Diseases Transmitted by Domestic Livestock: Perils of the Petting Zoo

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ABSTRACT Petting zoo venues encourage or permit public contact with animals which provide opportunities for education and entertainment. These venues vary but are common at county or state fairs, zoos, and aquariums. In addition to these common petting zoo settings, animals are present in many other venues where the public is permitted to contact them and their environment. Thus, humans may have contact with animals in a wide range of settings, and transmission of infectious diseases from animals to humans may occur at any of these venues, creating perils associated with petting zoos.

There are many considerations when evaluating perils associated with the wide range of venues where animal contact can occur. First, many venues or events draw large numbers of people; some operate during a short time frame, while others, such as zoos and aquariums, operate year round. Second, petting zoos and other animal contact venues are particularly popular with children, who compared with adults, commonly have less stringent hygienic practices and are more susceptible to severe disease outcomes. Finally, there is remarkable variability in the physical layout of venues that permit animal contact and in the types of animals that may be contacted. Animal contact areas range from well-designed permanent exhibits targeting risk reduction to various temporary or seasonal exhibits established without detailed planning. Many petting zoos house only small ruminant species such as sheep and goats, but other venues house a wide variety of mammalian species, exotic animals, poultry and other avian species, reptiles and amphibians, and aquatic animals.

INTRODUCTION

Contact with animals can be an enjoyable and beneficial activity. Health benefits have been attributed to animal contact. Reportedly, these benefits include reduced anxiety, lower blood pressure, and other physiologic effects (http://www.cdc.gov/healthypets/health-benefits/index.html). In addition to health benefits, petting zoos and animal contact settings provide educational opportunities. A growing segment of society in developed countries resides in urban or suburban settings with limited knowledge of agricultural practices or contact with farm animals. Petting zoos or agricultural exhibits provide education regarding food production, agricultural practices, and rural life. Similarly, zoological parks and aquariums are popular leisure attractions and provide opportunities for education about diverse and nonnative animal species and conservation of natural...
resources. Perils of animal contact can include allergies, injury, and zoonotic disease transmission.

**PERILS: ALLERGIES AND INJURY**
Allergens are encountered in petting zoos and animal contact areas. Possible allergens include animal dander, scales, fur, feathers, saliva, and urine. In addition, traditional petting zoo settings at fairs include environmental allergens such as hay, which is commonly fed to ruminant animals. While the frequency of people allergic to various animal allergens is not known, it is likely that the number is substantial. Allergic reactions due to contact with animals and their environment can pose risks themselves and may increase risks for transmission of zoonoses due to more frequent hand-to-face contact.

In addition to allergies, injuries associated with animals in public settings occur. Common injuries include kicks, falls, scratches, and crushing injuries of the hands, feet, or body. While any injury can predispose people to zoonotic disease transmission, animal bites present the greatest peril. Animal bites may also result in transmission of several bacterial and viral pathogens: bacterial pathogens include *Bartonella henselae*, *Capnocytophaga canimorsus*, *Francisella tularensis*, *Pasteurella multocida*, *Spirillum minor*, *Staphylococcus*, *Streptobacillus moniliformis*, and *Streptococcus*; viral pathogens include herpes B virus and rabies.

**PERILS: ZOONOTIC DISEASE TRANSMISSION**
Zoonotic diseases, infectious diseases transmitted between nonhuman vertebrate animals and humans, are widely considered the greatest risk to petting zoo visitors. Among zoonotic disease agents, enteric pathogens are of particular concern in petting zoos because these pathogens have been linked to numerous outbreaks of human illness in these settings.

**Enteric Pathogens**
The most commonly recognized peril of petting zoos and other animal contact settings is transmission of enteric pathogens. Infections with bacterial enteric pathogens such as *Shiga toxin–producing Escherichia coli* including *E. coli* O157, *Campylobacter*, and *Salmonella* and with enteric parasites such as *Cryptosporidium* typically result in gastrointestinal symptoms of nausea, vomiting, and diarrhea. While most infections with enteric pathogens are self-limited, severe symptoms and outcomes can occur. For example, *E. coli* O157 and other Shiga toxin–producing *E. coli* commonly cause hemorrhagic colitis and may result in hemolytic anemia, thrombocytopenia, and acute renal failure. This clinical triad is referred to as hemolytic-uremic syndrome (HUS). HUS occurs as a life-threatening, postdiarrheal complication in 5 to 10% of *E. coli* O157 infections, and the rate is highest among children. Childhood death from HUS complications associated with transmission of *E. coli* O157 at a petting zoo has been documented. HUS survivors suffer long-term sequelae including loss of renal function.

