Chapter 2

THE MANAGEMENT OF A MULTIDRUG-RESISTANT *SALMONELLA AGONA* OUTBREAK AT A LARGE ANIMAL TEACHING HOSPITAL

2.1 Abstract

Outbreaks of salmonellosis have been reported at a number of large animal teaching hospitals. Means to control these outbreaks vary widely and range from slight changes to hospital protocol to extensive measures, such as hospital closure, in order to fully disinfect facilities and prevent further spread of infection.

The following case report details the management of a multidrug-resistant *Salmonella agona* outbreak which occurred in 2001 at the Large Animal Teaching Hospital of the Virginia-Maryland Regional College of Veterinary Medicine (VMRCVM) located on the campus of Virginia Tech in Blacksburg, Virginia.

Medical records of all patients testing positive for *S. agona* between January 2001-2002 were reviewed. Other information was gathered through interviews of VMRCVM hospital personnel and the review electronic mail and invoices.

It is thought that a calf, from a university owned dairy herd, was the index case of the outbreak. A total of 16 equine patients acquired *S. agona* while hospitalized. The nosocomial disease incidence risk for in-house patients during this outbreak was estimated to be 33% (16/49). The LAH was closed for 7 months for cleaning, disinfection and renovations. The total cost of the outbreak was estimated to be at least $755,000.

This outbreak underscored the importance of biosecurity practices in preventing nosocomial and zoonotic infections.

KEYWORDS: nosocomial infection, outbreak, *Salmonella*, veterinary large animal teaching hospital

2.2 Introduction

Reports of nosocomial disease in veterinary facilities are on the rise (Schott, 2001). Resistance to antibiotics has been cited as one of the main reasons for their escalation (Johnson, 2002). A variety of organisms have been implicated including *Acinetobacter, Candida, Clostridium, Enterococcus, Pseudomonas, Serratia, Staphylococcus and Streptococcus* (Boerlin *et al.*, 2001; Fox *et al.*, 1981; Glickman, 1981; Johnson, 2002; Seguin *et al.*, 1999; Weese *et al.*, 2000). The most common organisms associated with nosocomial diarrhea in large animal hospitals (LAHs) are *Salmonella* spp. and *Clostridium* spp., although the literature suggests that *Salmonella* spp. are the most prevalent (Alinovi *et al.*, 2003b; Donahue, 1986; Ewart *et al.*, 2001; Hird *et al.*, 1984; Johnson, 2002; Lane *et al.*, 2001; Pare *et al.*, 1996; Schott, 2001; Tillotson *et al.*, 1997).

Several risk factors are associated with hospital-acquired salmonellosis including colic, diarrhea and other gastrointestinal problems, distance traveled to the hospital, duration of hospitalization, other things causing stress, antibiotic administration, exposure to an animal shedding the organism, any change in feeding and/or nasogastric intubation (Alinovi *et al.*, 2003b; Hird *et al.*, 1984; Lane *et al.*, 2001; Schott, 2001).

Although outbreaks involving *Salmonella* spp. have been reported at numerous LAHs, means described to control these infections vary widely and range in severity from slight changes to hospital protocol to hospital closure. The latter not only affects patient healthcare, but also decreases client trust, damages reputation in the community and decreases revenue for the facility. Ultimately, litigation may compound losses (Johnson, 2002; Schott, 2001).

Each outbreak is unique and with every new report, veterinary medical professionals have the opportunity to expand their knowledge of infection control. Outbreak investigations also increase our understanding of the epidemiology of infectious disease and highlight behaviors that enhance risk within susceptible populations (Schott, 2001; Koepsell and Weiss, 2003).

The following account describes the management of a multidrug-resistant *Salmonella agona* outbreak which occurred during 2001 at the Large Animal Teaching

Hospital of the Virginia-Maryland Regional College of Veterinary Medicine (VMRCVM) located on the campus of Virginia Tech (VT) in Blacksburg, Virginia.

2.3 Information Gathering

For the purpose of this investigation, a case was defined as an animal testing positive for *S. agona* between February 2001- January 2002. Medical records of all cases were reviewed. Information obtained from records included case number, patient name, client name, town/city where the animal originated, species, admission and discharge date, presenting complaint, date of first sample submission to bacteriology, date of first *Salmonella* positive sample, date that bacteriology results were disclosed, attending clinician(s), attending student(s), whether the patient was grazed and/or exercised, placed in a ward or full isolation and if it was necropsied. In addition, the admission date of in-house equine patients not testing positive for *S. agona* between February 28, 2001 - January 2002 was also obtained from medical records in order to estimate the nosocomial disease incidence risk.

Other information pertinent to the outbreak was gathered through interviews of VMRCVM hospital personnel and the review of electronic mail and invoices.

2.4 Bacteriological Methods

Cultures of samples submitted during the outbreak were performed by the Clinical Bacteriology Laboratory of the VMRCVM. This laboratory operates in accordance with the standards of the quality assurance programs of the College of American Pathologists, the Veterinary Laboratory Association, and the American Association of Veterinary Laboratory Diagnosticians.

Before and while the outbreak was occurring, the procedure for detecting *Salmonella* was as follows: Day 0: Samples were directly plated on Hektoen Enteric (HE) and MacConkey (MC) agar (Becton Dickinson, Sparks, MD) and enrichment was performed in Selenite broth (SB) (Becton Dickinson, Sparks, MD) at 35º C for 18- 24 hours. Day 1: Suspicious colonies were sub-cultured and SB was plated on HE and MC agar. Day 2: All plates were evaluated. Day 3: If no suspicious growth was present, a report indicating a *Salmonella* negative culture was made.

