been gaining popularity over the past few years. They work by denaturing the proteins of pathogens they come into contact with. These sanitizers are very convenient, and many people carry them in purses or pockets. Many venues have dispensers with alcohol-based sanitizers available to the public. The advantage is that they are quick, and do not require a water source. In addition, when used, a person simply has to put the product on their hands and rub them together, as opposed to having to stand at a sink with running water.

Despite their convenience, alcohol based sanitizers may be ineffective against certain parasites, bacterial spores, and viruses when hands are soiled (National Association of State Public Health Veterinarians, 2003). However, soiled hands are extremely common after handling wooled or haired mammals. When hands are coated with organic material, such as dirt or fur from petting animals in exhibits, the sanitizer is ineffective because it cannot penetrate those materials adequately to reach the pathogens on skin (CDC, 2002a).

A study that was recently published directly compared the reduction of bacterial counts of animal exhibitors between hand washing for 20 seconds and rubbing hands with alcohol sanitizer 20-25 times (Davis, Sheng, Newman, Hancock, Hovde, 2006). There was no difference reported between the two in reducing bacterial counts on hands. However, the sample size used in this study

was very small, and in many cases, the bacterial counts were actually higher after the use of sanitizer or hand washing (Davis et al., 2006). Further exploration on this topic is necessary prior to concluding that alcohol sanitizer use is as effective as hand washing in preventing pathogen transmission. At this point in time, washing with soap and water is the best strategy to prevent animal to human disease transmission.

Developing an intervention strategy based on guidelines specific to petting zoos could increase proper hygiene among visitors. There are several sets of published guidelines that address overall pathogen transmission in petting zoos, and all mention proper hand washing in particular as a way to prevent pathogen transmission (Bender et al., 2004; NASPHV, 2003; Washington State Department of Health, 2001). Although there are no data assessing the effectiveness of interventions conducted in petting zoos, studies involving health care workers have shown that setting appropriate interventions can greatly increase the number of people washing their hands (Bischoff et al., 2000; CDC, 2002a).

Project Overview

The current study was designed to examine hand washing behavior among petting zoo visitors and to explore demographic and environmental factors that may be associated with hand hygiene at a petting zoo exhibit. From this study we can provide specific recommendations and suggest interventions to reduce the risk of zoonotic disease transmission among visitors to this particular petting zoo.

The study was performed at the Trillium Family Farm Exhibit, a part of the Oregon Zoo, located in Portland, Oregon, during the summer and fall of 2005. This is a large urban zoo housing approximately 1,880 animals in 12 major exhibits. Attendance between July 1, 2004 and June 30, 2005 was 1,333,287 (Oregon Zoo, 2006). The Oregon Zoo is a major tourist attraction for the State of Oregon and Portland.

It is helpful to visualize the Oregon Zoo petting zoo layout, which may differ from other petting zoos or animal exhibits at fairs. See Appendix II for a schematic of the exhibit. When this study was conducted in the summer of 2005, the layout was an open exhibit bordered by the farmhouse on one side, the sheep and goat pens on the opposite side, and two sidewalks. The farmhouse was not open to visitors; it was only used by zoo staff. Animals including rabbits, reptiles, and poultry were displayed on the front porch of the farmhouse, or under tents towards one of the sidewalks. In the barn there were farmer clothes, riding toys, and a large stack of hay bales for children's play. In the open part of the exhibit there was a large display tractor, tractor seats, and benches. The hand washing station was a fixed unit with non-heated water located just outside the barn. There were also two hand sanitizer dispensers, one located in the front of the farmhouse, and the other located near the sidewalk closest to the goat pens. Several small signs (approximately 8X10 inches) are placed around the exhibit reminding visitors not to have food or drink and to wash their hands.

Research Question

This study was designed and conducted to answer the following questions:

- What proportion of petting zoo visitors attempt to clean their hands at all after visiting the exhibit, using either soap and water, or alcohol-based hand sanitizer.
- What proportion of petting zoo visitors demonstrate "proper" hand washing behavior, defined as at least 20 seconds washing with soap and water?
- Are demographic or environmental factors associated with hand hygiene and proper hand washing behaviors?

Specific Aims

The research question can be further separated into the following specific goals:

1. Determine the proportion of a) any hand hygiene, and b) proper hand washing among petting zoo visitors.
2. Explore associations between specific subject factors and the two outcomes of interest (any hand hygiene and proper hand washing).
3. Explore associations between environmental factors and the two outcomes of interest (any hand hygiene and proper hand washing).
4. Create logistic regression models that identify associations between factors and the two outcomes of interest (any hand hygiene and proper hand washing).
5. Make targeted recommendations based on the information gained from this study.

Methods

Pilot Study

A pilot study was performed during the summer of 2004 at the Trillium Family Farm exhibit at the Oregon Zoo to determine optimal data collection methods. The primary investigator and members of the Zoo Teen volunteer group collected the data. During the pilot study, 216 subjects were observed. In the pilot study, 30% of subjects washed their hands with soap and water. (The specific length of time subjects spent washing was not collected during the pilot phase.) The results of the pilot were used to help estimate the sample size needed for the larger, main study. It also provided information needed to redesign the main study and improve data collection methods. The pilot study results gave an estimation of the strength of association necessary to show a statistically significant difference. The pilot experience also led us to replace data collection by the Zoo Teen volunteers with a more experienced group of observers.

The Zoo Teens were only at the zoo once a week, and therefore, the investigator trained 2-3 people every morning prior to data collection. Lack of consistency and inability to correct problems in data collection led the investigator to find a core group of data collectors able and motivated to complete the data collection for the entire study. After careful review by the primary investigator, and feedback from the Zoo Teens, the data collection sheets were re-written to be clearer to observers in the main study.

Setting

Members of the Visitor and Animal Behavior Studies Team [VAST], adult volunteers trained in animal and human observation, performed the data collection. The VAST leaders selected volunteers based on their interest and availability throughout the data collection period.

Study Population and Sample Selection

The study population included any visitor to the Trillium Family Farm exhibit of the Oregon Zoo. A systematic sample selection method was designed to accurately reflect the composition of the population of petting zoo visitors. Since the layout of the petting zoo was an open one (See Appendix II.), "virtual" boundaries were specified to define when people entered and exited the exhibit. For sample selection, observers monitored these boundaries and selected the third person to cross into the exhibit. Observers were instructed to monitor the plane above the boundary, and to choose the third person that crossed after monitoring began. Using this type of systematic selection process, observers would not make potentially biased choices in subject selection, and the resulting estimates would adequately reflect the entire study population.

This study did not include any direct contact with subjects. Other than gender and approximate age, no identifying characteristics were recorded. The Institutional Review Board (IRB) at Oregon Health and Science University (OHSU) approved the study protocol. The Oregon Department of Health and Human Services deemed this study exempt from human subject review because it was an observational study only.

Data Collection Sheets and Variables

The data collection instrument (see Appendix I) contained information about animals and/or objects touched, subject characteristics, hand-to-mouth contact, and hygiene behaviors. These were collected in a yes/no/unknown format for each item.

The yes, no, and unknown response choices were chosen over more detailed choices, such as the length of time spent touching an animal, for several reasons. First, since several people collected data, this was a way to standardize collection. Second, to collect more thorough data, such as how long a subject touched an animal, would require the volunteer to move closer to the subject, therefore possibly alerting the visitor that he or she was being observed. This was not desirable, since subjects may change their behaviors, including hand washing, if they knew they were being observed.

The instrument also included information about the age of subject, size of the accompanying party, as well as ages of the accompanying party members. The observers estimated all ages to the nearest year. These data were used to assess demographic and social correlates of hand washing behaviors. To help correct for differences in age estimation by observers, the subject age variable was categorized into quartiles for analysis.

Separate from the visitor observation data, information was also collected about general conditions at the zoo including animals on exhibit, weather, and crowd density data on a day sheet form filled out at the beginning of each shift. A summary of the data collection steps were as follows:

1. Data collection was done in 3-hour shifts.

2. The VAST volunteer fills out the "day sheet" (see Appendix I.), a one-page document for environmental and external data.
3. The observer monitored the pre-selected boundary until the third person crossed and entered the exhibit (systematically drawn sample).
4. This person was selected as the subject and was observed.
5. The data collection sheet was filled out during the visit (see Appendix I.).
6. The observation concluded when that visitor exited the exhibit.
7. The observer finished the data collection form and added comments if necessary.
8. The observer returned to the entrance and waited for the next third person to cross the pre-selected boundary into the exhibit.