Fecal-oral transmission is the most common route for transfer of enteric pathogens from animals to humans. Transmission may be due to direct contact with animals or contact with animals through contamination of food and water contaminated with animal feces. Fecal material unavoidably contaminates areas in which animals are housed, and consequently, animal fur, feathers, scales, skin, and saliva are often contaminated as well. Indirect contact with the animal environment or objects (fomites) contaminated while in the animal area can also result in transmission of enteric pathogens. For example, contaminated shoes, wheels on a child’s stroller, animal bedding, and environmental surfaces in areas used to house animals have all tested positive for the outbreak strain of *E. coli* O157 during petting zoo outbreak investigations. Enteric pathogens have even been isolated from the rafters of a barn which was used to house animals at a fairground. Thus, movement of pathogens via air currents and dust is a plausible mechanism that could result in contamination of petting zoo environments and contamination of food or water. A rainfall event that caused runoff from a petting zoo area was also thought to contribute to an outbreak of *E. coli* O157. Food-borne and waterborne transmission are well-described perils for patrons visiting petting zoos and other animal contact venues. Multiple examples of food-borne and waterborne transmission following contamination of food and water at petting zoos and other venues exist. For example, in one report transmission of *E. coli* O157 was linked to consumption of cotton candy in the animal area.

Outbreaks associated with animal contact in petting zoos and other animal contact venues have increasingly been recognized by public health officials. From 1996 through 2012, approximately 200 human infectious disease outbreaks involving animals in public settings were reported to the CDC. The majority of these outbreaks were caused by *Salmonella* species, *E. coli*, and *Cryptosporidium*. Such outbreaks have substantial medical, public health, legal, and economic effects. In
addition, international outbreaks and reports of disease transmission are well described.

Notable outbreaks have led to a better understanding of transmission risks and preventive measures in petting zoos. The CDC first published recommendations to reduce perils associated with petting zoos following an outbreak of human E. coli O157 infections associated with animal contact in 2000. School trips to a Pennsylvania dairy farm where children could pet and interact with calves resulted in more than 50 children becoming ill; 8 (16%) developed HUS. Based on molecular subtyping using pulsed-field gel electrophoresis, human E. coli O157 isolates isolated from ill humans were shown to be indistinguishable from E. coli O157 isolated from cattle and the environment. Although not a traditional petting zoo, direct animal contact was allowed at the dairy farm. Several contributing risk factors were identified including direct contact with the cattle and the farm environment, inadequate hand-washing facilities for children, and no designated location where visitors could eat and drink outside of animal areas.

Outbreaks at some facilities have involved multiple enteric pathogens. Contact with calves and their environment at a children’s day camp on a farm in Minnesota resulted in transmission of Campylobacter jejuni, Cryptosporidium parvum, E. coli O157, non-O157 Shiga toxin–producing E. coli, and Salmonella enterica serovar Typhimurium. Eighty-four human cases occurred, and all of the above-mentioned pathogens were isolated from the farm day camp calves. An important finding of epidemiological investigations at the farm day camp was the protective effect of hand hygiene. People reporting that they washed their hands with soap after touching a calf or washed their hands before going home were less likely to become ill. Children reporting that they cared for an ill calf or had gotten manure on their hands were at increased risk. Another school farm program in Minnesota experienced recurrent outbreaks of cryptosporidiosis. An outbreak of 31 cases resulted in Department of Health recommendations being made to prevent further transmission. However, insufficient implementation of the recommendations resulted in a subsequent outbreak. Thirty-seven additional cryptosporidiosis cases occurred that were attributed to inadequate hand-washing facilities and procedures. Inadequate or incomplete maintenance of recommendations increases the risk of diseases transmission.

Outbreaks associated with traditional petting zoos, where people, especially children, were encouraged to pet, feed, and have contact with animals, have been dramatic. A 2005 CDC Morbidity and Mortality Weekly Report (MMWR) described three such petting zoo–associated outbreaks of E. coli O157. Outbreaks in Arizona and Florida occurred at a municipal zoo and at agricultural fairs, respectively. At the municipal zoo in Arizona, a temporary exhibit used to attract visitors was implicated. In Florida, 63 people were infected, including 7 with HUS. Cases occurred at multiple fairs supplied with animals from the same vendor. Risk factors for infection included direct animal contact, contact with sawdust or shavings, and feeding animals. Hand hygiene was demonstrated to be a protective effect if properly performed. Interestingly, knowledge of zoonotic disease risks was a protective factor, indicating that educational efforts may mitigate risks.