Suspicious colonies were sub-sampled in order to obtain pure cultures. Poly-O antiserum agglutination was performed. Suspect organisms were further evaluated biochemically using tests such as API 20E (bioMérieux, Inc., Hazelwood, MO), Sensititre (TREK Diagnostic Systems, Cleveland, OH) or Biolog ID (Biolog, Inc., Hayward, CA). After confirmation of a positive result, contact with the case clinician was made in person or by phone. If the clinician listed on the submission form could not be contacted, another responsible person (*e.g.* section chief, staff supervisor, etc.) was found.

All *Salmonella* isolates were sent to the *Salmonella* Serotyping Laboratory at the National Veterinary Services Laboratories (NVSL) in Ames, Iowa for speciation. A reply took approximately 1 month.

During the outbreak, environmental swabs taken from horse stalls (doors, mats and walls) and drains (covers, traps and interior) were also submitted to the bacteriology laboratory. Methods used for the detection of *Salmonella* from environmental samples were as follows: Day 0: Swabs were placed in SB at 35º C for 18- 24 hours. Day 1: Selenite broth was sub-sampled onto HE and MC plates. Day 2: Plates were evaluated. Day 3: If no suspicious growth was present, a report indicating a *Salmonella* negative culture was made. If *Salmonella* was suspected, bacteriological identification was performed as previously described. After the outbreak, protocols were modified to include XLT4 agar (Becton Dickinson, Sparks, MD).

2.5 Large Animal Hospital Operations

2.5.1 Personnel, Facilities and Services

Between 20- 30 personnel work in the LAH each weekday. These include clinicians, residents, interns, technicians, husbandry staff and veterinary students.

The hospital provides service for referral patients from a large area including Virginia, Maryland, West Virginia, North Carolina and Tennessee. Primary care is provided for clients within a 35-mile radius of the LAH either through the ambulatory service (Production Management Medicine, PMM) or in-house (Large Animal Medicine and/or Large Animal Surgery). PMM also

services university flocks and herds, *e.g.* a dairy farm, owned and operated by VT, which is located less than a mile from the LAH.

The LAH consists of three wards (A, B and C), radiology suites, personnel offices, two student conference rooms, equine receiving and standing surgery, one storage and feed room, one equipment room, the large animal surgery preparation, surgery and surgery recovery rooms and bathrooms. A floor plan of the LAH is shown in Figure 2.1.

Ward A is used for large animal medicine cases, which consist primarily of equine patients. There is also a food animal stall, a nuclear medicine stall and two intensive care areas that are used for the neonates of various species. Ward B is used for large animal surgery cases and typically houses equine patients. Ward C is primarily used to house food animals and in-house PMM patients. An isolation building, physically separated from the main LAH is used to house patients with suspected or confirmed contagious diseases. This building contains three isolation stalls, each with its own work/preparation room.