Other Data Sources

As weather and crowd density can be difficult to estimate, other, more objective, data sources were collected for these variables in addition to observer estimation. The daily high temperature in the city of Portland was obtained from the National Weather Service (National Weather Service, 2005). This data was used as a proxy for temperature as it was thought to be more consistent than estimation at the beginning of each shift due to daily temperature variation. Each day the numbers of visitors to the zoo were recorded from a count of tickets that were scanned at the front gate. Ticket scanning and petting zoo crowd estimates by observers were highly correlated; therefore volunteer collected data from the petting zoo was used for subsequent analyses.

Data Quality

The VAST volunteers had intensive training prior to the start of the study. A presentation was held to present the background and significance of the study, as well as study objectives. Dinner was provided and the volunteers were given basic supplies (pens, clipboard, and stopwatch) as well as a small Starbucks gift card. In the first week, data collection training sessions were held in groups of 2 or 3. Training began with the group and investigator observing a single visitor, and discussing proper data collection while practicing how to fill out the data collection sheets. As the training session continued, VAST volunteers collected data individually, and the investigator was present to answer any questions about filling out the data collection forms. Other quality control included: paired data collection (two investigators filling out data collection sheets on the same subject and comparing results), frequent contact with the investigator (by phone, email, and in person), and encouragement of the use of the comments space if any ambiguities arose. A common error was using the "other" category for duck or snake rather than the appropriate poultry and reptile column. However, this was easily corrected during data entry.

Data Management

At the end of each day, surveys were placed in a drawer in the locked volunteer office at the zoo. These were collected twice a week throughout the data collection period. The investigator examined the sheets for errors on a weekly basis. This ensured that any inconsistencies or problems with data collection were addressed and remedied in a timely fashion. The surveys were

assigned a unique identification number and stored at the primary investigator's residence.

Once data collection was completed, all surveys were gathered, and organized by day and observer. Customized data entry forms were created using Microsoft Access ®. The investigator entered all of the surveys into the database. Once all of the surveys were entered, the data was converted to SPSS 11.5 ® for statistical analysis. Additional data management was performed using this software as well.

Prior to statistical analysis, analytic variables were created from survey responses. Important analytic variables and detailed definitions are given below, and will be used throughout the remainder of this document.

- **Subject**- any person that was observed by a VAST volunteer.
    - **Walk Through**- any subject that spent less than one minute in the exhibit and did not touch an animal or object.
    - **No Touch**- a subject that did not touch anything in the exhibit.
    - **Visitor**- a subject that touched something in the exhibit.
- **Hand Hygiene**- refers to the first hygiene event; washing with soap and water, washing with water only, or using alcohol-based hand sanitizer.
    - **Alcohol Sanitizer**- alcohol-based sanitizer provided by the Oregon. Zoo or personal alcohol sanitizer such as *Purell.*
    - **Hand Washing**- washing hands with soap and water.
    - **Proper hand washing**- washing hands for greater than 20 seconds or more with soap and water.

- **Improper hand washing**- washing hands less than 20 seconds with soap and water, using water only, using alcohol sanitizer, or not utilizing any hygiene.
- **Wash time**- time from when water is turned on to when water is turned off.

- **Retouch**- touching an animal or object after completing the first hygiene event.
- **Rewash**- the second hygiene event; not designated as proper vs. improper.

Statistical Analysis

To answer some of the descriptive questions posed in the research questions and aims, we calculated percentages of walk-through subjects, those that did not touch anything, visitors that used hand hygiene, and those that properly washed hands. The percentage of visitors that retouched, and animals that were touched were also calculated. We also evaluated demographic and environmental characteristics using frequency distribution graphs to determine associations with hand hygiene and proper hand washing. We compared those that used any hygiene vs. none, and those with proper hand washing vs. not proper hand washing via Pearson's chi-square tests, odds ratios, and 95% confidence intervals.

A p-value of 0.05 was used as the cut point for determining statistical significance. It was felt that with a small sample size, this would give the best estimate of which factors were associated with the outcomes of interest (any

hand hygiene and proper hand washing). With a relatively small number of factors examined, this was thought to be adequate to avoid finding spurious associations.

Binary logistic regression was used to create multivariable models with both hand hygiene and proper hand washing as dependent variables. Independent variables were selected for the models based on significance of chi-square statistics from contingency tables. Variables were retained in final models if they were statistically significantly associated with hygiene use. The same variables were entered and retained in a model of proper hand washing to facilitate comparison between the different models.

Power and Sample Size

Prior to study implementation, the necessary sample size was determined by using a web-based calculator at University of Iowa (Lenth, 2005) and Epi-Info 2002 ® (CDC, 2002b), available from the CDC. The Lenth web application contains a module that calculates an estimated sample size around one proportion at a given level of confidence and precision. Epi-Info® has a power and sample size calculator that estimates a sample size for a given proportion in one group and a desired odds ratio (CDC, 2002b).

The pilot study gave us a point estimate that ~30% of visitors washed their hands with soap and water. Using this proportion, and an estimated proper hand washing proportion of 0.15, margins of error (i.e. width of the 95% confidence intervals) were calculated for several feasible sample sizes.

Table 1 - Proportions and Confidence Intervals Calculated based on Pilot Study for Different Sample Sizes

	Pilot Study Hand Washing	Estimated Proportion of Proper Hand washing
	0.30	0.15
Sample Size	95% CI	95% CI
150	0.23-0.37	0.10-0.20
200	0.24-0.36	0.11-0.19
250	0.25-0.35	0.11-0.19

Table 1 illustrates that the approximate confidence intervals that can be expected for each given sample size, given that the proportion in the larger study is close to that observed in the pilot study. The margins of error range from 0.05 to 0.07 using the overall hand washing proportion from the pilot study and from 0.04 to 0.05 using the estimate of proper hand washing. These yield reasonably precise estimates to at the 95% confidence level. The sample size required for this level of precision was between 150 and 250 subjects.

Aims 2 and 3 explore associations between specific factors and hand hygiene behavior. Using the approximate sample sizes estimated above, we determined the odds ratios that would be statistically significant (p=0.05 or less) when power equaled 80%. Different risk factor distributions were examined to determine what effect they would have on the detectable odds ratio. For example, if half of the visitors were male and half female, the risk factor distribution would be 0.50/0.50. Similarly, if age is categorized into 4 quartiles, and we are interested in comparing the youngest children to the other three groups, the risk factor distribution would be 0.25/0.75. Using the prevalence and estimate of hand washing and proper hand washing from the above table, with an 80% power and a level of significance of 0.05, we calculated the magnitude of

odds ratios needed to detect a significant association with these risk factor distribution estimates.

Table 2 - Confidence Intervals of Odds Ratios

Risk Factor Distribution	Proportion of Proper Hand washing	Detectable Odds Ratio	Sample Size
0.50/0.50	0.15	2.5-3.2	150-250
0.25/0.75	0.15	2.9-3.9	151-259
0.25/0.75	0.30	2.4-3.1	156-259

Table 2 illustrates that the association between a factor and an outcome must be strong (i.e. above 2.4) to be considered statistically significant given an approximate sample size between 150 and 250 subjects. Nonetheless, a sample size of 150-250, which was reasonable to achieve given the design, timing, and resources available for this study, can be used to create targeted recommendations and help guide future studies.

Results

During the study period, there were 334 subjects observed, with an average of 48 subjects per observer. Of the 334 subjects observed, 218 touched something in the exhibit and were analyzed for Aims 1 through 4.

Throughout the rest of the results and discussion section, reference is made to proper hand washing. The reader should note that this refers to proper hand washing in the first hygiene event. We also analyzed visitors for overall proper hand washing, or washing with soap and water greater than 20 seconds prior to leaving the exhibit without touching an additional animal or object.

Subject age as estimated by volunteers was categorized in the analysis to minimize variability in estimation. Figure one presents a graph of age distribution and illustrates that young children and 20-30 year olds make up the majority of visitors to the petting zoo. Adolescents and older adults are represented less frequently.

