MAJOR ARTICLE

Observation of Practices at Petting Zoos and the Potential Impact on Zoonotic Disease Transmission

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Background. Although petting zoos are common at public events and allow the public to interact with animals, there has been minimal evaluation of practices at petting zoos.

Methods. Unannounced observation was performed at 36 petting zoos in Ontario, Canada. Observers recorded information, including physical layout, animal species, animal health, types of animal contact permitted, animal sources, hand hygiene facilities, signage, sale of food for human consumption, and hand hygiene compliance.

Results. The majority of petting zoos (24 [67%] of 36 petting zoos) were part of temporary events, particularly agricultural fairs (21 [58%] of 36 petting zoos). A variety of animal species were present, including some animals that are considered to be at particularly high risk for disease transmission (neonatal calves and baby chicks). The following items that would come into contact with the mouths of infants and children were carried into the petting zoos: baby bottles (at 17 petting zoos; 50%), pacifiers (at 24 petting zoos; 71%), spill-proofs cups (at 19 petting zoos; 56%), and infant toys (at 22 petting zoos; 65%). Hand hygiene facilities were provided at 34 (94%) of 36 events, and hand hygiene compliance ranged from 0% through 77% (mean compliance [$\pm$SD], 30.9% $\pm$ 22.1%; median compliance, 26.5%). Predictors for increased hand hygiene compliance included the location of a hand hygiene station on an exit route, the presence of hand hygiene reminder signs, and the availability of running water.

Conclusions. Numerous deficiencies were encountered. Better education of petting zoo operators and the general public is needed. Provision of hand hygiene stations with running water that are placed near exits is one effective way to encourage compliance.

Petting zoos are commonplace at agricultural fairs, animal parks, and other public events. These events are popular, especially among young children, and it has been estimated that millions of human-to-animal contacts arise every year in the United States in venues such as these [1]. However, contact with animals inherently poses some risk of zoonotic pathogen exposure. Enteropathogens pose the highest risk, and the most commonly implicated pathogen is *Escherichia coli* O157:H7, which has caused numerous outbreaks of disease at petting zoos or similar public animal contact events [2–9]. Other pathogens reported to have caused outbreaks of disease associated with public animal contact situations include *Cryptosporidium* species, *Salmonella* species, orf virus, *Coxeilla burnetti,* and *Giardia duodenalis* [5, 10–13]. In addition, there is reasonable concern about other agents or diseases, such as *Campylobacter* species, dermatophytosis, *Chlamydophila psittaci,* leptospirosis, rabies, methicillin-resistant *Staphylococcus aureus,* and brucellosis [5, 14, 15].

Because of the widespread human exposure that can occur at petting zoos, guidelines designed to decrease the risk of exposure to zoonotic pathogens are important. Among the most common recommendations are providing information to visitors about zoonotic disease risks, training staff, preventing animal contact in food service areas, providing areas in the petting zoo where animals are not allowed, restricting food and beverages to animal-free areas, providing hand-washing facilities, ensuring hand-washing facilities are accessible to all individuals, and not permitting hand-to-mouth activities (i.e., eating, drinking, smoking, and carrying toys and pacifiers) in animal-contact areas [1, 7].

The practices and procedures used at petting zoos have been minimally evaluated; thus, it is unclear

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Table 1. Description of the number and proportion of various animal species at 36 petting zoos in Ontario, Canada.

Species	No. (%) of petting zoos where the species was present	Total no. of animals	Mean no. of petting zoos where the species was present
Goats	29 (81)	310	10.7
Sheep	26 (72)	233	9.0
Adult and/or juvenile cattle	19 (53)	90	4.7
Camelids	16 (44)	41	2.6
Horses	13 (36)	22	1.7
Rabbits	12 (33)	236	19.7
Adult and/or juvenile chickens	12 (33)	87	7.3
Donkeys	10 (28)	15	1.5
Pigs	9 (25)	55	6.1
Deer	9 (25)	500	56
Ducks	7 (19)	37	5.3
Baby chicks	6 (17)	120	20
Neonatal calves[a]	4 (11)	6	1.5
Ponies	2 (5.6)	2	1

[a] Calves aged ⩽1 month.

whether petting zoos comply with standard recommendations. The objectives of this study were to characterize practices in petting zoos in Ontario and evaluate the effect of certain factors within the zoo operators' control on the visitors' proclivity to practice hand hygiene.

