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Flood Injury in Horses

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Floods are the most common weather-related disasters known on earth and occur throughout the United States, causing billions of dollars in damage and threatening the lives of people and animals. The average yearly financial loss attributable to floods in the United States averages $6 billion [1]. Flooding damages infrastructure and depresses economic activity [1]. Flood-related livestock injuries and death make up a major component of these losses, affecting the economic and emotional welfare of livestock producers, including horse owners.

The principal causes of floods in the eastern United States are hurricanes and storms. In the western United States, causes include snowmelt and rainstorms. The Midwest flooding in 1993 and damage caused by Hurricanes Katrina and Rita in 2005 are the three costliest flood events in US history, estimated at $20 billion and more than $60 billion, respectively. The United States Geological Survey (USGS) mapping of flood-prone areas of the United States is extensive (Fig. 1), with greater than 85% of the United States having had at least one disaster declaration related to a flooding situation.

Planning and prevention

Horse owners must be proactive in taking responsibility for protection of the animals under their care. Advanced planning can help horse owners to minimize the loss of animal lives and the health problems associated with disasters, such as floods. Because of the vulnerability of coastal regions to

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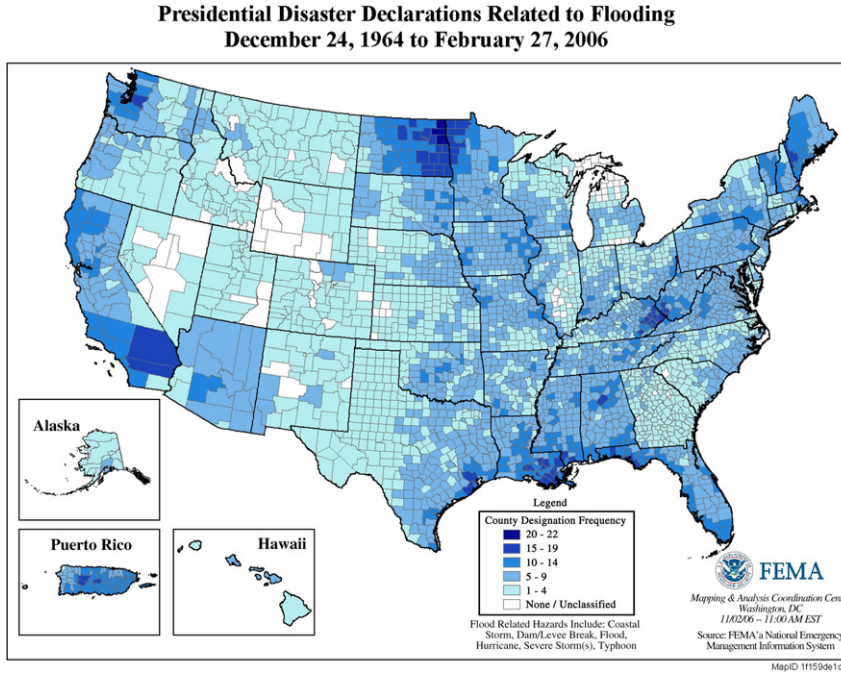

Fig. 1. Flood map (2006). Presidential disaster declarations related to flooding in the United States, 1964 through 2006, are shown by county or Louisianna parish. (*Courtesy of* Federal Emergency Management Administration [FEMA], Washington, DC.)

hurricanes and storms and the potential widespread damage caused by flooding, preparedness in these most vulnerable areas is essential. It must be stressed that although help may be available from many sources after a disaster, owners themselves are ultimately responsible for the welfare of their animals and should prepare accordingly. Well in advance of a potential disaster situation, horse owners and producers should evaluate their herd health programs with their veterinarian. Horses that undergo evacuation related to disaster response are stressed and are likely to commingle with other horses and livestock. Herd biosecurity is breeched, which makes increasing herd immunity imperative. Pneumonia and abortions should be anticipated and can be minimized with proper herd nutrition and vaccination. Before storm seasons, horses should be vaccinated with current strains for equine herpesvirus 1 and 4 and equine influenza 1 and 2 in addition to the encephalitides (eastern equine encephalomyelitis [EEE], western equine encephalomyelitis [WEE], and West Nile virus [WNV]) and tetanus.