Figure 1- Estimated Age Distribution of Subjects (n=334)

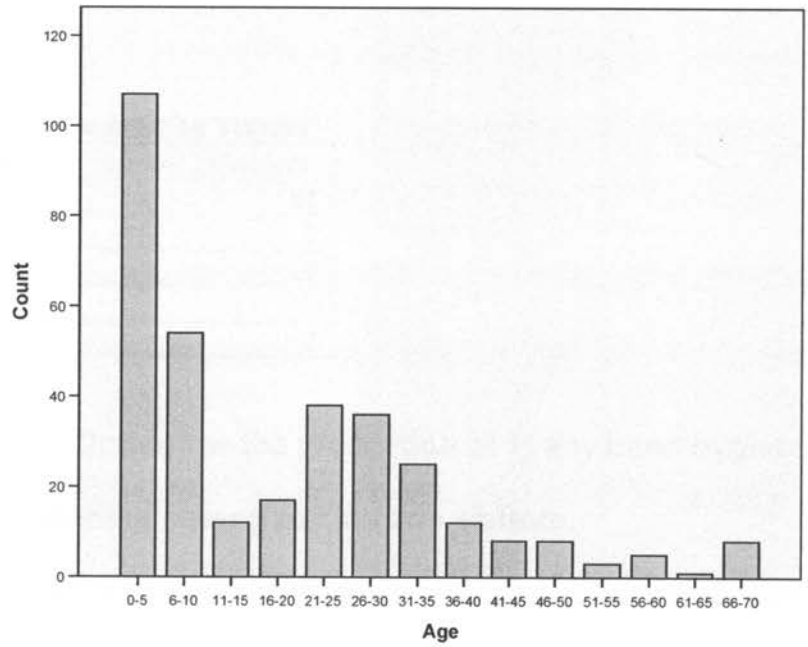


Table 3 - The Odds of Touching an Animal or Object by Age Using 0-4 Years as the Referent Category

Age	Touched an Animal or Object	Did not Touch Animal or Object	Crude OR (95% Confidence Interval)
0-4 Years	70 (79.5%)	18 (20.5%)	1.00
5-10 Years	57 (78.1%)	16 (21.9%)	0.92 (0.43-1.96)
11-28 Years	50 (59.5%)	34 (40.5%)	0.38 (0.19-0.74)
29+ Years	42 (47.2%)	47 (53.8%)	0.23 (0.12-0.45)

Table 3 illustrates that the odds of touching an animal or object decreased with age. Children 10 and under had the highest odds of touching an animal or object. Teens and adults were far less likely to touch anything.

During the study there were five species of animals available for visitors to touch. One hundred eleven visitors touched one or more animals during their visit (11 touched an animal only, 100 touched an animal and an object). The remaining 107 of the 218 who touched something in the exhibit touched an object only. Table 4 presents the animals available and how many visitors touched

each species. Note, however, that not all species were always on display; therefore Table 4 is largely a reflection of availability rather than visitor preference.

Table 4 - Animals Touched by Visitors

Animal Touched	Number of Visitors
Goats	81
Sheep	3
Rabbits	28
Reptiles	3
Poultry	7

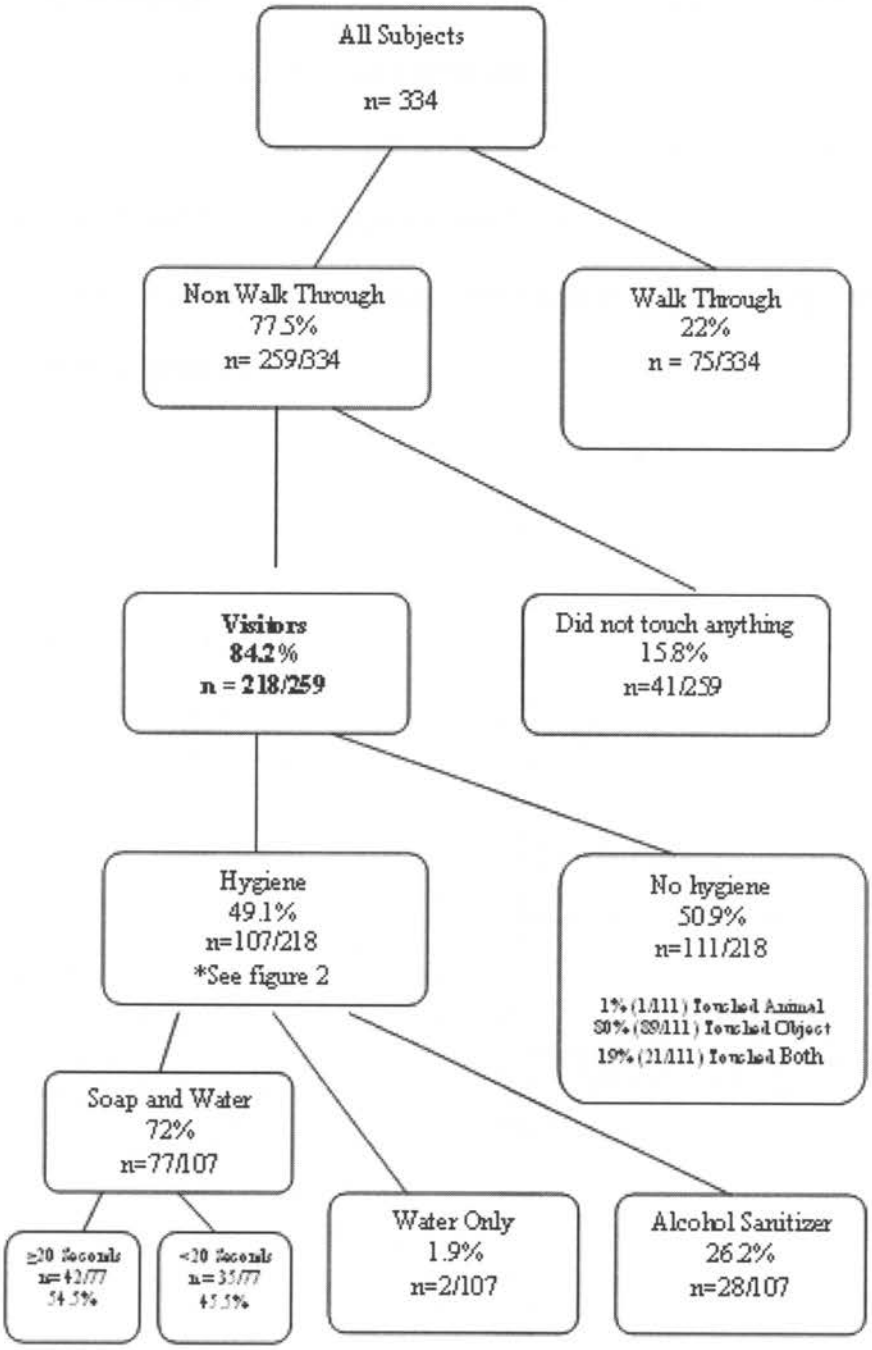
Specific Aim 1. Determine the proportion of 1) any hand hygiene, and 2) proper hand washing among petting zoo visitors.

Figure 2 clearly illustrates how each subject was categorized according to the definitions outlined in the data management section. As shown in Figure 2, 22% (75/334) of the subjects observed simply walked through the exhibit. Of those that spent time in the petting zoo, 84.2% (218/259) touched either an animal or an object during their visit.

About half of the subjects that touched something either washed their hands or used alcohol sanitizer. Of those that used some type of hygiene, 72% (77/107) washed with soap and water, 1.9% (2/107) washed with water only, and 26.2% (28/107) used alcohol sanitizer. Of the visitors that used soap and water, just over half washed properly. Just over half (111/219, 50.9%) of visitors that touched an animal or object used no hygiene at all. Of those, 19.8% (22/111) touched an animal, 97.3% (108/111) touched an object, and 18.0% (20/111) touched both an animal and an object. Overall, 42/218 or 19% of those subjects

that touched something properly washed their hands during the first hygiene event.

Figure 2 - Separation of Subjects According to Level of Interaction with the Petting Zoo Exhibit and Hygiene Characteristics



Figures 3 further addresses Aim 1, as it demonstrates the impact that retouching an animal or object has on proper hand washing. Of those that used any form of hygiene (n = 107), an additional 40 visitors re-touched an animal or object, and did not use hygiene products a second time. The decrease in the total number of visitors using hygiene went from 51.3% (107/218) to 30.7% (67/218). Less than half of the visitors that used any type of hygiene washed properly (from Figure 2).