MATERIALS AND METHODS

A convenience sample of public events in Ontario, Canada that advertised a "petting zoo" was used. Events were identified in a variety of ways, including through the Ontario Association of Agricultural Societies Web site, internet searches, newspaper searches, roadside signs, and our prior knowledge. Unannounced visits were performed from 25 May through 15 October 2006. A trained observer paid admission and discreetly observed activities. Information that was gathered included physical layout of the petting zoo, animal species, types of animal contact permitted, animal sources, supervision, manure removal, hand hygiene facilities, signage, and whether food intended for human consumption was for sale in the petting zoo area. Included in the assessment of animals were estimated age, whether animals were apparently pregnant or lactating, whether feeding of animals was permitted, and whether any clinical abnormalities were apparent in animals. The assessment of human-to-animal contact and hand hygiene compliance was performed during three 10-minute observation periods. These periods were chosen at convenience throughout the day.

STATISTICAL ANALYSIS

Descriptive analyses were performed to summarize observations. Hand hygiene compliance was measured as whether observed individuals washed their hands or applied hand sanitizer at hand hygiene stations. A Friedman 2-way analysis of variance was used to compare the hand hygiene compliance rates among different observation periods.

Categorical, dichotomous variables were examined for potential relationships with hand hygiene compliance. All analysis on factors associated with hand hygiene compliance was performed using Intercooled Stata, version 9.1 for Windows (StataCorp). Each variable was screened independently for a significant association with the outcome using χ^2 tests. Those variables achieving $P \leqslant .20$ in these analyses were considered for inclusion in a multivariable model. Variables were further screened by testing for strong pair-wise correlations ($r \geqslant 0.8$ or $r \leqslant -0.8$) and associations (OR, <0.3 or >8) between each other.

A backward elimination approach to building a main effects logistic regression model was used to perform a general analysis, without accounting for clustering at the level of the petting zoo. Variables were considered to be significantly associated with hand hygiene compliance if $P \leqslant .05$. The potential impact of clustering, by petting zoo, was subsequently accounted for by adding a random effect to create a mixed logistic regression model.

As an estimate of goodness-of-fit for the final mixed model, a Hosmer-Lemeshow test was performed on the main effects

Table 2. Observations of behaviors of visitors in petting zoo areas at 34 petting zoos in Ontario, Canada.

Observation	No. (%) of events
Holding food or beverage in petting zoo	28 (82)
Unsupervised physical contact with animals by children estimated to be <6 years of age	12 (35)
Physical contact with animals by children estimated to be <6 years of age	34 (100)
Physical contact with animals by children estimated to be <1 year of age	28 (82)
Physical contact with animals by women appearing to be pregnant	14 (41)
Feeding animals by hand	22 (65)
Feeding animals using ice-cream cones	9 (26)
Entering animal pens without permission	1[a] (2.9)

[a] One individual.

model, adding "petting zoo identity" as a categorical variable. A P value <.05 was used to indicate poor fit. Using the same model, outlier observations were identified by calculating both Pearson and deviance residuals. Influential and unusual (leverage) observations were investigated using delta-beta and hat matrix calculations [16]. This study was approved by the University of Guelph Research Ethics Board (Ontario, Canada).

RESULTS

Thirty-seven events were evaluated. It is believed that these represent the majority of petting zoos operated within a 200-km radius of Ontario, Canada; however, the lack of a central listing of these events makes it impossible to determine the percentage of local events that were evaluated. An observer was asked to leave 1 event after being questioned by a manager. Data from this facility were removed.

The majority of petting zoos (24 [67%] of 36 petting zoos) were part of temporary events. Agricultural fairs predominated, constituting 21 (58%) of 36 events. Six petting zoos (17%) were permanently located in animal parks and/or zoos, 2 (5.5%) were operated seasonally at farms that are open to the public, and 1 (2.8%) each was set up temporarily at an urban fair, greenhouse, conservation park, riding school, and town park. The origin of animals was apparent at 26 (72%) of the 36 petting zoos and consisted of resident animals (at 12 petting zoos; 33%), animals from multiple private (off-site) sources (at 10 petting zoos; 28%), and animals from commercial petting zoo operators (at 4 petting zoos; 11%). No commercial operator provided animals to >1 of the events visited.

Petting zoos consisted of a discrete area in 28 facilities (78%), and the remainder had ⩾2 animal-contact areas scattered around the event. A single combined entrance and exit was present at 12 events (33%), and multiple combined entrances and exits were present at the same number of events. Entrances and exits were not clearly defined at 10 events (28%). Only 1 event (2.8%) had a single entrance and a separate exit, and 1 other event had a single entrance and multiple exits. Food for human consumption was available for purchase in the petting zoo at 3 events (7.2%). Two events had a limited amount of food for sale, and 1 had a full concession area in the petting zoo.