The third outbreak described in the MMWR report occurred in 2004, when 108 people became ill after visiting a petting zoo at the North Carolina State Fair. The petting zoo associated with the outbreak was one of many exhibits where the public could contact animals. It contained numerous livestock species in pens but also allowed direct interaction and contact with goats and sheep in a large enclosure. The exhibit encouraged direct contact with the animals and facilitated contact with manure and manure-contaminated bedding. Additionally, visitors were permitted to feed the sheep and goats, increasing animal-to-human contact. Figure 1 shows photographs of children in the North Carolina State Fair Petting Zoo who were infected with E. coli O157. Manure and contact with manure-contaminated bedding are evident. The petting zoo was heavily visited by children, 15 of whom developed HUS. Alcohol-based hand sanitizer was available at the exit of the petting zoo, but hand-washing facilities were not. Similar to the findings in Florida, knowledge of zoonotic disease prior to the outbreak had a protective effect. The outbreak strain was isolated from the animal bedding, the animals, and the farm of origin. A subsequent MMWR report from North Carolina described another E. coli O157 outbreak at the North Carolina State Fair in 2011, associated with an animal area not intended for animal contact. Despite following some preventive recommendations, the outbreak occurred, and 25% of case-patients reported contact with animals.

Outside of the United States, other petting zoo and animal contact exhibit–associated outbreaks have been described. In Canada, 44 E. coli O157 cases occurred following daycare and school field trips to a pumpkin patch which had a petting zoo. The same molecular subtype of E. coli O157 was isolated from human cases.
and a petting zoo goat. Lack of hand-washing facilities and limited signage were implicated. Similar to the 2004 North Carolina State Fair outbreak, alcohol-based hand sanitizer was available although not optimally placed for use by children.

In addition to recognized outbreaks, studies of human infections not recognized to be part of an outbreak (i.e., sporadic infections) indicate that zoonotic transmission of enteric pathogens likely occurs in petting zoos and other venues where animal contact occurs. For example, risk factors for sporadic human *E. coli* O157 infection included visiting a farm with cows. Similar studies of human cryptosporidiosis and campylobacteriosis have described contact with farm animals as a risk factor for infection. Furthermore, outbreaks and sporadic cases of salmonellosis are recurrent in the United States each year in association with contact with live poultry purchased from mail-order hatcheries or direct contact with baby poultry at feed stores.

From outbreak investigations and studies of enteric pathogen colonization of animals, a number of factors have been noted which contribute to the peril petting zoos and other animal contact venues pose. Factors associated with the animals and the animal environment as well as human factors can increase transmission risks.

It is notable that most animal species harboring human enteric pathogens exhibit no clinical signs. This is true for ruminant species such as cattle, sheep, and goats, which are colonized by *Campylobacter*, *Cryptosporidium*, *Salmonella*, or Shiga toxin–producing *E. coli*, and for *Salmonella* in live poultry, reptiles, and amphibians. Factors associated with animal husbandry and management also contribute to increased risks of disease transmission. For example, enteric pathogen prevalence can be higher in young animals, which are popular in petting zoos. Fecal shedding of enteric pathogens is also more likely when animals are stressed. Temporary or seasonal petting zoos subject animals to transportation stress. In general, confinement, crowding, and increased handling by people increase stress and the risk of fecal shedding. Studies of some ruminant species indicate that enteric pathogens are shed more commonly in summer months, which is when many petting zoos and animal contact exhibits occur.

Cattle, sheep, goats, poultry, rodents, and other domestic and wild animals shed enteric pathogens in the environment intermittently. Contamination of the environment can last for months or years even after attempts to clean or decontaminate. *E. coli* O157 has been shown to remain viable in soil for months experimentally. Furthermore, viable *E. coli* O157 has been cultured from fairgrounds and petting zoos months after outbreaks despite efforts to decontaminate the soil with chemical and heat treatments. Environmental contamination alone, without direct contact with animals, has been implicated in outbreaks of *E. coli* O157 in Ohio and Oregon.