Animal identification is critical. If horses are evacuated and commingled or escape and are later captured, it is essential to be able to identify the herd of origin. Many horses look alike; thus, permanent brands, lip tattoos, or electronic identification that is unique to each animal or to each farm or

ranch is essential. The US Horse Industry Equine Species Working Group advisors to the US Department of Agriculture (USDA) National Animal Identification System recommends electronic microchip identification using International Standards Organization/American National Standards Institute (ISO/ANSI)-compatible radiofrequency identification (RFID 117.84/85, 134.2 kHz) as the standard equine identification method to ensure uniformity and compatibility [2]. A single microchip should be implanted deep in the horse's nuchal ligament midway between the poll and the withers on the left side. Photographs or videotapes of horses may also help in the identification process. Horses should have two forms of identification: a permanent form (microchip, lip tattoo, or brand) and a visible tag or marking with the owner's name and current contact information. Livestock paint sticks, etching using an electric clipper with a no. 40 blade, a permanent marking pen, and bright spray paint are household products that can be used to identify horses (Fig. 2). Official guidelines for predisaster visible identification of horses are not available, but current recommendations are to include, at a minimum, the owner's name and current viable contact telephone number or e-mail address. Copies of herd records, proof of ownership, and registration papers should be stored in a safe and secure location.

In situations like an impending hurricane, where advanced warning may be given, health papers should be provided by a veterinarian if horses are to be evacuated, particularly if there is a possibility of the horse traveling across state lines. In case of events in which widespread evacuation is recommended, including that of horses (eg, category 3 or greater hurricanes), state or federal veterinary officials are the authority for determining travel requirements necessary for interstate transport of evacuated livestock. Official health papers or an official Coggin's test result (proof of negative equine immunodeficiency anemia status) may suffice. In some situations, it may not be possible to evacuate or rescue all animals. Owners may need to prioritize so that their most valuable animals receive attention first.

Because of the possibility of mass evacuation of many animals, plans should be made weeks in advance of a potential disaster. Owners should partner with other farms and ranches to provide transportation and evacuation space so that public holding areas can be used for rescued animals. Biosecurity issues should be discussed when making these arrangements. Producers should have safe efficient handling facilities ready in advance. Livestock trailers should be inspected to make sure they are ready for hauling long distances. If flooding or high winds are expected and animals cannot be evacuated, they should be left in large open pastures and not placed in barns. Unable to flee or escape their confines during the flooding after Hurricane Katrina, hundreds of horses drowned because owners left them locked in their stalls thinking they would be safe from flying debris (Fig. 3). Horses that were able to make it to high ground survived (Fig. 4).

State animal response teams (SARTs) are taking the lead in many states in coordinating animal disaster preparedness efforts [3–5]. Owners