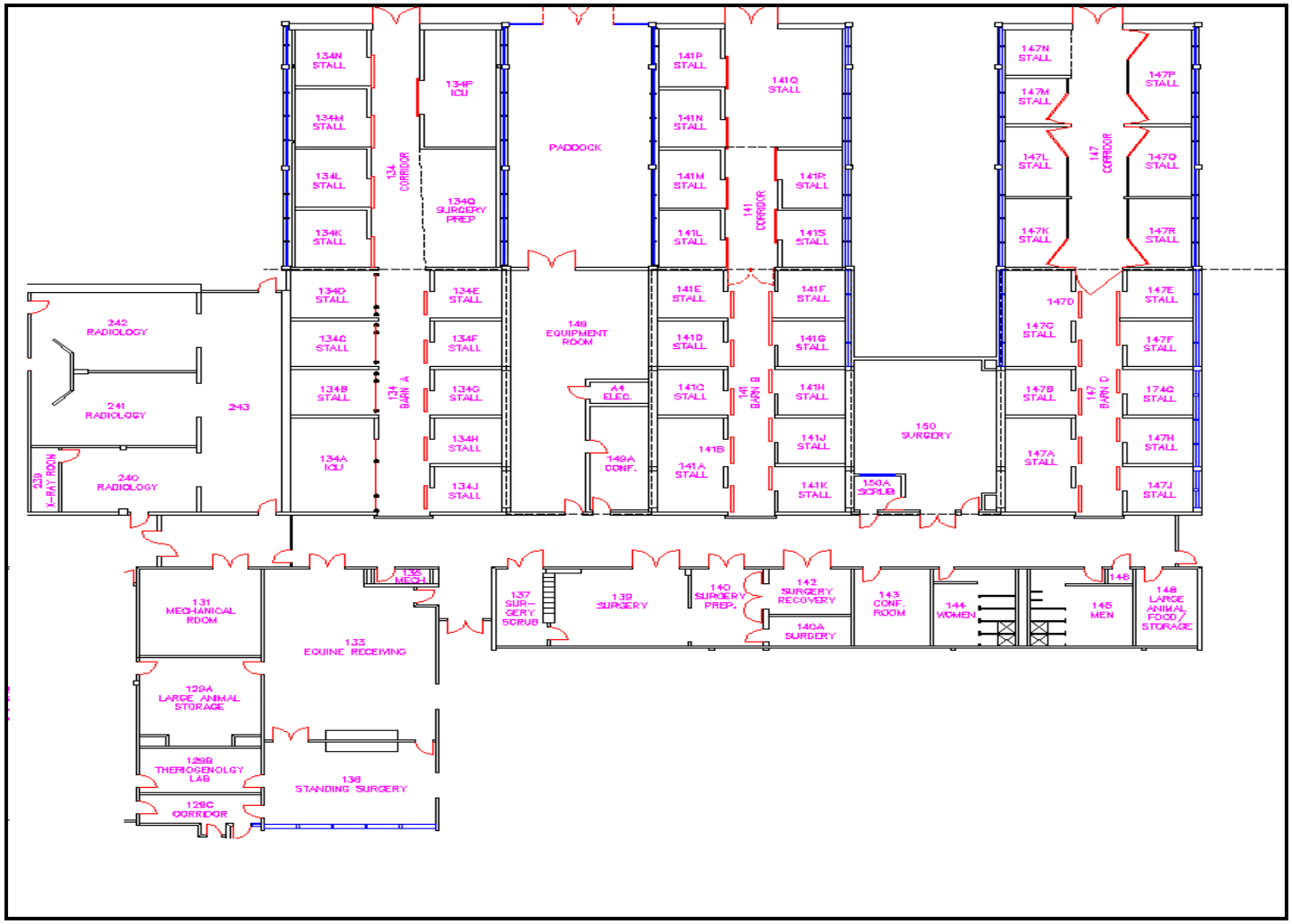

Figure 2.1. Floor plan of the Large Animal Hospital.

2.5.2 Generation of Patient Numbers

Patients were presented to the LAH as either referrals from other veterinarians or walk-ins who made their own appointments. Occasionally, cases seen by PMM in the field were transported to the hospital to make case management easier. Patient numbers were generated for most referral and walk-in patients. This number was used to identify the specific animal. On rare occasions this was not done. For example, when a mare was accompanied by a foal, a separate number may or may not have been generated for the foal. In situations where cases were brought into the LAH by PMM, a hospital number also may not have been generated. Lack of patient numbers in some cases may have resulted in an artificially, albeit marginally low census for the outbreak period.

2.6 Outbreak Synopsis

An abridged chronology of the outbreak is shown in timeline form in Table 2.1. On February 28, 2001 the carcass of a 7-day old male Holstein calf (a referral by PMM from the VT Dairy) was presented directly to necropsy. Because this was a spontaneous death, the calf never entered the LAH. The necropsy report, dated March 12, 2001, cites a mixed infection of enterotoxigenic *Escherichia coli*, *Salmonella,* and *Cryptosporidium* as the cause of death. A direct (verbal) effort was made by the pathologist to contact the case clinician regarding the culture results, but the individual was on vacation at the time. A copy of the necropsy report was sent to the clinician's mailbox. It is not known when the clinician was made aware of the calf's status. At least two weeks (time between the calf's presentation to necropsy and date of necropsy report) are thought to have passed before the clinician was informed. This calf is thought to have been the index case.

Between February 28 and April 3, 2001, 4 referral calves (2 from private owners and 2 from the VT dairy) were presented to the LAH. It cannot be definitively stated if these calves were admitted to the hospital and then sent to necropsy or whether they were sent directly to necropsy. From conversations with LAH personnel at least one of the calves from the VT dairy was admitted as an in-house patient. All of the calves either died spontaneously or were euthanized and found to be *Salmonella* positive. *Salmonella*

with the same antimicrobial susceptibility pattern found present in the first (index) calf examined by necropsy was also isolated from these calves.

Between April 7-23, 2001, 2 more calves were presented to necropsy. April 10, 2001 marked the first time *Salmonella* with the same susceptibility pattern was isolated from an equine patient. On April 13, 2001, Ward A of the LAH was closed to new patients. By April 25, 2001, 5 more equine patients tested *Salmonella* positive. The isolate was first identified as *S. agona* on May 3, 2001. On May 24, 2001 a horse hospitalized for less than 24 hours was necropsied and found to be infected although the horse did not exhibit clinical signs of salmonellosis. On May 31, 2001 the last non-emergency animal was admitted as an in-house patient before the closure of the LAH. The last patient tested *Salmonella* positive on June 4, 2001. On June 8, 2001 the *Salmonella* strain was isolated from Ward B of the LAH; the only ward considered being free of the pathogenic organism. The hospital was officially closed on June 9, 2001. After the official closure of the hospital, 10 emergency cases were admitted from July 16-November 28, 2004. During the official outbreak period, a total of 16 equine patients and 11 calves (admitted or presented directly to necropsy) tested positive for *Salmonella* (Table 2.2). The nosocomial disease incidence risk of infection for in-house patients (those with patient numbers) during this outbreak is estimated to be 33% (16/49). Because the calves and one equine patient spent less than 24 hours in the LAH before their deaths, they were not considered to have acquired the disease nosocomially.

Table 2.1 Abridged chronology of the 2001 *Salmonella* outbreak.