Not surprisingly, the risk for infections or outbreaks is increased by human factors and behaviors, especially
in children. These factors include lack of awareness of the risk of disease, inadequate hand-washing, a lack of close supervision, and hand-to-mouth behaviors (e.g., thumb sucking). As mentioned, children are particularly attracted to animal venues and have increased risk for serious infections. Children aged <5 years are at particularly high risk of serious infections or outcomes. Other groups at increased risk include people with waning immunity and people who are mentally impaired, pregnant, or immunocompromised. Recent observational studies have demonstrated that people visiting petting zoos engage in a number of high-risk behaviors and do not commonly wash their hands when exiting petting zoos or other animal contact venues. One such study conducted in the United States found that 74% of petting zoo visitors had direct contact with animals, 87% had contact with potentially contaminated surfaces in animal contact areas, 49% had hand-to-face contact, and 22% ate or drank in animal contact areas, but only 38% used hand sanitizer when they exited the petting zoo. Multiple studies including a study in Canada have demonstrated similar results. Despite the availability of hand-hygiene facilities, they are infrequently used by visitors. Hand hygiene stations located on an exit route, the presence of hand hygiene reminder signs, and the availability of running water were reported to increase hand hygiene compliance among visitors in the Canadian study.

Other Zoonotic Pathogens
A broad range of other zoonotic pathogens pose potential risks in petting zoos and animal contact settings. Influenza virus transmission between humans and animals has been recognized for decades, and the emergence of pandemic strains typically involves reassortment of viruses from humans and other animals such as swine and birds. The role of transmission in petting zoo and other animal exhibit settings has been highlighted by hundreds of confirmed cases of influenza A (H3N2) variant virus infection reported across 10 states in 2011 and 2012. Most cases occurred in children who visited fairs and animal exhibits and had contact with swine. Sixteen hospitalizations and one death in an adult with underlying medical conditions were documented. Recommendations to minimize transmission of influenza in settings where animals and humans have contact are available.

Rabies virus can infect all mammalian species and is a peril to humans exposed to infected animals in petting zoos and other animal contact venues. Rabid mammals transmit the virus through bites or contamination of mucous membranes, scratches, or other wounds with virus-laden saliva or nervous tissue. The Advisory Committee on Immunization Practices provides detailed recommendations for assessment and prophylactic treatment of human rabies. Potential for transmission to humans is of concern because infection leads to acute, progressive encephalomyelitis, which is almost always fatal. Although no human rabies deaths caused by animal contact in petting zoos or public animal exhibits are documented, the potential for zoonotic transmission of rabies has required extensive public health investigation, medical follow-up, and administration of post-exposure prophylaxis to thousands of people following exposures at fairs, petting zoos, and other animal exhibits. Species exposing humans have included bears, cats, dogs, goats, horses, and sheep. Mass rabies exposures occurring at petting zoos present unique challenges for health officials and medical providers. These challenges include identification and notification of potentially exposed people, proper risk assessment, and provision of timely postexposure treatment. In 2006, over 150,000 people attended the Tennessee National Walking Horse Celebration, where a horse from Missouri was diagnosed with rabies. The rabid horse was accessible to the public visiting the event. State and federal public health officials notified attendees and assessed rabies risk among people who reported contact with the horse. The Tennessee Department of Health consulted with 53 people and recommended treatment for 9. In addition, approximately 25 people in Missouri were advised to receive treatment. In New York, a rabid goat in a petting zoo resulted in 465 people receiving rabies postexposure prophylaxis.

Query fever, or Q fever, is caused by a rickettsial organism, Coxiella burnetii. Q fever can cause acute or chronic illness in humans. In humans, infection may be asymptomatic, result in acute influenza-like illness, or progress to life-threatening endocarditis. Chronic Q fever can manifest within a few months or several years after acute infection and can follow symptomatic or asymptomatic infections. C. burnetii frequently infects cattle, sheep, and goats. In ruminants, infection can result in abortion but more commonly does not cause a clinical illness. Animal birthing exhibits at fairs or petting zoos have become popular attractions. Despite limited contact by the public during parturition, contact with newborn animals is often encouraged or permitted. Transmission of Q fever is a peril of petting zoos and animal venues that have live-birthing exhibits. Infected animals shed large numbers of organisms at parturition that contaminate the animals and the animal’s...
environment and can become aerosolized, leading to outbreaks of Q fever. Ninety-five Q fever cases, including forty-one hospitalizations, were described in association with goats and sheep giving birth at petting zoos in indoor shopping malls. Indoor birthing exhibits might pose an increased risk for Q fever transmission because of inadequate ventilation. Other less common perils from petting zoo birthing exhibits include leptospirosis, listeriosis, brucellosis, ringworm, and chlamydirosis.

