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I. SUMMARY

From September 27 through October 2, 1993, investigators from the National Institute for Occupational Safety and Health **(NIOSH)** and the United States Department of Agriculture, Animal and Plant Health Inspection Service **(USDA/APHIS)**, conducted a health hazard evaluation **(HHE)** in the Sheyenne River valley of southeastern North Dakota. The evaluation was in response to a request from the North Dakota State Department of Health and Consolidated Laboratories, Division of Disease Control, Office of the State Epidemiologist. The purpose of the evaluation was to investigate the potential occupational transmission of anthrax among livestock producers during an anthrax outbreak, or epizootic.

Because of severe flooding, approximately 75% of the state of North Dakota was designated a federal disaster area in August 1993, including Barnes, La Moure, and Ransom Counties. Eight cases of confirmed livestock anthrax were reported from seven production facilities located within those counties, which are situated in and around the Sheyenne River valley. Affected livestock included beef and dairy cattle, and swine. Prior to this outbreak there had not been a confirmed case of livestock anthrax in this region for approximately 11 years.

The investigators visited 14 livestock production facilities in the Sheyenne River valley region and conducted 18 interviews, including seven affected producers, seven unaffected producers, and four veterinarians. Blood samples were collected from 2 producers with infected livestock and 2 veterinarians with exposure to infected animals to determine anthrax antibody titer, and environmental samples of soil, water, and feed were collected in an attempt to identify any remaining potential sources of infection.

Although the state health department did not receive any confirmed reports of human anthrax infection during the epizootic, producers and family members from three of the seven affected farms received antibiotic therapy because of direct exposure to known or suspect anthrax-infected livestock and/or because they experienced respiratory or other illness potentially associated with anthrax infection. Although asymptomatic, two veterinarians and a laboratory technician were also treated with antibiotics because of direct contact with infected livestock. Four individuals were tested for serum antibody titers to the anthrax organism; results were negative. Five of the 13 bulk samples of soil, water, bedding, and feed collected were culture positive for anthrax. Interviews with affected producers revealed that inconsistent and potentially hazardous work practices

were fairly common among them. The investigators determined that producers overall had very limited knowledge regarding the handling and disposal of anthrax-infected livestock and carcasses, and that there was little or no communication between affected and unaffected producers and their veterinarians concerning anthrax. All of these factors contributed to increases in occupational exposure risks.

Evaluation of the state's surveillance and information dissemination techniques regarding health issues indicated that test results and quarantines were shared between the diagnostic laboratory, state veterinarian's office, and affected producers in a timely manner; however, public and especially community awareness of anthrax and its effects was at best delayed, and improvements here are necessary.

A higher than usual reported prevalence of livestock anthrax may have been related to the flooding of the Sheyenne River and grazing pastures in the surrounding valley in southeastern North Dakota. Environmental samples indicated that the anthrax organism was present and viable at two of the affected animal production facilities at the time of this investigation. No cases of human anthrax infection were identified. The state surveillance and notification system for animal health issues was observed to be timely and efficient for the affected producers; however, state notification efforts could be improved in the area of public outreach.

KEYWORDS: SIC 0291 (Agricultural production—general farms, primarily livestock and animal specialties), anthrax, zoonoses, epizootic, *B. anthracis*, farmer, producer, veterinarian, livestock, beef, dairy, swine, flooding, agriculture.

II. INTRODUCTION

On September 17, 1993, NIOSH received a request from the North Dakota State Department of Health and Consolidated Laboratories, Division of Disease Control, Office of the State Epidemiologist, to conduct an HHE in the Sheyenne River valley of southeastern North Dakota where an anthrax epizootic was reported during August and September 1993. In response to this request, NIOSH investigators, including an occupational health nurse and an industrial hygienist, and a veterinary epidemiologist from USDA/APHIS, conducted an evaluation of the epizootic from September 27 through October 2, 1993. Cooperation and assistance were provided by state and federal public and animal health department officials and an agricultural health nurse working with the NIOSH Occupational Health Nurses in Agricultural Communities **(OHNAC)** program. This report provides details of the anthrax epizootic investigation, including the medical and environmental assessments and recommendations for reducing occupational exposure to the anthrax organism.

The investigators met first with state health department officials, the state veterinarian, and a representative of the North Dakota office of the USDA/APHIS in Bismarck, North Dakota. A second opening conference was held in Valley City, North Dakota, with Barnes County Health Department officials and Barnes County Cooperative Extension Service representatives. Also included were two staff veterinarians from the North Dakota State University **(NDSU)** Veterinary Diagnostic Laboratory in Fargo, North Dakota. Discussions at each opening conference focused on the investigators' plans to address the state's request. It was decided that the focus of the investigation would be 1) to obtain a detailed description of the epizootic that would include personal interviews of producers with anthrax-affected (those with livestock that had culture-positive anthrax infection) and unaffected livestock and their veterinarians; 2) to collect medical and environmental samples; 3) to evaluate the efficacy of the current NIOSH OHNAC surveillance system; 4) to determine methods for decreasing occupational exposure to anthrax; and 5) to evaluate the need for a more extensive investigation. The investigation concluded with a closing conference held in Bismarck, North Dakota, on October 2, 1993, with the North Dakota State Department of Health and Consolidated Laboratories State Epidemiologist.