2/28/01	VT dairy calf presented directly to necropsy. Case clinician (on vacation) was not immediately informed about the calf's *Salmonella* positive status.
3/12/01	Necropsy report dated for this calf. It is thought case clinician did not learn of the calf's status until at the earliest 2 weeks later.
4/7-23/01	14 equine patients admitted to the large animal hospital (LAH). Two calves, later found to be *Salmonella* positive, were presented to necropsy. One of them was housed in the LAH.
4/10/01	First equine patient tested positive for *Salmonella*.
4/11/01	Concern was expressed by the bacteriology laboratory about the high number of *Salmonella* cases in necropsy and LAH.
4/13/01	Ward A closed to new patients and quarantined.
4/25/01	5 more equine patients found to be *Salmonella* positive.
4/23/01-5/31/01	22 in-house equine patients admitted to LAH.
5/03/01	Isolate identified by NVSL as *S. agona*.
5/24/01	Horse not suspected of having salmonellosis was necropsied and reported to be *Salmonella* positive.
5/31/01	Last date a non-emergency horse was admitted to LAH.
6/04/01	Last date an equine patient tested *Salmonella* positive.
6/08/01	*Salmonella* isolated from Ward B (environmental), previously considered free of the organism.
6/09/01	Decision was made by the "*Salmonella* Task Force" to officially close of the LAH for cleaning, disinfection and renovations.

Table 2.2. Chronology of *Salmonella* positive bacteriological samples.

Case #	Species	Admission Date	1st Date Positive	Date Reported
1	Bovine	2/28/2001	2/28/2001	3/12/2001
2	Bovine	3/27/2001	3/28/2001	3/31/2001
3	Bovine	3/29/2001	3/29/2001	4/18/2001
4	Bovine	4/03/2001	4/04/2001	4/06/2001
5	Bovine	4/03/2001	4/04/2001	4/06/2001
6	Equine	4/07/2001	4/10/2001	4/12/2001
7	Equine	4/08/2001	4/11/2001	4/13/2001
8	Equine	4/07/2001	4/12/2001	4/15/2001
9	Equine	3/08/2001	4/13/2001	4/16/2001
10	Bovine	4/13/2001	4/13/2001	4/17/2001
11	Bovine	4/13/2001	4/13/2001	4/16/2001
12	Equine	4/08/2001	4/14/2001	4/17/2001
13	Equine	4/23/2001	4/25/2001	4/28/2001
14	Equine	3/07/2001	5/08/2001	5/11/2001
15	Equine	5/05/2001	5/08/2001	5/11/2001
16	Equine	5/05/2001	5/08/2001	5/13/2001
17	Equine	5/07/2001	5/13/2001	5/26/2001
18	Equine	3/22/2001	5/16/2001	5/20/2001
19	Equine	5/16/2001	5/21/2001	5/25/2001
20	Equine	5/07/2001	5/23/2001	5/27/2001
21	Equine	5/14/2001	5/23/2001	5/26/2001
22	Equine	5/15/2001	5/23/2001	5/26/2001
23	Equine	5/15/2001	5/24/2001	5/26/2001
24	Bovine	5/23/2001	5/25/2001	5/28/2001
25	Equine	5/31/2001	6/04/2001	6/08/2001
26	Bovine	8/20/2001	8/20/2001	8/23/2001
27	Bovine	8/27/2001	8/27/2001	8/30/2001
28	Bovine	8/31/2001	8/31/2001	9/03/2001

2.7 Implemented Biosecurity Procedures

On April 11, 2001, 4 weeks after the initial isolation of the organism, the Clinical Bacteriology Laboratory expressed concern over the high number of *Salmonella* isolations from necropsy and the LAH. On April 13, 2001, Ward A of the LAH was closed to new patients and effectively isolated from the rest of the hospital. Only personnel directly involved with patient care were permitted inside. Protocols designed specifically for use in the isolation unit were implemented. Steam cleaning of Wards A and C was performed. "Keep-out" signs were posted and footbaths containing disinfectant were placed at all possible entrances to the LAH. Shovels and other cleaning implements were cleaned and disinfected. Disposable coveralls were made available to personnel as well.

At the end of May, VMRCVM personnel formed a task force to develop more stringent infection control procedures. Until such procedures could be developed, a short-term plan was instituted which entailed depopulation of Ward A, cleaning and disinfection of Wards A and C using steam and a phenolic disinfectant and environmental sampling to validate the process.

On May 30, 2001 a decision was made to restrict the necropsy facility to faculty, staff and students directly associated with necropsy cases. Pathology rounds were held at the discretion of the duty pathologist. Clinicians were instructed to notify the duty pathologist if a suspect salmonellosis case was to be presented to for necropsy.

On June 8, 2001 the "*Salmonella* Task Force" consisting of internal administrators, bacteriologists, epidemiologists, large animal clinical and infection control personnel held its first meeting. Members of the task force decided to completely close the LAH for only a few weeks in order to thoroughly decontaminate the premises and make necessary repairs. In addition, changes to necropsy procedures were implemented which included restriction of access to the necropsy floor, prohibition of street clothes under coveralls as well as vigorous sanitation of coveralls and boots. These changes were instituted in an effort to prevent any infectious material from leaving the necropsy room.

Five horses (3 in Ward A, and 2 in the isolation unit) and a bovine case (Ward C) still remained in the LAH at the time of closure. No new cases were admitted to the LAH

with the exception of emergencies. Out-patients that elected to visit the facilities after complete disclosure of the current situation were restricted to equine receiving, standing surgery and radiology. Two local newspapers as well as the Virginia Veterinary Medical Association featured articles publicizing the outbreak. Referring veterinarians and equine medical centers were personally called and mailed a letter informing them of the decision to temporarily close the hospital and alerting them of the possibility of referral cases being sent to their facilities.