Figure 3- Diagram Illustrating that Visitors Re-touched Animals or Objects after the First Hygiene Event and did not Re-wash or Reuse Alcohol Sanitizer Prior to Leaving the Exhibit

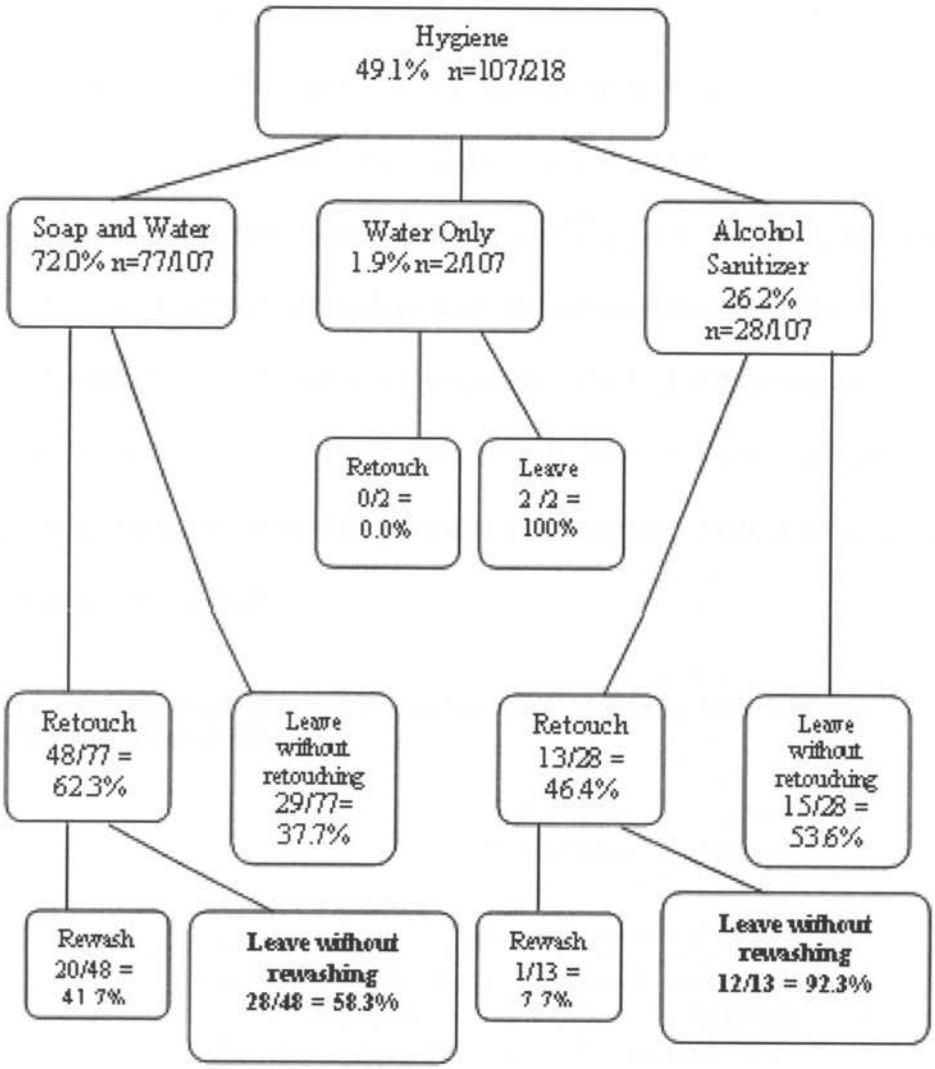
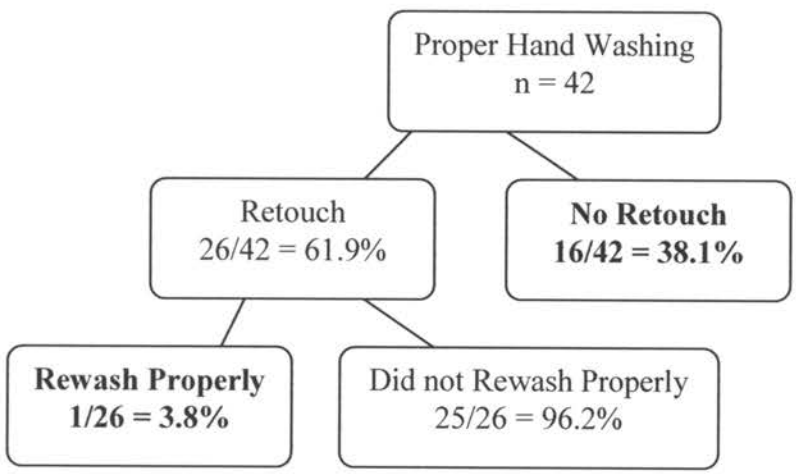


Figure 4 illustrates the impact of retouching an animal or object, and failure to re-wash properly prior to leaving the exhibit. Of the 42 visitors who washed with soap and water greater than 20 seconds for the first hygiene event, 61.9% (26/42) retouched an animal or object. Of these, only 3.8% (1/26) rewashed properly. This reduces the number of visitors washing properly prior to leaving the exhibit from 19% (42/218) to 7.8% (17/218). As the outcome we are examining in this section is proper hand washing prior to leaving the exhibit, we also examined the data for visitors that did not wash properly the first time, but washed properly prior to leaving the exhibit. We found that one visitor washed improperly the first time, but washed properly prior to leaving the exhibit. This brings the proportion of visitors properly washing their hands prior to leaving the exhibit to 8.3% (18/218).

Figure 4- Diagram Illustrating the Proportion of Visitors who Re-washed Properly after Re-touching an Animal or Object



Specific Aim 2. Explore associations between specific subject factors and the two outcomes of interest (any hand hygiene and proper hand washing).

Specific Aim 3. Explore associations between environmental factors and the two outcomes of interest (any hand hygiene and proper hand washing).

The data collection sheet contained many factors, including subject characteristics and environment descriptors that could potentially be associated with hand hygiene behavior. Table 5 presents the proportion and crude odds ratios for the association between each factor examined and the use of any hand hygiene. Table 6 presents the proportion and crude odds ratios for the association between each factor and proper hand washing. The mean time spent in the exhibit is presented as a continuous variable and an independent samples t-test p-value is given for this variable to determine significance. For each of the categorical variables, the first category is the referent category, and labeled with a crude odds ratio of 1.00.

Table 5- Hygiene Usage Differences between Demographic Groups and Environmental Factors among Visitors to the Petting Zoo that Touched an Animal or Object (n=218)

Any Hygiene	Yes	No		
	107(49.1%)	111(50.9%)		
Animal Touch			Crude OR	
No	20 (18.5%)	88 (81.5%)	1.00	
Yes	87 (79.1%)	23 (20.9%)	**16.64 (8.53-32.47)**	
Age	Hygiene Yes	Hygiene No	Crude OR	
0-4 Years	44 (62.8%)	26 (37.1%)	1.00	
5-10 Years	28 (49.1%)	29 (50.9%)	0.57 (0.28-1.16)	
11-28 Years	17 (34.7%)	32 (65.3%)	**0.31 (0.15-0.67)**	
29+ Years	18 (42.8%)	24 (57.1%)	**0.44 (0.20-0.97)**	
Of those that used hygiene	Soap and Water	Water	Alcohol Sanitizer	Total
0-4 Years	29 (64.4%)	1 (2.2%)	15 (33.3%)	45
5-10 Years	20 (66.7%)	1 (3.3%)	9 (30.0%)	30
11-28 Years	14 (73.7%)	0	5 (26.3%)	19
29+ Years	77 (95.1%)	0	4 (4.9%)	81
	Hygiene Yes	Hygiene No	Crude OR	
Male	50 (45.9%)	59 (54.1%)	1.00	
Female	50 (52.3%)	51 (50.9%)	1.30 (0.79-2.21)	
Of those that used Hygiene	Soap and Water	Water Only	Alcohol Sanitizer	Total
Male	34 (64.2%)	1 (1.9%)	18 (34.0%)	53
Female	43 (74.1%)	1 (1.7%)	14 (24.1%)	58
			Crude OR	p-value
	Hygiene Yes	Hygiene No		**<0.001**
** Mean Time Spent in exhibit	9.12 +/- 0.44	6.24 +/- 0.41	**1.17 (1.09-1.25)**	
Ratio of Children to Adults	Hygiene Yes	Hygiene No	Crude OR	
0-0.5	27 (42.2%)	37 (57.8%)	1.00	
0.6-1.0	39 (53.4%)	34 (46.6%)	1.57 (0.80-3.09)	
1.1-2.0	27 (48.2%)	29 (51.8%	1.28 (0.62-2.63)	
2.1+	14 (56.0%)	11 (44.0%)	1.74 (0.69-4.43)	
Crowd Density	Hygiene Yes	Hygiene No	Crude OR	
0-14 Visitors in Exhibit	78 (49.4%)	80 (50.6%)	1.00	
15+ Visitors in Exhibit	29 (48.3%)	31 (51.7%)	0.96 (0.53-1.74)	

*** Mean time spent is a continuous variable.*

The crude OR presented from logistic modeling refers to an increase in the odds of hand washing per minute of time spent in the exhibit.