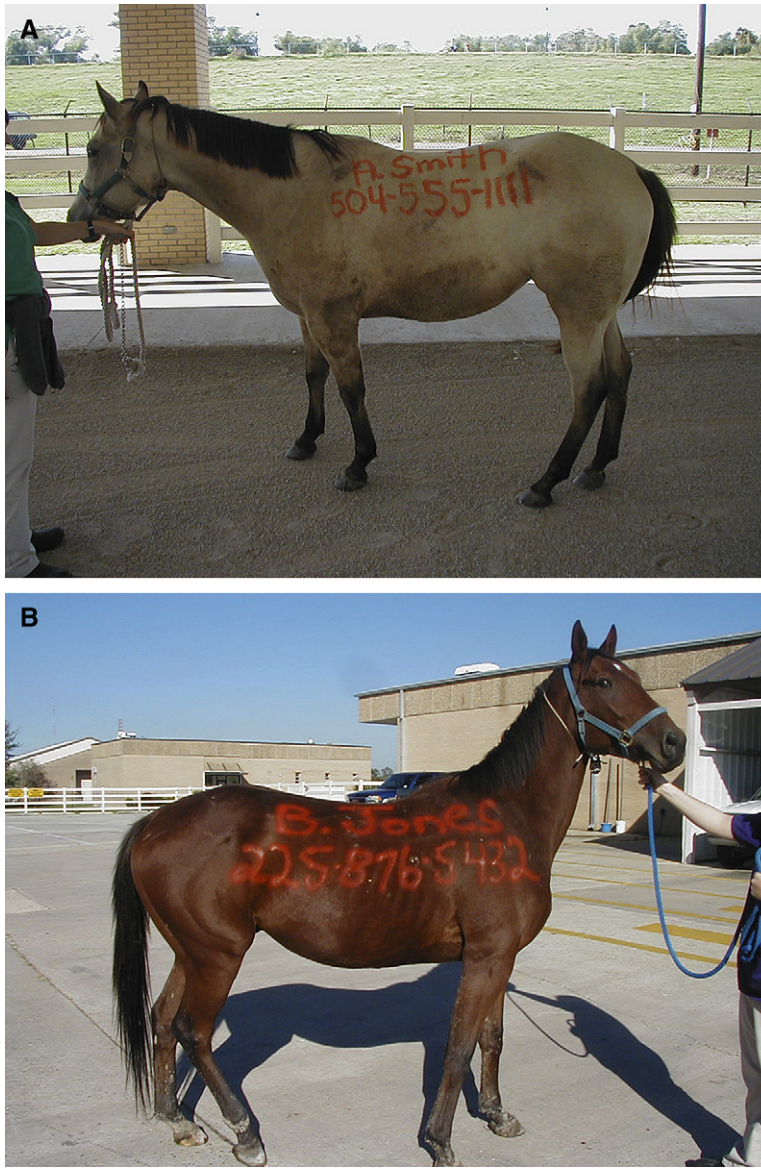

Fig. 2. Predisaster body marking with horse owner name and contact information using livestock paint stick (*A*) and fluorescent spray paint (*B*). (*Courtesy of* Rebecca McConnico, DVM, PhD, Baton Rouge, LA.)

should take an active part in coordinating and making known their plans with these organizations and other local lead agriculture-related groups, such as agriculture extension agencies; the USDA's natural resource conservation services and farm service agencies; local farm bureaus; state,

Fig. 3. Weanling horse left in the stall during Hurricane Katrina. Note the hoof marks and water line on the stall walls where the horse attempted to escape. (*Courtesy of* Leslie Talley, Baton Rouge, LA.)

regional, or local producer groups; livestock auction markets; and feed stores. Different tasks, such as livestock hauling; feed, fuel, and generator acquisition and distribution; and animal evacuation, rescue, and treatment, should be assigned to individuals or groups in advance. Primary and contingent holding areas for evacuated or rescued livestock (eg, show facilities, race tracks) as well as staging areas for feed and fuel distribution should be identified in advance. Special evacuation routes for livestock should be considered so that loaded trucks and trailers can keep moving to avoid development of heat stress in transported animals. Along with the numerous human lives lost during the traffic gridlock evacuation of the Texas and Louisiana coastal regions before the landfall of Hurricane Rita (autumn of 2005), hundreds of horses and cattle perished because of heat stress while being transported. Roads may be closed to trailer and towing traffic as a storm approaches. Early evacuation is imperative to avoid these problems.

In large-scale disasters involving large numbers of livestock, providing food and fresh water to animals that have been sheltered or pastured in-place, is the first priority. Owners should have enough emergency hay and water sources for 3 to 5 days, because most rescue and response efforts go toward saving human lives first. Adult horses need 5 to 15 gal of water per head per day. Storage tanks previously holding chemicals should not be used to store water. If wells depend on electricity to pump water, hand

Fig. 4. Horses able to escape to high ground (levees) survived the storm surge and flooding in Plaquemines Parish, Lousiana, in September 2005 during the aftermath of Hurricane Katrina. Note the debris fields on either side of the levee. (*Courtesy of* Leslie Talley, Baton Rouge, LA.)

pumps or generators should be available in case of electrical outages. Producers should make their local extension office aware in advance of the numbers of animals and their locations. This helps to ensure that your animals are included in immediate feed distributions if available. Otherwise, feed may not be distributed until this information can be verified, which puts the animals at risk.

Response

In flood situations, horse owners are often frantic and demanding. It is important for communities to have a livestock plan that includes trained personnel and resources so that reasonable decisions can be made quickly to save lives as well as to meet the urgent health-related needs of flood-affected horse victims. Horse owners should do their part to evacuate ahead of a flood and to make sure that their horses can be haltered and handled. For example, in the aftermath of Tropical Storm Allison (2001 in Louisiana), a horse farm owner located near the Red River overflow area in central Louisiana requested rescue and evacuation of 16 horses because his farm land and barn would soon be flooded [6]. On arrival, veterinarian and animal technician rescue crews found that more than half of these horses were not wearing halters and that they were not congregated in a safe paddock holding area. The horses were difficult to gather and restrain,

Fig. 5. Rescue of horse from flooded farm area in April 2001 during Tropical Storm Allison in Pineville, Louisiana. (*Courtesy of* Harry Cowgill, Baton Rouge, LA.)

sustained traumatic injury associated with fleeing the rescuers, and were difficult to restrain chemically and prepare for rescue. Eventually, all 16 horses were safely transported by boat using short-acting general anesthesia or an Anderson sling combined with Coast Guard helicopter rescue (Fig. 5) [6].