Within the timeframe of the outbreak, one confirmed and three probable cases of salmonellosis among VMRCVM personnel were reported. It is not known if the isolated organism had the same susceptibility pattern of the animal isolates. An informational sheet describing salmonellosis, its mode of transmission, clinical manifestations and means of prevention was distributed to faculty, staff and students within the VMRCVM. All personnel were instructed to report cases of gastroenteritis.

Fecal samples of all in-house equine patients were cultured every 48 hours. Owners of patients were advised not to remove their animal(s) from the hospital until they were confirmed to be negative for *Salmonella*. Procedures were put in place to culture horses at discharge and again 72 hours after discharge (a kit was provided to the owners). Owners were advised to isolate their animals upon arrival at home and to monitor them for clinical signs. Owners whose animals had been in the hospital during the outbreak but that had been asymptomatic and discharged were also contacted. Efforts were made at this time to identify the source of the outbreak. Other schools of veterinary medicine that had experienced similar outbreaks were consulted in regard to their methods of infection control.

2.8 Cleaning and Disinfection

Initial management of the outbreak included depopulation of the LAH, dry and wet cleaning, disinfection, renovations and pest control. Bird nests were removed from ceiling cross beams and efforts were made to trap resident pest species. Rodent traps were also set. Fresh bird and rodent droppings as well as trapped vermin were cultured and proved to be negative for *Salmonella*.

Bedding was removed from every stall and as much equipment as possible was cleaned and moved off of the floor. Heavy equipment that could not be moved such as fork-lifts, was dry cleaned with compressed air or by brushing. Special attention was also given to removing debris from gravel areas.

Residual organic material was loosened using a foaming detergent applied by low-pressure spray. Equipment kept in the LAH such as halters, leads, brooms, shovels, etc., were also pre-soaked. Heavily soiled areas were hand scrubbed.

An attempt was made to further clean the ceiling, beams, walls and then the floor using detergent applied by high pressure spray. Treatment and feed preparation areas were pressure washed as well. Drains were flushed and heavy equipment was cleaned. Smaller items were immersed in a detergent solution and hand scrubbed. Any location resisting initial efforts was manually cleaned. All surfaces were rinsed with water following the completion of the washing process.

After inspection, it was determined that cleaning of the ceiling, beams, ductwork, pipes and upper walls could not be adequately or safely performed by LAH personnel. Therefore, a private firm, specializing in hazardous materials was contracted.

2.9 Renovations

Two features of the LAH were identified as possibly contributing to the spread of infection. The floor, made of 9mm thick rubber tiles (Norament 922, Freudenburg-NOK, Purcellville, VA) had deteriorated to the point that debris and liquid were trapped underneath in a number of places. Before the outbreak, plans had already been made to repair loose sections of the floor. Some sections had already been replaced by late March. The possibility of loose tiles and seams in the floor harboring *Salmonella* and other infectious organisms prompted a decision to install a new floor in the LAH. Before

this could occur, a 1-ton scale embedded in the floor had to be removed and the pit filled with concrete. A private contractor removed old tiles and adhesive. Moisture permeability testing of the concrete sub-floor was also performed.

A new floor surface made of cementitious urethane (Dex-O-Tex Tekcrete, Crossfield Products Corporation, Roselle Park, NJ) was poured in all sections of the LAH with the exceptions of Ward C, the equipment, storage, conference rooms and bathrooms. The expected advantage of this product was that it would provide a seamless floor with coved floor-wall joint, thus eliminating areas for liquid and infectious agents to accumulate. Damaged or deteriorated drywall, plumbing and stall door fixtures were repaired or replaced. Some electrical rewiring necessary for renovations was performed. Wooden cabinetry at floor level was replaced with stainless steel. Old equipment such as stall mats, neurology stall padding, buckets and food bins that could potentially harbor infectious agents were also replaced.

Although culture negative, birds and rodents were considered as possible vectors of infectious organisms. Pest control before the outbreak, consisting of annual exterminator visits and several bait stations placed outside of the wards, was considered by itself inadequate. An outside pest control company was contracted to carry out extensive extermination throughout the facilities. Efforts were made to bird-proof the LAH by applying expanded steel panels to all gates at exterior access points.

The whole process took much longer than the few weeks originally anticipated. The hospital was officially closed in June of 2001 and was not reopened until January 2002; approximately 7 months.

2.10 Costs Associated with the Outbreak

Itemized costs of the outbreak are shown in Table 2.3. Contract labor and materials totaled $277,339.13. Due to the intensive care that managing *Salmonella* in horses entails, the bills to clients for patient care were much higher than initially estimated. Approximately $25,000 in patient costs were therefore absorbed by the hospital. Client bill reductions, lost revenue for 7 months and the costs of new equipment were modestly estimated to be $478,000. The total cost of the outbreak was estimated to be at least $755,000.

Table 2.3. Itemized cost of the outbreak.