Crude odds ratios presented in bold font are statistically significant at the 0.05-level.

Table 6- Hygiene Usage Differences between Demographic Groups and Environmental Factors among Visitors to the Petting Zoo that Touched an Animal or Object (n=218)

Proper First Hygiene	Yes	No		
	42 (19.3%)	176 (80.7%)		
Age	Proper Yes	Proper No	Crude OR	
0-4 Years	16 (22.9%)	54 (77.1%)	1.00	
5-10 Years	11 (19.3%)	46 (80.7%)	0.81 (0.34-1.91)	
11-28 Years	10 (20.4%)	39 (79.6%)	0.87 (0.36-2.11)	
29+ Years	5 (11.9%)	37 (88.1%)	0.46 (0.15-1.35)	
	Proper Yes	Proper No	Crude OR	
Male	18 (16.5%)	91 (83.5%)	1.00	
Female	24 (22.4%)	83 (77.6%)	1.46 (0.74-2.89)	
				p-value
	Proper Yes	Proper No	Crude OR	**0.004**
**Mean Time Spent	9.50 +/- 0.63	7.22 +/- .35	**1.10 (1.03-1.18)**	
Ratio of Children to Adults	Proper Yes	Proper No	Crude OR	
0-0.5	8 (12.5%)	56 (87.5%)	1.00	
0.6-1.0	18 (24.7%)	55 (75.3%)	2.29 (0.92-5.70)	
1.1-2.0	11 (19.6%)	45 (80.4%)	1.71 (0.64-4.61)	
2.1+	5 (20.0%)	20 (80.0%)	1.75 (0.51-5.98)	
Crowd Density	Proper Yes	Proper No	Crude OR	
0-14 Visitors in Exhibit	126 (79.7%)	32 (20.3%)	1.00	
15+ Visitors in Exhibit	50 (83.3%)	10 (16.7%)	0.79 (0.36-1.72)	

*** Mean time spent is a continuous variable.*
The crude OR presented from logistic modeling refers to an increase in the odds of hand washing per minute of time spent in the exhibit.
Crude odds ratios presented in bold font are statistically significant at the 0.05-level.

Tables 5 and 6 present associations between selected visitor and environmental characteristics on hygiene and proper hygiene. Age was marginally significantly associated with whether or not any hygiene was used. Compared to the youngest age group (0-4 years), subjects in all of the other groups had lower hygiene usage rates; the oldest two groups had statistically significantly lower rates. Age was not significantly associated with proper

hygiene, but was with any hand hygiene. Gender was not associated with either outcome variable. Very few visitors used water only to wash their hands (2/107, 2%). Daily precipitation was not associated with hygiene usage. The time spent in the exhibit was very strongly associated with whether or not a visitor used hygiene at all, and also significantly associated with proper hand washing. Those who used any hygiene spent an average of 9.1 minutes in the exhibit, while those that did not use hygiene spent an average of 6.2 minutes. Those visitors who used properly washed their hands spent an average of 9.5 minutes in the exhibit, compared to 7.2 minutes for those that did not properly wash their hands. Lastly, group ratio and petting zoo crowd density (as estimated by observers, not ticket sales) were not associated with either outcome variable.

An additional factor that was examined was whether or not Zoo Teen volunteers had an impact on hand hygiene of visitors. We chose to present this separately as its role in confounding is explored in the next section. The teen volunteers were responsible for monitoring all of the animal exhibits when open, and to remind visitors to wash their hands after touching animals. The following table illustrates the impact on hygiene.

Table 7- Impact of Zoo Teen Volunteers Verbally Instructing Visitors that Touched an Animal or Object to Wash Hands

	Hygiene Yes	Hygiene No	Crude OR
Volunteers Not Present	9 (25.7%)	26 (74.3%)	1.00
Volunteers Present	98 (53.5%)	85 (46.4%)	**3.33** (1.48 - 7.50)

	Proper Yes	Proper No	Crude OR
Volunteers Not Present	4 (11.4%)	31 (86.6%)	1.00
Volunteers Present	38 (20.8%)	145 (79.2%)	2.03 (0.68 - 6.1)

Crude odds ratios presented in bold font are statistically significant at the 0.05-level.

Table 7 illustrates that when Zoo Teen volunteers were there to remind people to wash, the odds of using any hand hygiene were 3.3 times higher than when they were not present. The odds of proper hand washing were 2.0 times higher than when volunteers were not present although it must be noted that this latter estimate is not statistically significant as the confidence interval contains 1.0.

However, as shown in Table 8, when Zoo Teen volunteers were not present, there were no animals on display for visitors to touch. There could be a confounding effect between the presence of Zoo Teen volunteers, touching an animal, and outcome. This is because during times when Zoo Teen volunteers were not present, visitors could touch objects, but not animals. An exception to this is the 7 visitors that touched animals through the fence in the barn.

Table 8- The Impact of the Presence of Zoo Teen Volunteers on Touching an Animal, among the 218 Visitors who Touched an Animal or Object in the Trillium Farm Petting Zoo Exhibit

	Did Not Touch an Animal (Touched Object Only)	Touched an Animal	p-value*
Volunteers Not Present	28 (80.0%)	7 (20.0%)	<0.001
Volunteers Present	81 (44.3%)	102 (55.7%)	

* *p-value from chi-square test of independence.*

The presence of Zoo Teen volunteers was very strongly associated with whether or not a visitor touched an animal. The presence of Zoo Teen volunteers was used as the factor of interest in logistic regression models (next section), as removing animals, or discouraging visitors from touching the animals, defeats the purpose a petting zoo, and thus, would not be helpful for intervention planning.

There were other variables assessed that were not presented in tables 5 through 7. These include hand-to-mouth contact (Y/N), day of week, and whether hand hygiene supplies were available (Y/N). Hand-to-mouth contact documented by observers included eating, drinking, and thumb sucking behavior Overall, 4.2% of visitors that touched an animal or object engaged in some or all of these hand-to-mouth contact activities. Additionally, 1.8% of the same population had hand-to-mouth contact after the first hygiene event. The day of week had no impact on whether or not a visitor was more or less likely to wash their hands. It was noted on the day sheet at the beginning of every shift that water, soap, and paper towels were available. There were no subjects recorded that did not have available supplies. Observers also recorded whether or not it was a zoo-sponsored special day (e.g. reduced admission, senior day, or a

concert that evening), but this was not found to have a significant relationship with hand hygiene or hand washing behavior.

Specific Aim 4. Create logistic regression models that identify associations between factors and the two outcomes of interest (any hand hygiene and proper hand washing).

The factors identified in the previous section that were significant at the 0.05 level were placed as independent variables into a binary logistic regression model with any hand hygiene and proper hand washing as dependent variables. Those factors that remained significant at the 0.05 level in the multivariable model with first hygiene as the dependent variable were retained in both models. These results are presented in Tables 9 and 10 (columns 4 and 5).

Table 9- Odds Ratios from Simple and Multiple Logistic Regression Models with First Hygiene as the Dependent Variable

	Crude OR	95% Confidence Interval	Model OR	95% Confidence Interval
Age				
0-4 Years	1.00			
5-10 Years	0.57	0.28 - 1.16	0.46	0.21 - 1.02
11-28 Years	0.31	0.15 - 0.67	0.24	**0.10 - 0.57**
28+	0.44	0.20 - 0.97	0.33	**0.14 - 0.79**
*Time Spent	1.12	1.09 - 1.25	1.20	**1.12 - 1.30**
Volunteers Present				
No	1.00			
Yes	3.33	1.48 - 7.5	6.63	**2.50 - 17.60**

**Time spent was a continuous variable, thus the OR is interpreted as for every one minute increase in time spent in the exhibit, the odds of hygiene are X times higher.*

Table 10- Odds Ratios from Simple and Multiple Logistic Regression Models with Proper First Hygiene as the Dependent Variable

	Crude OR	95% Confidence Interval	Model OR	95% Confidence Interval
Age				
0-4 Years	1.00			
5-10 Years	0.81	0.34 - 1.91	0.76	0.31 – 1.86
11-28 Years	0.87	0.36 - 2.11	0.85	0.34 – 2.15
28+	0.46	0.16 - 1.35	0.41	0.14 – 1.26
*Time Spent	1.10	1.03 - 1.18	1.12	**1.04 – 1.20**
Volunteers Present				
No	1.00			
Yes	2.03	0.68 - 6.11	2.61	0.82 – 8.27

** Time spent was a continuous variable, thus the OR is interpreted as for every one minute increase in time spent in the exhibit, the odds of hygiene are X times higher.*

In model with any hand hygiene (y/n) ad the dependent variable, the independent variables retained in the model included: age group (4 categories), time spent in the exhibit (in minutes), and the presence of volunteers (yes/no). Young children were the most likely to engage in a hygiene activity, as the odds of first hygiene use were less for all other age groups versus the 0 – 4 age group. The longer a person spent at the exhibit, the more likely they were to

use hygiene (OR = 1.20; 95%CI: 1.12 – 1.30). Zoo Teen volunteer presence was very highly associated with visitors engaging in a hand hygiene activity after touching something, with odds being over 6 times higher when they were present versus not.