Equine emergency field response activities should be performed by an experienced team of individuals including veterinarians, first responders, and trained animal handlers to provide for safety of human beings and horses. With equine rescue, responders often get hurt and the horse may sustain more injury as a result of the rescue activities. A basic guideline is to use the simplest, safest, and most "low-tech" approach in an effort to minimize injury to the victims and rescuers [7]. Stressed and injured horses can be extremely unpredictable and can pose significant endangerment situations for people. Decisions regarding the appropriate type of response (whether it is rescue, field medical treatment, sheltering, or simply provision of feed and water) should be made with the safety of response personnel being a primary objective.

During the Hurricane Katrina aftermath response, the equine branch communications center received numerous calls from evacuees who wanted to know the status of their horses that had weathered the storm or had been evacuated to an area that had then received storm damage. Countless calls were received from people who simply wanted information on the status of something that they had seen on television, often hampering the calls from people with true needs. Equine branch communications center leaders were tasked with prioritizing numerous requests from equine owners (Fig. 6). Response plans were organized with intelligence received from the field about

Fig. 6. Equine branch communications center at Louisiana State University, School of Veterinary Medicine, in September 2005 during the aftermath of Hurricanes Katrina and Rita.

known animals in need of rescue or urgent medical care and were then grouped into geographic location.

Triage and medical treatment

For horses stranded in a flood, stress is a major contributor to flood-related equine medical problems and can include colic, diarrhea, dehydration, neurologic disease, respiratory disease, laminitis, sole abscesses, skin abrasions, cellulitis, lacerations, fracture disease, and corneal injuries. The innate equine "fight or flight" response can often accentuate even minor medical problems into sometimes life-threatening situations. If possible, injured horses should be examined by a veterinarian in the field and medically stabilized before transport. Stabilization may include sedation to prevent further traumatic injury to the patient and handlers. Attempts to transport fractious patients can make the situation worse, especially if the horses are improperly restrained. Horses that are severely dehydrated or exhibiting signs of cardiovascular shock may benefit from large-volume bolus intravenous fluid therapy in the field before transport (isotonic polyionic fluids, 50 mL/kg administered intravenously initially, followed by 20–30 L per 450-kg adult horse). During heightened stressful situations, such as flood response and rescue, it is important to move the patient to an area for initial triage and assessment as soon as possible.

Equine flood victims should be decontaminated by bathing with detergent soap products and require thorough rinsing to remove toxins, debris, or microorganisms from the skin and to identify additional sites of injury. Recommended products for bathing include Dawn or Ivory dishwashing soap or human or animal shampoo products without additives. The underside of the hooves should be scrubbed clean and examined to determine if debris or hoof punctures can be identified.

Handling and restraint

Chemical restraint is often indicated to manage the rescue, medical evaluation, and treatment of flood-stranded horses safely. Chemical restraint can minimize further injury to the patient and prevent human injury as well as allowing rescue activities (including trailer extraction or helicopter sling rescue). Recommended chemical restraints include acetylpromazine (0.02–0.08 mg/kg administered intravenously), xylazine (0.5–0.75 mg/kg administered intravenously), detomidine (5–20 μg/kg administered intravenously), and butorphanol (0.01–0.02 mg/kg administered intravenously). Yohimbine (0.1–0.15 mg/kg administered intravenously) may be indicated for α_2-agonist reversal in the event of significant bradycardia and hypotension [8]. An adverse response to sedation and tranquilization can produce hypotension, decreased gastrointestinal motility, and exacerbation of cardiovascular shock. Several veterinarians experienced in equine rescue recommend detomidine sedation (5–20 μg/kg administered intravenously) followed by butorphanol (0.01–0.02 mg/kg administered intravenously) for airlift or trailer extraction [8]. Horses rescued by means of flat boats (pontoon boats) require general short-acting anesthesia using the ''triple-drip'' method (guaifenesin, ketamine, and detomidine) [9]. The horse or pony is typically premedicated with detomidine (10–20 μg/kg) and then induced with a ketamine (2 mg/kg) intravenous bolus; after induction, anesthesia is maintained using the triple drip (2 mL/kg/h). If a 15-drop/mL infusion set is used, the rate for administration of the triple-drip solution is 1 drop per second to maintain the horse under general anesthesia. Recovery usually occurs 35 to 40 minutes after discontinuing the infusion. It is critical to provide a safe area for recovery. This may be particularly challenging in a disaster flood environment.