Contract Labor and Materials	
Pipe cleaning and removal of old floor adhesive	$38,901.33
Painting	29,864.55
Electrical rewiring	7,050.36
Restocking charge for sending old flooring material back	695.94
New floor and installation of stainless steel stall door stops	108,515.75
Miscellaneous Charges	307.86
Miscellaneous equipment contracted from various companies	4,106.19
Concrete moisture testing	1,615.56
Demolition services	6,323.88
Steel gates, door frames, stall doors stops	47,680.81
Extermination services	692.16
Removal of old flooring	9,242.00
VT Physical Plant	9,174.47
Other	13,168.27
Total	**$277,339.13**
Other Costs (Estimated)	
Client bill reductions	$25,000.00
Lost revenue	400,000.00
New scale	3,000.00
New mats	20,000.00
New padding in neurology stall	20,000.00
New buckets and food bins	10,000.00
Total	**478,000.00**
Estimated Grand Total	**≥$755,000.00**

2.11 Permanent Changes Made to Biosecurity

Before the outbreak occurred, if a patient was determined to have a potentially infectious disease, the case was either moved to the isolation unit or isolated within the ward by restricting traffic. A biosecurity protocol existed with regard to the isolation unit, but no formal protocol was in place for the LAH main facilities.

After the outbreak, extensive changes were made pertaining to biosecurity within the LAH. An internal biosecurity coordinator was appointed for the LAH. Numerous meetings, training sessions and literature were presented to LAH personnel in an attempt to increase awareness and impact behavior. These presentations addressed cleaning, disinfection, modes of disease transmission, handwashing, appropriate traffic patterns within the hospital and other means of biocontainment. Emphasis was put on the shared responsibility of everyone in the LAH for the success of the biosecurity program.

Changes were made to the Student and Husbandry Handbooks and Orientation sessions given to students prior to their rotations in the LAH. Efforts were also made to increase biosecurity education in the curriculum of veterinary medical students, *e.g.* lectures addressing principles of biosecurity.

Official biosecurity protocols for the LAH were developed. This included new scheme for assignment of patient biosecurity status. Each patient is now evaluated for communicable disease risk and designated as a "red dot" (known or suspected contagious disease), "yellow dot" (increased risk for acquiring contagious disease such as immunosuppressed patients) or "green dot" (no historical, laboratory or physical examination evidence suggesting infectious disease or increased susceptibility to infection) (VMRCVM, 2002) (Appendix, Section 2.15). The colors indicate where the patient will be placed and how it will be monitored and managed while in the hospital. This designation is placed on the stall door along with a sheet dictating the appropriate protocol for handling the case. Large animal hospital personnel are made aware that the status of a patient can change during hospitalization. The new protocol also requires a fecal sample to be obtained upon admission to determine if the animal is shedding *Salmonella*. Depending on the status of the patient, regular re-sampling is required.

Prior to the outbreak, environmental swabs for the detection of bacterial pathogens were taken only in the isolation facility following cleaning and disinfection.

Environmental cultures within the LAH were only performed if a hazardous organism was known to have been previously present in the stall. Post-outbreak biosecurity protocols now require environmental swabs to be taken from all stall floors, drains, mats and buckets after cleaning and disinfection. The stall must be designated as "clean" (*Salmonella* negative) before a new patient can be housed there.

The monitoring of animals in regard to their location in the hospital is more stringent. A daily census of all patients and their location in the LAH is kept. Personnel are now more conscious of traffic patterns between wards, radiology suites, exercise paddocks, etc., so as to prevent cross-contamination.

In addition, the medical records of all *Salmonella* positive animals are clearly marked on the exterior of the file and a "*Salmonella* positive" patient database has been established.

2.12 Post-Outbreak Effects

The LAH suffered severe losses due to the outbreak. Historical data suggests that the approximate revenue lost during the outbreak was $400,000. To date, patient load has not fully recovered from the outbreak, although other factors such as a downturn in the regional economy and faculty vacancies may be influential. Patient load may have also been affected by the increased costs associated with biosecurity in the LAH. Patients designated as "yellow" or "red" dots require more costly care and monitoring. While the hospital absorbs some of the extra costs, others are passed onto the client, which may deter them from patronizing the hospital.

The LAH has also suffered losses that cannot be quantified. Although efforts were made to offset the animal experience lost to the school during closure, the impact was definitely felt by students, residents and interns. A few residents added an additional year to their program as a result.

2.13 Discussion and Conclusion

Although each outbreak is unique, several basic steps must be followed in every situation. They include: establishing a case definition, enhancing surveillance, identifying the outbreak origin, implementing interventions, analyzing and reporting results. Prompt identification of the organism and mode of transmission is needed in order to halt the spread of infection (Koepsell and Weiss, 2003).

In the 2001 outbreak, a multi-drug resistant *Salmonella* (*S. agona*) was identified early. The presence of this organism in the field was known. Unwittingly, at least one calf from an infected premise was hospitalized without the appropriate safeguards being taken. Transmission from a VT Dairy calf housed in Ward C to an equine patient in Ward A is thought to have been the first inter-species transmission in the LAH. Although the exact mode of transmission could not be identified, it is thought that the organism was carried from one patient to another on hands, garments or equipment. Environmental persistence of the organism may have also played a role in its further spread. Seven in-house patients that were grazed in the same exercise paddocks later tested positive for *S. agona*. Although stalls were thoroughly cleaned and disinfected before the introduction of another patient, the old LAH floor may have been harboring *S. agona* underneath the tiles. Several environmental samples submitted to the Bacteriology Laboratory tested positive for *S. agona.* Research suggests that 2 cycles of cleaning and disinfection should be used before introducing new patients to stalls previously occupied by horses with salmonellosis (Alinovi *et al.*, 2003a). The spatial relationship between patient stall location and disease transmission could not be determined because patient census information was not considered to be reliable before the outbreak.