Animals that were available for people to touch are shown in table 1. Animals that were on display in distant areas where no human contact was possible were excluded. Additionally, 1 of each of the following animals was present at a single event: eland, addix, yak, bison, kangaroo, and reindeer. The number of different species present at any 1 event ranged from 1 through 14 species (mean number of species [$\pm$SD], 5.4 $\pm$ 2.8). Four through 450 animals were present per event (mean number of animals [$\pm$SD], 50.4 $\pm$ 79.4). All events included adult animals. Juvenile animals were present at 28 events (78%), and neonates (estimated age, ⩽1 month) were present at 8 events (22%). Contact with visibly pregnant animals, including goats, sheep, and cattle, was allowed at 3 events (8.3%). Contact with lactating animals was permitted at 22 events (61%) and involved goats, horses, cattle, and sheep.

People were allowed direct entry into the animal housing area of at least some of the animals at 18 events (50%), and at the remaining events, contact was only allowed over or

Table 3. Hand hygiene station locations at 36 petting zoos in Ontario, Canada.

Location	No. (%) of petting zoos
None	2 (5.6)
Entrance	1 (2.8)
Inside petting zoo	11 (31)
Inside and outside petting zoo	2 (5.6)
Entrance, inside, and at exit	1 (2.8)
Exit	1 (2.8)
Outside, ⩽5 m from the petting zoo	10 (28)
Outside, >5 m from the petting zoo	8 (22)

Table 4. Supplies provided at hand hygiene facilities at 34 petting zoos.

Supplies	No. (%) of petting zoos
Running water	30 (88)
Bar soap	0
Liquid soap	29 (85)[a,b]
Disposable paper towels	25 (74)[b]
Reusable towels	4 (12)
Alcohol-based hand sanitizers	8 (24)[a,b]

[a] Ran out during observation at 1 event.
[b] Empty at 1 event.

though fences or similar barriers. Feeding of animals was encouraged at 22 events (61%), as evidenced by the sale of animal food.

Clinical abnormalities were apparent in animals at 11 events (31%). These included skin lesions (at 4 events), lameness (at 4 events), dehorning lesions (at 2 events), and diarrhea (at 2 events). All affected animals were available for petting.

Contacts between visitors and animals that were observed during the observation periods are presented in table 2. Contact observation was not performed at 2 events because of a lack of people in the area (at 1 event) or because the event was too dispersed for proper observation (at 1 event). Various items that would come into contact with the mouths of infants and children were carried into the petting zoo. Baby bottles were observed in the petting zoo area at 17 events (50%), pacifiers were observed at 24 events (71%), spill-proof cups were observed at 19 events (56%), and infant toys were observed at 22 events (65%). Additional objective data for these items were not collected; however, in at least 1 situation, an infant toy was dropped in the petting zoo and immediately returned to the child. No incidents of injury to visitors (i.e., bites or kicks) were observed.

Hand hygiene facilities were provided at 34 (94%) of 36 events. However, the location of hand hygiene stations and the layouts of the petting zoos were such that all people entering the petting zoo were required to walk by hand hygiene stations when leaving the event at only 10 (29%) of 34 facilities. A summary of locations of hand hygiene stations is presented in table 3. The number of hand hygiene stations ranged from 0 through 6 stations per event (mean number of stations [$\pm$SD], 1.6 $\pm$ 1.3; median number of stations, 1). Hand hygiene stations were accessible to children and people in wheelchairs at 33 (97%) of 34 events. A summary of hand hygiene supplies that were provided at the stations is shown in table 4. At 4 facilities, the 10-minute hand hygiene observation periods were not performed, because the event was too large or dispersed for accurate observation (at 3 events) or because of lack of people in the petting zoo area (at 1 event). The number of people observed for hand hygiene compliance at different events ranged from 4 through 115 people (mean number of people [$\pm$SD], 29.9 $\pm$ 25.4). The percentage of people performing some form of hand hygiene method ranged from 0% through 77% (mean value [$\pm$SD], 30.9% $\pm$ 22.1%; median value, 26.5%). There was no difference in hand hygiene compliance among the 3 observation periods for each event ($P = .17$). Of concern, facilities that permitted contact with neonatal chicks, a high risk group for shedding of enteropathogens [1], were more likely to have hand hygiene compliance rates that were less than the mean ($P = .024$).