Integument and musculoskeletal injury

Extremity, head, neck, and trunk lacerations and abrasions are commonly seen in equine flood victims. Limb lacerations are especially common and can involve fractures or tendon lacerations. A horse exhibiting moderate to severe lameness requires detailed examination to localize the lameness and prevent further exacerbation. Diagnostics should focus on blunt and

penetrating traumatic injuries, which can result in bone fracture, soft tissue injury, nail penetration into the foot, or a combination of injuries. Access to splinting devices, such as lower limb protection using a Kimsey splint, is beneficial.

Flood-affected horses may develop dermatitis and cellulitis because of breeches in the skin's barrier capabilities from standing in contaminated water for long periods. Contaminants may include chemicals (eg, oil spill related), sewage, minerals (involving mining or rock quarries), elevated salinity (gulf, ocean, or brackish waters), or other substances. Flood waters with high saline levels are more likely to cause diseases associated with ingestion of water, such as colitis or neurologic disease. Mild to moderate cases of dermatitis and cellulitis can lead to more serious complications, such as septic tenosynovitis or septic arthritis, and if not treated aggressively, these infections can lead to severe lameness or loss of use, and some may even be life ending. Early recognition and diagnosis of cellulitis enable the rapid aggressive intervention necessary for a positive outcome. Delay in diagnosis and treatment increases complication and mortality rates and makes these conditions difficult to treat successfully. Horses with cellulitis have swelling and heat in affected areas. They show signs of pain and lameness and often have a low-grade fever (102°F–104°F). Horses with more severe infections become anorectic and show signs of serious discomfort. Their legs become extremely painful when touched, and they may show moderate to severe lameness of that limb. Systemic antimicrobial therapy is indicated in cases of cellulitis and should be based on broad-spectrum capabilities and tissue penetration. β-Lactam antimicrobials are indicated because of the risk of clostridial diseases and other anaerobic bacterial infections. Standard dosing of ceftiofur sodium (2.2 mg/kg administered intravenously or intramuscularly every 6 to 8 hours), procaine penicillin G (22,000 IU/kg administered intramuscularly every 12 hours), or penicillin G potassium (22,000 IU/kg administered intravenously every 6 hours) combined with an aminoglycoside and oral metronidazole (20–25 mg/kg administered per os or per rectum) offers excellent coverage of most bacterial organisms. Antimicrobial treatment for cellulitis should continue for 10 to 14 days and possibly longer if necessary.

Horses exposed to flood waters may be at higher risk of developing extremity dermatitis- and cellulitis-associated fungal or fungal-like diseases, such as equine Pythium or Basidiobolus. In horses, fungal skin infections can be invasive and rapidly progressive and can cause proliferative pyogranulomatous disease. Lesions can be ulcerative and oozing and may have a foul odor. The growing cutaneous mass might be especially pruritic, and affected animals often are stressed and agitated, which might lead to self-mutilation in an attempt to relieve the discomfort. Grossly, the lesions may be confused with exuberant granulation tissue. Fungal skin disease requires definitive diagnosis by means of a biopsy and fungal culture (Pythium Laboratory, Louisiana State

University, Baton Rouge, Lousiana) for determination of appropriate treatment [10]. If skin lacerations, dermatitis, and cellulitis fail to respond to standard care, including systemic antibacterial therapy, fungal infection needs to be ruled out by means of a skin biopsy for histopathology and fungal culture. Treatment includes a combination of surgery, antifungals, and immunotherapy.