In the model with proper hand washing (y/n) as the dependent variable, the independent variables showed similar trends as the previous model. Age and volunteers were not significant at the 0.05-level; however they remained in the model for comparison to the first hygiene model. In addition, each odds ratio estimate was in the same direction as the previous model, and would likely have been statistically significant, and noted as important, if the sample size were larger. As with the first hygiene model, the youngest age group (0 – 4 years) was the most likely to engage in proper hand washing, as the odds ratios were lower for the other three groups. Time spent was positively associated with proper hand washing (OR 1.12; 95% CI: 1.04 – 1.20). The findings stayed consistent with the presence of Zoo Teen volunteers as well. When they were present, the odds of proper hand washing were 2.6 times higher then when volunteers were not present in the exhibit.

Discussion

The most important result noted in this study was that visitors to petting zoos, who touch animals and/or objects, do not, as a rule, properly cleanse their hands. Our study found that few of the subject and environmental factors explored were significantly associated with hand hygiene. Those that were associated included visitor age and time spent in exhibit. The presence of Zoo Teen volunteers, who were present when animals were on display, and who would routinely remind visitors to wash their hands, also showed a positive association with hygiene behaviors.

Our study may be the first of its type to examine proper hand washing prevalence in petting zoo attendees. The low prevalence of proper hand washing is important when taken in the context of potential for disease transmission. A recent article cultured animals at agricultural fairs for a pathogenic strain of *E. coli,* and found that 14% of beef cattle, 4% of goats, and 2% of sheep were positive (Keen et al., 2006). *E. coli* is only one of the diseases animals can harbor. Changes need to occur in animal settings to reduce the risk, and the most effective way to do this is to wash hands.

Two major outbreaks of enteric disease associated with animal settings, close the Oregon Zoo, in Lane County and Snohomish County in Washington occurred prior to the opening of the petting zoo exhibit studied in this investigation (CDC, 2001; Keene, deBroekert, Gillette, 2004). Likely, as an indirect result, several venues, including the Oregon Zoo and the Oregon State Fair, made changes to animal petting exhibits. One example was the hand

washing challenge station installed at the petting zoo exhibit at the 2005 Oregon State Fair. The station was designed to ensure that all visitors washed, and did so properly by washing for 20 seconds or greater with soap and water (KGW News Channel 8, 2005). The challenge involved a staff member monitoring visitors for proper hand washing behavior, and a black light available for visitors to examine hands after washing for residual soiling. Those that washed properly received a sticker. Although no study was performed to look at hand washing prevalence at the fair, it would be interesting to compare those rates to the fair before these changes were made, and to other settings to explore if these changes made a difference in hand washing.

It has been long known that animals can harbor disease and that visitors should wash their hands. The low hand washing prevalence found by our study shows that having a hand washing station is not enough motivation for the majority of visitors. Every venue needs to have published guidelines and proactive methods, such as licensing and inspections, to ensure the safety of petting zoo visitors.

In the current study, the youngest visitors were the most likely to use any hand hygiene (soap and water, water only, or alcohol-based sanitizer), also most likely to properly wash hands. Since adults supervise infants and young children when visiting the petting zoo, this finding likely reflects the emphasis the caregiver places on hand washing. There are several reasons that other age groups may not feel it is as important to wash. Adults may feel that their contact with animals and/or objects was minimal, and does not require hand hygiene.

Their children, however, may have had more contact with the animals or toys and have dirtier hands. Adults may also be more focused on child hygiene, since infants and young children are more likely to engage in hand- to-mouth contact. Some adults may perceive that only young children are at risk for contacting disease. Finally, time may be limited for some adults caring for children, and they simply do not have the opportunity to wash. However, it must be noted, that although the youngest age group is most likely to exhibit hand hygiene and proper hand washing behaviors, the overall prevalence in all groups is still very low. Recommendations to increase hand washing should be targeted to all visitors, not just the older age groups, to most effectively discourage the spread of pathogens.

The amount of time spent in the exhibit was significantly associated with each outcome. A small part of this is likely due to the physical time spent walking to the hand washing (or alcohol sanitizer) station, and the time spent engaged in hand hygiene. However, this cannot account for the large average difference in time spent between those that washed, and those that did not, which was well over the 20 seconds it takes to properly wash hands. Visitors that spent more time in the exhibit could have been exposed more frequently to signs and reminders from Zoo Teens. A visitor may perceive that their hands are more soiled after spending a greater length of time in the exhibit. A future study could incorporate exit interviews with visitors to determine why those that stay longer are more likely to cleanse their hands.

The presence of Zoo Teen volunteers and touching an animal were both strongly associated with engaging in some type of hand hygiene activity. It should be noted, that Zoo Teen presence and animal touching were strongly associated with each other as well. Animal exhibits in the petting zoo are not officially open to the public without a Zoo Teen or other Zoo staff member present. Zoo staff members are responsible for opening gates to the sheep and goat pens, and for transporting and holding the other animals for visitors to touch. The Zoo Teens are commonly assigned this duty during summer months. Due to the timing of the current investigation (late summer 2005), the majority of observations occurred when the Zoo Teens were present in the exhibit. However, we did observe some visitors touching animals during times when the petting zoo exhibit was not open, and Zoo Teens were not present. This corresponded to visitors reaching through fences to touch animals housed in pens (sheep and goats), even though the gates to the pens were closed. We elected to keep all of the visitors' observations in our analysis, whether the petting zoo was officially open or not, as touching animals through fences placed visitors at risk of pathogen transmission if they failed to properly wash their hands.

Interestingly, when Zoo Teen presence and animal touching (yes/no) were placed in the multiple logistic regression models together, the adjusted odds ratios for each factor became stronger than the crude odds ratios. This illustrates their confounded relationship further. The Zoo Teen volunteers reminded visitors to wash after touching an animal (if they were available) and/or an object on display in the exhibit. This reminder likely had a positive impact on hand hygiene.

On the other hand, visitors may be more motivated to wash after touching an animal versus touching objects on display. People often perceive animals as dirty and therefore their hands are dirty after touching an animal. An important finding of this study is that those who touched an object only were less likely to wash. This is a specific issue with the layout of the Trillium Family Farm exhibit as with the open design, there is no boundary between animal and non-animal areas.

To the author's knowledge, no study has examined or reported gender differences in hand washing behavior. We found no statistically significant difference in either any hygiene or proper hand washing between male and female. It is unknown whether or not this could translate to other settings, but could easily be examined again in future studies.

The guidelines previously cited for animal exhibits include banning food and drink, as well as placing signs to remind visitors to refrain from hand-to-mouth contact while in the exhibit (Washington State Department of Health, 2001). We found that hand-to-mouth contact was not very commonly observed in our study. The Trillium Farm had implemented some prevention measures to reduce hand-to-mouth contact during the time this study was conducted. There were signs posted telling visitors not to eat or drink, and, in addition Zoo Teens (when they were present) required that food and drink not be allowed near the animals. The low incidence observed in this study may mean that these measures were effective. It is unknown if this low rate of contact is unique to this petting zoo, all petting zoos, or the general population.

During the data collection period, goats were on display the most often. The sheep were taken off exhibit at the beginning of the data collection period due to behavior problems. Reptiles and poultry were only available intermittently. Due to the inconsistency of availability, and the small number of visitors who touched each type of animal, differences in hand hygiene between species available or species touched could not be explored. However, visitors to the petting zoo could potentially view the risk of disease of one species of animal as higher than another, and alter their hand hygiene behavior according to which type of animal was touched. A future study could explore this relationship in more detail.