Signs indicating the need for hand hygiene were present at 17 (47%) of 36 petting zoos. Interestingly, permanent petting zoo establishments were significantly less likely than temporary establishments to have signage promoting hand hygiene (OR, 0.32; 95% CI, 0.22–0.45; $P < .001$). Additional signs included instructions on how to handle animals (at 7 petting zoos; 19%), directions prohibiting food or beverages in the petting zoo (at 3 petting zoos; 8.3%), requests that people supervise children (at 2 petting zoos; 5.6%), warnings not to feed the animals (at 1 petting zoo; 2.8%), and warnings about placing hands in the mouth after touching animals (at 1 petting zoo; 2.8%).

Supervisors were evident at $\geq$1 time during 22 (61%) of 36 events. They were identified by clothing (at 18 events; 50%), location (at 7 events; 19%), and name tags (at 4 events; 11%). More than 1 form of identification was present at some events. Manure removal was observed at 9 events (25%). Removed manure was left accessible to the public at 2 of these events (22%), by having the manure pile in a public area or leaving the wheelbarrow in a public area.

Factors significantly associated with increased hand hygiene compliance on univariate analysis are presented in table 5. After eliminating highly correlated variables from the multivariable model, only 4 variables were retained as significant (table 6). In addition, after adjusting for petting zoo, only access to run-

Table 5. Unconditional associations between petting zoo characteristics and hand hygiene compliance observed at 30 petting zoos in Ontario, Canada, in 2006.

Variable	OR (95% CI)	P[a]
Discrete zoo present[b]	3.02 (1.73–5.60)	.000
Permanent zoo	1.12 (0.77–1.63)	.520
Hand hygiene station near exit	1.44 (1.02–2.02)	.030
Running water available	2.54 (1.51–4.49)	<.001
Liquid soap provided	2.75 (1.76–4.43)	.000
Disposable towels provided	2.19 (1.52–3.18)	.000
Reusable towels provided	1.33 (0.73–2.37)	.313
Alcohol sanitizer provided	1.26 (0.88–1.80)	.176
Hand hygiene signs present	1.82 (1.34–2.48)	<.001

[a] Determined using χ^2 test.
[b] Pens were located in 1 area of the event rather than scattered.

Table 6. Results of logistic regression model showing petting zoo characteristics associated with hand hygiene compliance in 30 petting zoos in Ontario, Canada, in 2006, without adjusting for clustering at the event level.

Variable	OR (95% CI)	P[a]
Discrete zoo present[b]	2.89 (1.62–5.15)	<.001
Hand hygiene station near exit	2.438 (1.66–3.58)	<.001
Running water available	4.19 (2.35–7.46)	<.001
Hand hygiene signs present	1.49 (1.07–2.07)	.017

[a] Significant at $P < .05$.
[b] Pens were located in 1 area of the event, rather than scattered.

ning water and the positioning of the hand hygiene station near the exit were found to be significantly associated with hand hygiene compliance (table 7). In the mixed effects model, using "petting zoo identity" as a random effect, the intraclass correlation was found to be 0.17, suggesting a moderate amount of clustering at this level ($P = .003$).

When assessing overall fit, 1 particular petting zoo was found to have a large influence on the final model. A manual review of the dataset showed that, although hand hygiene signs and running water were provided at the hand hygiene station that was located on an exit route (factors that should have predicted hand hygiene compliance), mean compliance was low (i.e., only 5 [18%] of the 28 observed individuals washed their hands). When this petting zoo was removed from the model, the significance of hand hygiene signs was restored (OR, 1.89; 95% CI, 1.01–3.54; $P = .046$).

DISCUSSION

This study represents one of the most comprehensive observations of practices at petting zoos and has identified a number of areas of concern. Most guidelines for petting zoos focus on a few general themes, including education, animal access, hand hygiene, discouraging hand-to-mouth contact, and supervision; deficiencies were identified in all of these areas at some events in this study.

It has been recommended that facilities be designed such that there is a proper visitor flow through transition areas that include educational information and hand hygiene facilities [1]. This type of organized flow was uncommonly present and might have had an impact on observation of educational materials (if present) and hand hygiene compliance.

Animals can shed a variety of pathogens without any overt clinical abnormalities; therefore, even well kept, apparently healthy animals may pose an infectious disease risk. Young ruminants, young poultry, reptiles, amphibians, and ill animals are considered to be particularly high risk for shedding infectious agents [1], and exposure to young ruminants or young poultry or both was allowed at 8 events (22%). Perhaps most concerning were the diarrheic neonatal calves present at 2 events, because such animals have been associated with a high likelihood of shedding of zoonotic enteropathogens, such as *Cryptosporidium parvum* [17]. It has been recommended that children aged < 5 years not have contact with neonatal ruminants and chicks [1], and considering that this age group comprises a significant percentage of petting zoo visitors, it is reasonable to exclude those animals altogether.