Hoof problems

Horses that have been standing in mud or water for long periods may develop thrush, soft soles, and sloughing of the frog, which compromise the strength of the hooves' support structures and can make the horse more prone to sole bruising and other hoof problems. Once dry, their hooves may be more susceptible to separation of the laminae and to subsequent white line disease, laminitis, or foot abscessation. The horse's feet should be cleaned using a hoof pick and brush as soon as possible to remove sharp debris capable of puncturing the hoof wall or sole. Horses that have been standing in mud, water, or debris for extended periods may require medical farriery (podiatry) to treat thrush, hoof or sole defects, coronitis, or laminitis. Application of iodine-based hoof preparations toughens up soft soles and draws some of the moisture out of hooves that are too soft. Additionally, thrush-fighting products found in farm supply and tack stores can effectively treat minor cases of thrush if used appropriately.

Ophthalmic injuries

Ophthalmic injuries, especially traumatic corneal ulceration and uveitis, are common medical emergencies observed in equine flood victims as a result of flying storm debris and damaged stable and pasture environments. Animal handlers and first responders may not recognize ophthalmic injuries as they concentrate on more obvious injuries and participate in rescue activities. A thorough ophthalmic examination and early recognition and treatment are important for preventing more serious infections. Equine eyes should be irrigated with sterile eyewash solution, and the veterinarian should perform a close detailed ophthalmic examination, which requires sedation in most cases. The eye examination should include fluoroscein staining of both eyes to rule out the presence of traumatic corneal defects. Corneal abrasions and ulcers may quickly become bacterial or fungal infections if not treated preventatively and aggressively. Deep corneal invasion of fungi and concurrent bacterial infection can lead to corneal perforation and iris prolapse. Common clinical signs of fungal keratitis include ocular pain manifested by blepharospasm, epiphora or photophobia, fluorescein-positive corneal ulceration, or corneal neovascularization as well as and uveitis manifested by miosis and aqueous flare. Prevention of fungal keratitis

should include topical treatment with antifungal agents, such as miconazole or silver sulfadiazine cream [11]. Broad-spectrum antibacterial agents include ophthalmic triple-antibiotic ointment, ciprofloxacin, and tobramycin. Atropine 1% ophthalmic solution or ointment should be applied topically as frequently as is necessary to maintain pupillary dilation in horses with storm-related traumatic corneal defects. Fungal infections may be difficult to treat; thus, early recognition and treatment are important to a successful outcome. Ocular pain may also be controlled by the systemic administration of nonsteroidal anti-inflammatory (NSAIDS) drugs, such as phenylbutazone (2.2 mg/kg every 12 to 24 hours) or flunixin meglumine (1.1 mg/kg every 12 to 24 hours) for 5 to 7 days, thereafter gradually reducing the dose to 50% or less. Corticosteroid therapy should not be included in treating traumatic corneal ulceration in the horse.

Gastrointestinal dysfunction

Horses that are stressed from being stranded, injured, or unattended during a flood situation or have ingested contaminated water, hay, or grain may develop colitis or another form of colic or systemic toxemia requiring moderate to aggressive medical care. Frequently, horses show signs of lethargy, inappetence, and colic, and some may develop mild to severe diarrhea. Physical examination may reveal an increased respiratory rate or heart rate attributable to abdominal discomfort as well as an increased rectal temperature attributable to toxin absorption. Signs of abdominal discomfort can range from mild (eg, recumbency, inappetence) to severe (eg, rolling, thrashing). There is often gross abdominal distention if the large colon is affected. Colitis may be confused with other large bowel disorders, including large colon torsion or volvulus, whereby surgical intervention may become necessary. Mucous membranes may be tacky with a delayed capillary refill time, and skin turgor may be reduced. Systemic absorption of endotoxin can result in peripheral arteriovenous shunting and classic ''brick-red'' mucous membranes. Hypovolemia and subsequent circulatory shock can cause purple mucous membranes and weak peripheral pulses.

Treatment regimens are supportive and aimed at plasma volume replacement (crystalloid fluid replacement), analgesia and anti-inflammatory therapy, antiendotoxin therapy, antimicrobial therapy if indicated, and nutritional support. Aggressive intravenous polyionic fluid therapy should be instituted immediately in horses showing signs of toxemia, colic, clinical dehydration, or colitis. Total fluid deficits should be calculated based on clinical assessment of dehydration (eg, for 8% or moderate dehydration, 0.08×450-kg body weight $= 36$ L), and replacement fluids should be administered rapidly (up to 6–10 L/h per 450-kg adult horse). Many horses with colic associated with dehydration and electrolyte imbalances voluntarily consume various types of electrolyte mixture. In addition to offering a fresh clean water source, offering mixtures of electrolytes in water may

be beneficial in some cases. Mixtures to consider providing include water with baking soda (10 g/L), water with sodium chloride (NaCl) and potassium chloride (KCl) (“lite” salt) at a rate of 6 to 10 g/L, and water with a commercial electrolyte solution. Horses with nasogastric reflux should not be offered water until normal transit of fluid and ingesta is re-established. Horses with unrelenting signs of an abdominal crisis, including colitis, with a minimal clinical response should be referred to a veterinary facility capable of providing intensive care treatment or surgical intervention.