Methodological Challenges

A challenging aspect of this study was determining what constituted proper hand washing. The literature sources reviewed recommended hand washing with soap and water as the most effective method of cleansing hands after visiting a petting zoo (Bender et al., 2004; LeJeune & Davis, 2004; Middlesex-London Health Unit Investigation, 2002; Milne et al., 1999; NASPHV, 2003, 2004, 2005; Washington State Department of Health, 2001). However, none of these sources give a consistent length of time required to wash hands. One reference recommends washing greater that 10 seconds (Wendt, 2001), while another uses the amount of liquid soap used as part of the definition of proper hand washing (Bischoff et al., 2000). The CDC recommends washing for 20 seconds for food handlers and with the Clean Hands Save Lives campaign (CDC, n.d.). However, the CDC does not define precisely what is meant by 20

seconds in this campaign. Keen et al. define proper hand washing as 10 seconds lathering with an antibacterial soap, and rinsing for another 10 seconds (Keen et al., 2006). For our study, to ensure the observers did not have contact with visitors and to have the most consistent data collection, we used the time from when the water was turned on, to when it was turned off. In our study, the mean and median time spent washing (among those who washed with soap and water) were 22.6 seconds and 20 seconds respectively. Therefore, we felt that using other guidelines of 20 seconds to define proper hand washing was reasonable for this study.

The decision was made during analysis to analyze only those subjects that touched an animal or object. Although this reduced the analytic sample size by 35%, this was thought to be the best representation of the population we wanted to study. There are many ways people can contract zoonotic disease other than through pathogens on their hands, such as through breathing in dust. However, our outcome was not zoonotic disease potential, but hand hygiene and proper hand washing in particular. Therefore, the most important population was those subjects that touched something in the petting zoo, not those that simply were present at some point.

Recommendations

The final aim of this project (Aim 5) was to provide targeted recommendations for the Oregon Zoo based on the study findings. Several publications are available that give general recommendations for petting zoo proprietors. The *Compendium of Measures to Prevent Disease and Injury*

Associated With Animals in Public Settings is published yearly by the National Association of State Public Health Veterinarians gives very complete recommendations (NASPHV, 2003, 2004, 2005). Individual states also have similar publications. The Washington State Department of Health produced a publication titled *Recommendations to Reduce the Risk of Disease Transmission From Animals to Humans at Petting Zoos, Fairs and Other Animal Exhibits* (2001). Each of these titles is completely referenced in the reference section at the end of the document.

The open design of Trillium Farm allows for cross-contamination between animal and non-animal areas (See Appendix II for exhibit layout schematic). The ideal solution is to separate the two sections of the exhibit. The petting zoo animal area should be reserved for those that want to touch an animal and their parent or guardian, if applicable. Ideally, the visitor traffic flow would be through an entrance area to animal areas of the petting zoo, then through a distinct exit that funnels directly to a hand washing station (LeJeune & Davis, 2004). In the current layout, visitors are moving in different directions, making it more difficult to physically get to the hand washing station. The most effective way to improve traffic flow is to have a separate area for animal exhibits. There should be a fence around this area, and the animals should be prevented from reaching this fence to prevent visitors from petting animals through the fence. In the current Trillium Farm layout, a fence could be installed enclosing the hand washing station, barn, sheep and goat exhibits without major disruption to the exhibit. Alternative animal exhibits such as reptiles, poultry, rabbits, and animal hides

could be moved inside the barn. Moving the animal exhibits inside the barn would require that the hay bales, farmer clothes, and other toys be moved outside this area to make it an animal interaction area only. The fence could have two gates clearly marked as entrance and exit to inform visitors they are entering an animal area. Implementing these changes should have a big impact on reducing the number of people entering the animal areas that are not directly interacting with the exhibit, yet still allow people to walk through to other exhibits.

If fencing is adopted, the alcohol sanitizer dispensers would not need to be removed. Instead, they could remain, as they would be located outside of the fenced animal interaction area. This would decrease the number of visitors using alcohol sanitizer, rather than soap and water, after touching an animal. Visitors could still use the alcohol sanitizer after touching other objects outside the animal area of the exhibit.

An alternative, if fencing is not adopted, would be to change signage around the alcohol sanitizer dispensers. Signs near the dispensers could state that alcohol sanitizer is not as effective when hands are soiled after touching an animal, and that visitors should wash with soap and water instead if they have touched an animal. Zoo teens could also routinely suggest this to visitors to bring attention to this issue.

There are several ways to increase the hand washing among visitors. Signs at the hand washing station can state that washing for 20 seconds is ideal for removing all potential pathogens from hands. However, it is challenging for visitors to measure 20 seconds. One recommendation is to sing "Happy

Birthday" silently at a normal tempo two times (CDC, n.d.). Another suggestion is to have second clocks installed above the hand washing station. Visitors could measure hand washing according to the clocks. Increasing awareness and giving visitors concrete ways to measure the time spent hand washing should increase the number of visitors washing greater than 20 seconds.

Time spent visiting the petting zoo, while associated with proper hand washing, does not lend itself to targeted recommendations. It is unlikely that encouraging visitors to stay longer in the petting zoo would increase proper hand washing rates.

Decreasing the number of visitors retouching animals or objects without rewashing their hands can be addressed in several ways. Adding the fencing as described above would make this behavior much less likely. Visitors would have to consciously re-enter the animal exhibit and walk past the hand washing station again. Since animal exhibits would no longer be present at the periphery of Trillium farm, it would be more challenging for visitors to touch an animal and fail to rewash.

Again, an alternative that does not involve fencing would be signage targeted at this issue. Informing visitors that they must wash their hands with soap and water each time they touch an animal would decrease any perception that hands remain clean for a time after washing.

Zoo Teen volunteers should continue to remind visitors to wash after touching an animal. The teens can also include that visitors should wash with soap and water greater than 20 seconds. They should be present whenever the

exhibit is open. If unavailable, Oregon Zoo staff should fulfill that roll. These volunteers should be trained that these animals can carry pathogens that can make visitors very ill. They can also monitor to ensure that visitors do not bring food or drink into the exhibit and help watch young children for hand-to-mouth contact while in the exhibit.

Strengths and Limitations

The above study is the first to systematically observe hand washing behaviors in a petting zoo. It has produced valuable information about the overall prevalence of hand washing and associated factors. Recommendations given in this document can be implemented at Trillium Farm, or, potentially at other similar petting zoos, that will help to prevent pathogen transmission. When new petting zoos are designed, the information gained from this study can aid in the new design.

The unobtrusiveness of the observers was strength of the current investigation. The study described in the prevention section of the background compared observed data to a telephone survey shows that the behavior can be very different when outcome is known to the participant (American Society of Microbiology, 2003). These subjects are both unaware of the hypothesis and that they are taking part in a study allowing accurate data to be collected.

Since trained observers did not have any contact with petting zoo visitors, they were forced to estimate ages rather than asking people to report their age. Using age estimation rather than directly collecting age data has a potential to introduce bias. Each volunteer may have estimated somewhat differently. This

could add non-differential misclassification of age between the different volunteers. However, age was collapsed into 4 broad categories that should have minimized small differences in age estimation. During the training session

There were some additional limitations in the timing and with data collection methods used in this study. One of the VAST members became ill and was unable to collect any data during the study. As the data was collected over a very short, intense period of time, the subjects that would have been collected by that volunteer could not be replaced resulting in a smaller sample size. Similarly, on several occasions the exhibit would open late or close early and volunteers were unable to collect data during their designated shift. Since observers had other obligations around the zoo, these missed data collection shifts were not replaced, also contributing to a smaller than anticipated sample size. However, an adequate sample size was still reached to provide meaningful conclusions.

Collecting the data in "yes or no" fashion can potentially limit the information that can be obtained from the study. For example, there may be a relationship between the length of time a visitor spends touching an animal and the frequency and duration of hand washing. This cannot be determined by the format of data collection used in this investigation. Nonetheless, this format was most feasible and improved consistency between observers and shortened data collection time.

Each petting zoo, fair, and other animal exhibits are all designed differently. This may affect the generalizability of the results from this study.

What may be effective in the Oregon Zoo may not be in other animal settings. However, this study is very valuable, as it will lay the framework for specific recommendations and further studies.

Another limitation expected is the timing of the study. Originally, the zoo requested that the originally proposed study (intervention) take place after Labor Day to avoid conflict with the public during the busy season. The study was modified to become strictly observational and the zoo allowed it to occur earlier in the season. To complete the study during this year, once clearance was given, there were only a few weeks to conduct the study. As a result there was homogeneity of the weather and crowd density during the data collection period, as well as a smaller sample size than if the study had been conducted over a longer period of time.

The last limitation was the reduction in sample size after eliminating those that walked through or did not touch an animal or object from the analysis. Although this did decrease the sample size, it was felt that it was more important to analyze those visitors realistically at risk for contracting a zoonotic disease, rather than to examine all visitors.