In order for an organism to be labeled nosocomial, common characteristics among isolates from different patients must be identified. *Salmonella agona* isolated during this outbreak was shown to be susceptible to amikacin, enrofloxacin and gentamicin and was resistant to ampicillin, cephalothin, chloramphenicol, neomycin, sulfamethoxazole with trimethoprim, tetracycline and ticarillin. The susceptibility of the organism to carbenicillin varied throughout the outbreak between intermediate and resistant.

Interestingly, *S. agona* with the same sensitivity profile, was isolated from 2 calves (not owned by VT Dairy) that were presented directly to necropsy. On March 1,

2001, the Virginia Department of Agriculture and Consumer Services also reported 2 cases (1 *S. agona* and 1 *Salmonella* spp.) that were sent to the National Veterinary Services Laboratories with the same antimicrobial sensitivity profile as well. In total, this particular organism was isolated from animals in 3 states and 13 different locales. It appears that this organism was already a problem in the region prior to when the LAH outbreak took place. The nosocomial disease incidence risk for in-house patients during this outbreak was estimated to be 33% (16/49). However, the mortality rate among these individuals was 0%.

Increased levels of biosecurity have required the addition of approximately $2,000 to the LAH annual budget. In this context the saying, "an ounce of prevention is worth a pound of cure" applies (Graves, 2004; Spearing *et al.,* 2000). Since the initial outbreak, a *S. agona*, strain similar to the original, has been isolated on at least 2 occasions from in-house LAH patients. No nosocomial disease spread was detected suggesting that the newly implemented biosecurity protocols are indeed effective.

The lesson that should be learned from any nosocomial outbreak is that no one person is to blame. Multiple lapses in procedures and protocol help to facilitate the spread of infection. It is the shared responsibility of all hospital personnel to practice the outlined biosecurity protocols of their institution. Failure to do so cannot only be expensive, but often results in long-term repercussions from which a hospital may have difficulty recovering.

There were several limitations inherent to this analysis. The most crippling limitation that affected the reconstruction of this outbreak was recall bias of personnel involved. It was difficult for people to remember how and when things specifically occurred. When at all possible, report of an outbreak should be done while it is occurring or immediately thereafter.

The generation of patient numbers also affected this study. Because, no one system is followed fully in regard to generating patient numbers by the LAH or PMM, the retrospective tracking of medical records to distinguish in-house from out-patients was very difficult.

2.15 References

Alinovi CA, Ward MP, Couëtil LL, et al. Detection of *Salmonella* organisms and assessment of protocol for removal of contamination in horse stalls at a veterinary teaching hospital. *J Am Vet Med Assoc*. 2003a; 223(11): 1640-44.

Alinovi CA, Ward MP, Couëtil LL, et al. Risk factors for fecal shedding of *Salmonella* from horses in a veterinary teaching hospital. *Prev Vet Med*. 2003b;60:307-17.

Boerlin P, Eugster S, Gaschen F, et al. Transmission of opportunistic pathogens in a veterinary teaching hospital. *Vet Microbiol*. 2001;82:347-59.

Donahue JM. Emergence of antibiotic-resistant *Salmonella agona* in horses in Kentucky. *J Am Vet Med Assoc*. 1986;188(6):592-4.

Ewart SL, Schott HC, Robison RL, et al. Identification of sources of *Salmonella* organisms in a veterinary teaching hospital and evaluation of the effects of disinfectants on detection of *Salmonella* organisms on surface materials. *J Am Vet Med Assoc.* 2001;218(7):1145-51.

Fox JG, Beaucage CM, Folta CA, et al. Nosocomial transmission of *Serratia marcescens* in a veterinary hospital due to contamination by benzalkonium chloride. *J Clin Microbiol*. 1981;14(2):157-60.

Glickman LT. Veterinary nosocomial (hospital-acquired) *Klebsiella* infections. *J Am Vet Assoc.* 1981;179(12):1389-92.

Graves N. Economics and preventing hospital-acquired infection. *Emerg Infect Dis*. 2004;10(4):561-6.

Hartmann FA, Callan RJ, McGuirk SM, et al. Control of an outbreak of salmonellosis caused by drug-resistant *Salmonella anatum* in horses at a veterinary hospital and measures to prevent future infections. *J Am Vet Assoc*. 1996;209(3):629-31.

Hird DW, Pappaioanou M and Smith BP. Case-control study of risk factors associated with isolation of *Salmonella saintpaul* in hospitalized horses. *Am J Epidemiol*. 1984;120(6):852-64.

HyGenius. The history of handwashing. Available at: www.hygenius.com/history.htm. Feb 24 2004.

Johnson JA. Nosocomial infections. *Vet Clin Small Anim*. 2002;32:1101-26.

Koepsell, TD and Weiss, NS. Epidemiologic methods. New York, NY: Oxford University Press, Inc. 2003;464-89.

Koterba A, Torchia J, Silverthorne C, et al. Nosocomial infections and bacterial antibiotic resistance in a university equine hospital. *J Am Vet Assoc*. 1986;189(2):185-90.