Horses with signs of toxemia (elevated heart rate, brick-red mucous membranes, and clinical dehydration) may have absorbed large amounts of endotoxin from a disrupted intestinal mucosal barrier, thus putting these horses at high risk for developing laminitis, thrombophlebitis, and disseminated intravascular coagulation. Specific treatment to combat endotoxemia is crucial for patient survival. The choice of treatment options is based on the severity of the disease, renal function, and hydration status as well as on economics. Antiendotoxin treatment target areas include (1) endotoxin neutralization before interaction with inflammatory cells; (2) prevention of the synthesis, release, or action of mediator activity; and (3) general supportive care (Table 1).

NSAIDs are the most frequently used group of drugs for treating abdominal pain in horses (flunixin meglumine, 1.1 mg/kg administered intravenously every 12 hours; phenylbutazone, 2.2 mg/kg administered per os or intravenously every 12 hours). The veterinarian must weigh the benefit of the analgesic effect of NSAIDs against the possibility of further damaging

Table 1
Antiendotoxin therapy

Product	Dosing information
Endoserum	1.5 mL/kg of body weight intravenously diluted at a 1:10 or 1:20 ratio in sterile isotonic saline or lactated Ringer’s solution
Polymyxin B	1000–6000 IU/kg of body weight administered intravenously every 8–12 hours for up to 3 days. Because of the possibility of causing nephrotoxic side effects, polymyxin B should be used judiciously, and its use in azotemic patients is not recommended
Flunixin meglumine	0.25 mg/kg of body weight three or four times daily
Dimethylsulfoxide	0.1 g/kg of body weight administered intravenously (higher doses have been associated with exacerbating intestinal reperfusion injury in horses)
Allopurinol	5 mg/kg of body weight administered intravenously
Pentoxyphylline	8 mg/kg of body weight administered per os three times daily

the bowel by potentially blocking the protective effects of intestinal mucosal prostaglandins. Endogenous prostaglandins have been shown repeatedly to be important inhibitors of the development of intestinal inflammation, and blocking these with NSAIDs may slow the recovery and healing of inflamed cecal or colonic mucosa. Alternative choices for analgesia need to be considered. Butorphanol (an opioid analgesic, 0.06–0.1 mg/kg administered intramuscularly) combined with detomidine (an α–agonist, 0.01–0.02 mg/kg administered intramuscularly) every 6 to 8 hours is a useful combination that has minimal effects on gastrointestinal motility.

The use of broad-spectrum intravenous antibiotics in cases of colic and colitis is not always indicated. Mild and transient neutropenia or fever may not justify the use of broad-spectrum antimicrobials, but they should be considered when the patient has concurrent problems warranting treatment or profound or persistent neutropenia and may be at an increased risk for complications associated with sepsis, such as peritonitis, pneumonia, cellulitis, thrombophlebitis, or coagulation dysfunction. Potassium penicillin (22,000 IU/kg administered every 6 hours) in combination with gentamicin (4.4–6.6 mg/kg administered every 24 hours) is a commonly used therapy in these cases. Oral broad-spectrum antimicrobial medications are not recommended because they may further disrupt the intestinal microbial population. Oral metronidazole (15–25 mg/kg administered every 8 hours) may be indicated in cases in which *Clostridium* spp are suspected as playing a role in the pathogenesis of the disease. In addition, metronidazole may have local anti-inflammatory effects and may be effective in treating acute equine colitis of unknown cause. Treatment with metronidazole has been associated with causing anorexia in some horses [12]. Effective antisecretory medications targeting the equine large colon have not been identified. It is unlikely that bismuth subsalicylate or similar protectant agents are effective for treating large-bowel diarrhea in the adult horse because of the large volume of large intestinal contents. Horses with diarrhea may benefit from treatment with oral adsorbents, such as activated charcoal or smectite powder. Nasogastric intubation with mineral oil may promote resolution of intestinal impaction colic and may inhibit absorption of toxins through the damaged intestinal mucosal barrier. Nutritional needs of horses with resolving colic and colitis are an important consideration. Flood-affected and injured horses often have a ravenous appetite and should be allowed to eat judicious amounts of good-quality hay and fresh green grass (if available). Fresh water should be provided in small amounts initially and then ad libitum. Re-establishment of normal feeding and watering should occur over 48 to 72 hours.