*Mycobacterium tuberculosis* infects humans and animals, notably elephants. Contact with elephants occurs in some petting zoos and animal exhibits. Elephant rides are sometimes incorporated into animal exhibits. Transmission of tuberculosis from elephants to circus elephant handlers at an exotic animal farm was reported in Illinois. Because treatment and cure of *M. tuberculosis* in elephants is difficult, guidelines for removal of infected animals from public contact have been developed.

Herpes B virus (*cercopithecine herpesvirus 1*) is a zoonotic agent found in macaque monkeys. In macaques, herpes B virus causes mild oral lesions or no clinical signs. As mentioned previously, the virus is transmitted to humans via bites. However, transmission has been reported following scratches or splashes to mucous membranes as well. Human infections can result in fatal meningoencephalitis. Although not commonly found in petting zoos, macaques are sometimes available in public settings. Internationally, macaques may be present in locations frequented by the public, especially tourists interested in contacting or feeding them. Recommendations for herpes B assessment and postexposure prophylaxis are available.

*Chlamydiophila psittaci* infections cause respiratory disease (commonly called psittacosis) and are usually acquired from psittacine birds. Outbreaks among humans have occurred in public settings. Infection typically causes pneumonia. Walk-through aviaries and interactive avian exhibits have become increasingly popular, especially in zoos. Guidelines for testing and treatment of birds and diagnosis in humans have been published to address the risks of psittacosis in humans. On rare occasions, chlamydial infections acquired from sheep, goats, and birds result in reproductive problems in women.

Orf virus infection has been described in goats and sheep at a children’s petting zoo. Infection of humans can result in painful ulcerative lesions. Transmission in public settings following contact with infected sheep has occurred. Transmission can be due to direct animal contact or contact with contaminated objects such as blankets, halters, or brushes.

Zoonoses from aquarium water are of increasing concern. Mycobacterial infections, *Aeromonas* species, *Vibrio* species, *Edwardsiella* species, *Salmonella* species, *Streptococcus iniae*, and *Erysipelothrix rhusiopathiae* can be encountered in “touch tanks” or aquatic petting zoos. Although few outbreaks have been documented, transmission may occur sporadically, particularly among people who are immunocompromised.

**REDUCING PERILS OF THE PETTING ZOO**

In the United States, federal oversight of animals in public settings relates to animal care and welfare but not public health. Some states have developed legislation, usually in response to outbreaks, governing petting zoos and other venues where animals are present in public settings to address zoonotic disease risks. The Association of Zoos and Aquariums includes zoonotic disease risk reduction measures in their accreditation standards. As mentioned previously, the CDC developed guidelines following the outbreak of *E coli* O157 in Pennsylvania. The CDC has also published guidelines for preventing reptile- and amphibian-associated and live poultry–associated salmonellosis. Other organizations have published guidelines for specific populations (e.g., immunosuppressed) and settings (e.g., health care settings).

The National Association of State Public Health Veterinarians (NASPHV, Inc.) and the CDC have published well-recognized, comprehensive recommendations to reduce zoonotic disease perils associated with animals in public settings, including petting zoos. Recommendations are designed for use by public health officials, veterinarians, animal venue staff, animal exhibitors, visitors to animal venues, physicians, and others. The NASPHV and the CDC state that the single most important prevention step for reducing zoonotic disease risks is hand-washing. Other recommendations address communication and cooperation among agencies and education for venue operators and staff as well as the visiting public. Management of public and animal contact is also addressed with respect to design of facilities and animal pens, cleaning procedures, and veterinary care and management of animals.

**PRACTICAL TIPS**

- Hand-washing is the single most important preventive measure to minimize infectious disease perils of the petting zoo.
• Educate the public to recognize zoonotic disease perils of the petting zoo.
• Consider contact with animals in public settings, particularly petting zoos, in diagnosing and treating potential zoonotic infections.
• Report possible petting zoo–associated infections and outbreaks to public health officials for further investigation.
• Implement the NASPHV and CDC recommendations to reduce zoonotic disease risks associated with animals in public settings.

RECOMMENDED READINGS