Lane TJ, Braun RK, Madison J, et al. Equine Salmonella Infection (Salmonellosis). Available at http://edis.ifas.ufl.edu/BODY_VM046. Oct 19 2001.

Morley P. Biosecurity of veterinary practices. *Vet Clin North Am Food Anim Pract*. 2002;18:133-5.

Pare J, Carpenter TE and Thurmond MC. Analysis of spatial and temporal clustering of horses with *Salmonella krefeld* in an intensive care unit of a veterinary hospital. *J Am Vet Assoc.* 1996;209(3):626-8.

Schott HC, Ewart SL, Walker RD, et al. An outbreak of salmonellosis among horses at a veterinary teaching hospital. *J Am Vet Assoc.* 2001;218(7):1152-9.

Seguin JC, Walker RD, Caron JP, et al. Methicillin-resistant *Staphylococcus aureus* outbreak in a veterinary teaching hospital: potential human-to-animal transmission. *J Clin Microbiol*. 1999;37(5):1459-63.

Spearing NM, Jensen A, McCall BJ, et al. Direct cost associated with a nosocomial outbreak of *Salmonella* infection: An ounce of prevention is worth a pound of cure. *Am J Infect Control*. 2000;28(1):54-7.

Tillotson K, Savage CJ, Salman MD, et al. Outbreak of *Salmonella infantis* infection in a large animal veterinary teaching hospital. *J Am Vet Assoc*. 1997;211(12):1554-7.

Virginia-Maryland Regional College of Veterinary Medicine (VMRCVM). VA-MD large animal teaching hospital biosecurity protocols. 2002.

Weese JS, Staempfli HR and Prescott JF. Isolation of environmental *Clostridium difficile* from a veterinary teaching hospital. *J Vet Diagn Invest*. 2000;12:449-452.

2.15 Appendix

Taken from: VA-MD Large Animal Teaching Hospital Biosecurity Protocols

Section 1 Equine

I. Contagious Disease Status Indicators

All equine patients presented to the VTH should be evaluated for contagious disease risk by the clinician and student on the case. Each patient will be designated as "red dot", "yellow dot", or "green dot" based on their signalment, history and physical findings (see below). These designations will dictate where the patient is hospitalized, patient monitoring and management procedures, and stall cleaning protocols. The appropriate colored dot should be **placed on all stall cards** (adhesive dots will be located in each ward and in the conference rooms). Once designated, the appropriate protocol sheet will be posted stall side. Be aware that the contagious disease status (and the corresponding dot color) of an individual case may change during hospitalization. **It is the responsibility of the primary clinician on each case to review the Biosecurity SOP for each "dot" category and to institute the appropriate containment procedures.**

RED DOT	Horses with **known or suspected contagious disease.** Patients should be placed in the Isolation Unit. If the Isolation Unit is full, institute 'Red Dot' Ward Isolation.
YELLOW DOT	Horses **at increased risk** for developing/acquiring contagious disease (immuno-compromised animals, all animals less than 30 days of age, etc.).
GREEN DOT	Horses with **no** historical, laboratory, or physical examination evidence of contagious disease.

Query/questions on assigned status:

- If technical staff has a concern over the Contagious Disease designation for a patient, they should contact the LA supervisor.
- If students/house officers/clinicians have a concern over the Contagious Disease designation for a patient, they should contact the clinician of record.
- If a concern over the Contagious Disease designation for a patient is not resolved after following the above procedures, contact the Hospital Director.

Section 2 Food Animal

I. Contagious Disease Status Indicators

All foods animal patients presented to the VTH should be evaluated for contagious disease risk by the clinician on the case. Each patient will be designated as "red dot", "yellow dot", or "green dot" based on their signalment, history and physical findings (see below). These designations will dictate where the patient is hospitalized, what attire is required to enter the stall and how the stall is cleaned. The appropriate colored dot should be **placed on all stall cards** (adhesive dots will be located in each ward and in the conference rooms). Once designated, the appropriate protocol sheet will be posted stall side. Be aware that the contagious disease status (and the corresponding dot color) of an individual case may change during hospitalization. **It is the responsibility of the primary clinician on each case to review the Biosecurity SOP for each "dot" category and to institute the appropriate containment procedures.**

RED DOT — Food Animals with known or suspected contagious diseases with zoonotic potential. Should be placed in the Isolation Unit if able to restrain manually for examination and treatment (usually < 250 lbs). If the Isolation Unit is full, or if safety dictates otherwise, institute 'Red Dot' Ward Isolation. Examples: *Cryptosporidia, Salmonella, Tuberculosis, Rabies, and all calves with diarrhea.*

YELLOW DOT — Food Animals at increased risk of acquiring/developing contagious disease or animals with known or suspected contagious diseases where routine vaccination is thought to give protection to contact animals. Includes animals less than 30 days of age. Examples: *BRDC, BVDV, Rotavirus, Coronavirus, footrot (sheep), Leptospirosis, BRSV, Moraxella, ORF.*

GREEN DOT — Food Animals with **no** historical, laboratory, or physical examination evidence of contagious disease.

Query/questions on assigned status:

- If technical staff has a concern over the Contagious Disease designation for a patient, they should contact the LA supervisor.
- If students/house officers/clinicians have a concern over the Contagious Disease designation for a patient, they should contact the clinician of record.

If a concern over the Contagious Disease designation for a patient is not resolved after following the above procedures, contact the Hospital Director.