Neurologic disease

Equine flood victims are at increased risk of developing head and neck injuries and are more susceptible to infectious diseases, such as viral

encephalitides or clostridial infections (tetanus and botulism). During patient triage, initial physical examination findings suggestive of central neurologic disease require immediate action to prevent further progression of neurologic abnormalities. Vaccination with tetanus toxoid is indicated if the vaccination status of the patient is unknown. Vaccinating against encephalitides or viral and bacterial respiratory diseases may be contraindicated, because the immune response in an extremely stressed horse is minimal and may actually contribute to a raised stress level in equine flood victims [13]. In hindsight, there was a general consensus from Hurricane Katrina and Rita equine response veterinarians that tetanus vaccine was indicated for animals rescued because of their increased risk for this potentially life-threatening disease but that vaccinating extremely stressed horses with respiratory and encephalitis vaccines was not effective and may have contributed to the adverse reactions observed in a few of the horses.

If ingested water contains elevated saline levels, such as waters contaminated with coastal storm surge, veterinarians treating potentially salt-intoxicated horses must be judicious with administration of intravenous or oral fluids to prevent exacerbation of potential salt toxicity. Ingestion of water containing total dissolved salt at a rate more than 7000 mg/L has the potential to cause acute salt poisoning. Salt poisoning may occur secondary to water deprivation, which may happen when horses are left unattended for several consecutive days. This was the case for several dozen horses during the aftermath of Hurricane Katrina. With the looting and civil unrest that ensued 3 to 5 days after the storm's landfall and the declaration of martial law in the Greater New Orleans area, rescue teams were denied access to these animals for 3 to 5 additional days and many horses were found to have been locked in their stalls in ankle to knee-deep mud without access to potable water for up to 7 days. Detailed specific management of salt poisoning in horses is covered elsewhere. The basic principles include prevention by replenishing plasma volume hydration more slowly than in standard cases of hypovolemia as well as close monitoring of serum sodium or osmolality and clinical neurologic signs. Treatment with systemic anti-inflammatory medications may help to minimize signs of cerebral edema.

Respiratory disease

Aspiration of water in horses exposed to flood waters may cause acute pulmonary edema and pneumonia, which is usually life threatening. Even small amounts of aspiration may lead to inflammation and consolidation of the lungs. Secondary bacterial invasion is likely, and if the horse survives acute insults, this could later develop into severe septic pneumonia or pleuropneumonia. Horses that have been found to be stranded or "stuck" in ponds, deep mud, or flood waters and struggle and flail for long periods can develop upper respiratory tract inflammation (eg, chondritis, pharyngitis, laryngitis). Emergency tracheotomy may be necessary in horses that

have developed URT obstruction secondary to long periods of struggling. Aspiration pneumonia may occur secondary to laryngeal dysfunction. Treatment includes aggressive anti-inflammatory therapy, systemic broad-spectrum antibiotics, and, if the horse is not dehydrated, furosemide to address pulmonary edema.

Horses that are evacuated or rescued after a flood event may be commingled and become infected with respiratory infections, such as equine influenza, rhinopneumonitis, or *Streptococcus equi*. Herd health programs aimed at providing herd immunity optimization before storm seasons can help to minimize herd outbreaks in the event of such a situation.

Summary

Of the nearly 500 horses evacuated, rescued, and sheltered in Louisiana after Hurricanes Katrina and Rita, most were only mildly affected and seemed to need only the ''basics'' of solid dry footing, food, and clean drinking water. There is no way to prepare for every situation that arises in a disaster. By working closely with other producers and agricultural leaders, however, horse owners can lessen the impact of a disaster on their operation. Preparation and detailed planning are the most important aspects of flood-related injury prevention. Encouraging animal owners and caretakers to have an evacuation plan and dispersing knowledge about local and regional disaster authorities are critical for a successful disaster response. Educational programs on future disaster response empower communities to care for their people and animals responsibly.

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