The commonness of items that would be exposed to the mouth of infants and children (i.e., pacifiers, spill-proof cups, infant toys, and baby bottles) was of concern, particularly in light of a previous case-control study that identified use of a pacifier or "sippy cup" or sucking a thumb as a risk factor for petting zoo–associated *E. coli* O157 diarrhea [2] and recommendations that such items not be allowed in petting zoos [1].

It was noteworthy that food was available for sale in the petting zoo area at 3 facilities, because purchasing food from an outdoor concession in an animal contact area has been associated with *E. coli* O157 diarrhea [7]. Food should not be available for sale or consumption in animal contact areas.

Hand hygiene is a critical component of infection-control programs, yet compliance is often poor, even when facilities are provided. The complete lack of hand hygiene facilities at 2 events was remarkable, considering the increased general awareness of zoonoses and the importance of hand washing. A review of outbreaks involving animal exhibits reported inadequate hand-washing facilities at 6 of 10 facilities, and hand washing was identified as a protective factor in 4 of 5 outbreaks of disease during which case control studies were performed [5]. The observation of empty hand hygiene supplies at 3 events might indicate frequent use of these items but also indicates inadequate supervision and maintenance.

This study identified some key factors that appear to influence the likelihood of people washing their hands after visiting petting zoos, all of which are in the control of the event operator. Characteristics such as the location of hand hygiene stations and the provision of running water should be given careful consideration when setting up temporary zoos and designing permanent ones. Signage that promotes hand hygiene is inexpensive and simple, and signs might be an effective means of prompting visitors to protect themselves. Further studies of sign types, size, and location would be useful. Hand hygiene

Table 7. Results of mixed effects model showing petting zoo characteristics associated with hand hygiene compliance at 30 petting zoos in Ontario, Canada, in 2006, adjusting for clustering at the event level.

Variable	OR (95% CI)	P
Hand hygiene station near exit	3.06 (1.37–6.87)	.007[a]
Running water available	4.72 (1.34–16.67)	.016[a]
Hand hygiene signs present	1.85 (0.91–3.76)	.089

[a] Significant at $P < .05$.

education also needs to be directed at individuals who are in the petting zoo area but do not have direct contact with animals, because indirect contact with animals (e.g., contact with sawdust or shavings) was associated with *E. coli* O157 diarrhea in an outbreak of disease at a petting zoo [2]. Signs providing other recommendations, such as signs instructing people not to eat, drink, or touch their mouths in the petting zoo, discouraging people from taking strollers, baby bottles, pacifiers, food, and beverages into the area, and avoiding contact with manure or bedding, were less commonly present or not present at all. Proper content and placement of signage needs to be addressed.

Proper supervision is an important and potentially neglected aspect of infection-control practices in petting zoos [1]. Supervisors were commonly observed in this study, but it is unclear whether part of their responsibility was to ensure adherence to infection-control precautions and facilitate hand hygiene compliance. Inadequate education of supervisors was particularly clear at 2 events, where supervisors were handing out baby chicks for children to hold. Another example of improper supervision was displayed in a photograph taken at 1 of the events in this study, which was subsequently published in a newspaper. The photograph showed a supervisor holding up a 1-week-old lamb for a 4-year-old child to kiss.

This study cannot quantify the infectious disease risks associated with the issues identified here. Although it is almost impossible to objectively evaluate cost-versus-benefit for these programs, it has been stated that the risks of these programs can be minimized and managed [1]. It is apparent from this study that there are a number of theoretical risks that require additional evaluation. It is further apparent that current guidelines are frequently not being followed, either intentionally or through lack of understanding. Multiple factors are likely to be involved in these issues, including a lack of education of or understanding by petting zoo operators and event managers, inadequate understanding of zoonotic disease risks by the general public, and economic factors. Better education of petting zoo operators is required to encourage compliance with standard guidelines. Alternatively, enforcement measures may be required to mitigate some of the more serious concerns that were present, such as lack of hand hygiene facilities, sale of food in animal contact areas, or contact with inappropriate animals. Petting zoos offer numerous benefits to the public and should not be ignored, but greater effort is required to reduce the risks to participants and maximize the benefits.

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