Conclusion

The prevalence of visitors using any hygiene was very low, and the prevalence of visitors washing properly was lower. The results of this study identify factors that are associated with the low number of visitors washing their hands. Recommendations based on the results were presented. Implementing these changes should increase the number of visitors washing their hands and may help prevent the transmission of zoonotic disease among petting zoo attendees.

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Appendix I.

Family Farm Study Survey Initial Form
(Fill out once at the beginning of each shift)

Interviewer _____

Day of Week _____
Specify Time (circle one) Morning Afternoon

Special Day – (i.e. 2$ Tuesday, concert, Holiday)
_____

Animals On Exhibit (circle all that apply)
Goats
Sheep
Reptiles
Rabbits
Poultry
Other (please specify) -

Weather –
_____F Degrees
Cloud cover (choose one) None, Partial, Full
Precipitation None, Light, Heavy

Are soap, water, paper towels, and alcohol based sanitizer stations all available?

Soap	Yes	No
Water	Yes	No
Paper towels	Yes	No
Alcohol Sanitizer	Yes	No

Are volunteers routinely reminding people to wash their hands? Y / N

FAMILY FARM STUDY AT THE ZOO Observer _____

Date _____ Time In _____ Time Out _____

Estimated Age _____ Sex ❒ M ❒ F ❒ can't tell

At entrance, subject is... ❒ walking ❒ carried ❒ in stroller

Group Size (*include subject*) Adult Males ____ Adult Females ____ Children 0–5 ____ Children 6–18 ____

Estimated crowd density in exhibit area at subject's starting time:

❒ sparse (0-4) ❒ low (5-14) ❒ moderate (15-29) ❒ high (30-44) ❒ very high (45+)

Yes	DK	No	ANIMALS AND OBJECTS TOUCHED
A ❒	❒	❒	goats
B ❒	❒	❒	sheep
C ❒	❒	❒	rabbits
D ❒	❒	❒	reptiles
E ❒	❒	❒	poultry
F ❒	❒	❒	other animal _____
G ❒	❒	❒	handrails hay
H ❒	❒	❒	ground/asphalt/dirt
I ❒	❒	❒	Inanimate exhibits (shells, hides, etc.)
J ❒	❒	❒	toys, tractor, clothes in the barn
K ❒	❒	❒	hay

Use this box to capture all events before the first hand washing. Go on to the back page only if they continue in the exhibit after their first hand washing.

Yes	DK	No	HAND-TO-MOUTH CONTACT
M ❒	❒	❒	Did subject eat any food during visit?
N ❒	❒	❒	Did subject drink anything?
O ❒	❒	❒	Did subject use a pacifier or bottle?
P ❒	❒	❒	Did subject suck thumb or put fingers in mouth?

Yes	DK	No	FIRST HAND WASHING
S ❒	❒	❒	Did subject wash hands at all?
T ❒	❒	❒	If yes, did subject use soap?
U ❒	❒	❒	Did subject use any alcohol sanitizer?
____ *seconds*			Washing time in water
V ❒	❒	❒	Did subject leave exhibit directly after this first washing? (*Leave blank if subject did not wash.*)

COMMENTS:

Yes	DK	No	ANIMALS AND OBJECTS TOUCHED AFTER FIRST HAND WASHING
A ❐	❐	❐	goats
B ❐	❐	❐	sheep
C ❐	❐	❐	rabbits
D ❐	❐	❐	reptiles
E ❐	❐	❐	poultry
F ❐	❐	❐	other animal _____
G ❐	❐	❐	handrails hay
H ❐	❐	❐	ground/asphalt/dirt
I ❐	❐	❐	Inanimate exhibits (shells, hides, etc.)
J ❐	❐	❐	toys, tractor, clothes in the barn
K ❐	❐	❐	hay

Use this box to capture events if subject continued in the exhibit after their first hand washing

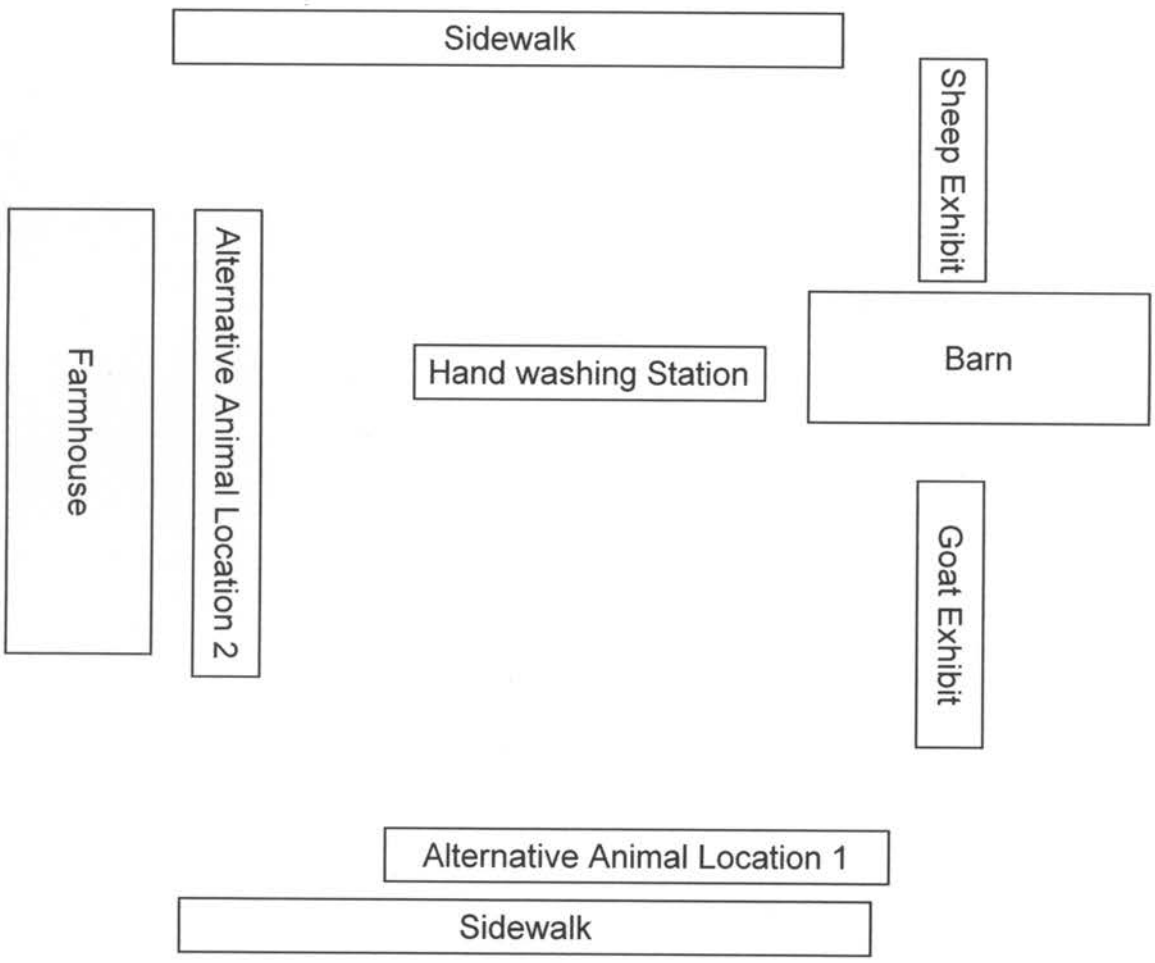
Yes	DK	No	HAND-TO-MOUTH CONTACT
M ❐	❐	❐	Did subject eat any food during visit?
N ❐	❐	❐	Did subject drink anything?
O ❐	❐	❐	Did subject use a pacifier or bottle?
P ❐	❐	❐	Did subject suck thumb or put fingers in mouth?

Yes	DK	No	SECOND HAND WASHING
S ❐	❐	❐	Did subject wash hands at all?
T ❐	❐	❐	If yes, did subject use soap?
U ❐	❐	❐	Did subject use any alcohol sanitizer?
____ *seconds*			Washing time in water
V ❐	❐	❐	Did subject leave exhibit directly after this first washing? (*Leave blank if subject did not wash.*)

X ❐ Check here if subject washed more than twice.

COMMENTS:

Appendix II.


Sidewalk
Sheep Exhibit
Farmhouse
Alternative Animal Location 2
Hand washing Station
Barn
Goat Exhibit
Alternative Animal Location 1
Sidewalk