III. BACKGROUND

During the 1993 summer, much of the midwestern region of the United States experienced severe and prolonged flooding. In North Dakota, by late August 1993, 39 of the 52 counties (approximately 75% of the state) were designated federal disaster areas. Counties in the northeast, central, and southeastern regions of the state were most affected, including three within the Sheyenne River valley—Barnes, La Moure, and Ransom. The statewide precipitation average for July 1993, was 7.9 inches, which is 5.4 inches (320%) above normal; during the same month, Barnes County alone reported 8.7 inches of rain (Figure 1).

The state of North Dakota historically averages one or two diagnosed cases of animal anthrax annually, and these typically occur in the drier western section of the state. On August 9, 1993, a blood specimen obtained from a heifer carcass was submitted for culture to the NDSU Veterinary Diagnostic Laboratory. This case was the state's first confirmed anthrax death for 1993; the cow was from near Adams County, which is located in the southwest section of North Dakota (Figure 2). (Because this case appeared to be isolated, and because several similar livestock anthrax deaths have been reported from the Adams County area in years past, it was not considered part of the epizootic).

On August 16, 1993, a blood sample submitted to the NDSU laboratory by a veterinarian practicing in the Sheyenne River valley revealed that anthrax was the cause of death of a dairy heifer in Barnes County. From August 17 to September 16, 1993, the North Dakota State Veterinarian received laboratory confirmation of seven additional livestock deaths found to be directly attributable to anthrax infection. The cases originated from seven different production facilities within and around the Sheyenne River valley (Figure 2), and included beef cattle, dairy cattle, and swine (Table I).

The North Dakota State Department of Health received no reports of human anthrax infection during this time period. However, one livestock producer with blackened sores on his arm and who described having severe systemic illness was seen by a physician who prescribed penicillin. In addition, several other farmers and their family members were reportedly treated with antibiotics by a physician as a result of respiratory symptoms they had experienced during the epizootic.

Anthrax Epidemiology

Anthrax, which can infect both animals and humans, is caused by an aerobic spore-forming bacterium, *Bacillus anthracis* **(*B. anthracis*)**. Retained as spores within soil, *B. anthracis* can remain viable for decades until favorable conditions permit dispersion and germination. Plains and grasslands that experience cyclic periods of drought and flood are usually where spores are found, and anthrax can be dispersed when these environmental conditions are moderately severe.[1] Periods of drought may cause livestock to forage much closer to the ground, and spores may be ingested as the soil is eaten. After flooding, the concentration of spores caught in standing water increases when preexisting or transitory ponds begin to evaporate. Transmission to swine, horses, and ruminants (cattle, sheep, and goats) occurs primarily through the ingestion of soil-borne spores, and animals pastured on these plains or grasslands are more likely to ingest an infective dose. Contact with infected carcasses may initiate secondary transmission to predators or carrion-eating birds, and insects, such as biting flies, can potentially transmit infection to other livestock. Ruminants appear to be the most susceptible to anthrax infection, while swine tend to be more resistant; pigs may become infected after ingesting anthrax-infected carcasses, and are more likely than other animals to suffer the effects of chronic anthrax infection.

The incubation period for anthrax is from one to seven days, and animals infected with the anthrax organism manifest disease symptoms in one of three ways: (1) Apoplexy (cerebral hemorrhage) is observed most often in ruminants and is characterized by sudden onset and death; (2) Acute or subacute infections are observed in horses and some ruminants, mainly cattle and sheep; infected animals may stumble, appear lethargic, and will usually develop moderate to severe swelling of the chin and neck (sublingual) areas. Death usually occurs two days to one week following infection, decomposition is rapid, and carcasses may display a bloody discharge from orifices, edema, bloating, and incomplete rigor mortis;[2] (3) Chronic anthrax infection occurs primarily in less susceptible species (such as swine), is characterized by pharyngeal and lingual edema, and usually results in asphyxiation.

Risk of infection to humans is correlated with disease incidence in animals and can occur through direct contact with infected animals and contaminated animal products or through ingestion of undercooked contaminated meat.[2] Approximately 80% of all reported human anthrax infections in the United States have been industry-related, while the remainder were from exposures in the agricultural community.[3] No cases have been reported in the United States (U.S.) since 1978.[4]

As might be expected, anthrax infection associated with agriculture is more common in less industrialized nations. Non-agricultural workers who become infected with anthrax are primarily those employed in industries which process hides, hair, wool, bone and bone products. Veterinarians and agricultural workers who handle infected animals and carcasses are also at increased risk of becoming infected.[5]

Human anthrax infection can present in one of three clinical forms. Historically the most commonly observed, cutaneous anthrax represented approximately 95% of all reported cases in the U.S.[5] Cutaneous infection can result when open wounds or insect bites become contaminated with anthrax spores; the spores, having located a favorable medium, germinate and multiply and subsequently release an exotoxin. Within one to seven days, a small, red papular skin lesion develops; the lesion gradually becomes blue-black in color as it develops into a fluid-filled vesicle which eventually ruptures. As surrounding tissue is destroyed by the released toxins, eschars develop. Eschars heal naturally in approximately 90% of cases involving untreated cutaneous anthrax lesions; 10% of infected individuals go on to develop widespread infection and septicemia.[5]

Inhalation infection can occur if an infective dose is introduced and spores are deposited in the alveoli. The bacteria and toxins enter the blood and cause septicemia and toxemia, and the fatality rate has historically approached 100%. Inhalation anthrax infection accounts for approximately 5% of reported human anthrax cases, and initial symptoms are generally mild and nonspecific, making early diagnosis especially difficult. Patients may initially present with common URI symptoms, but if left untreated, may develop acute respiratory distress, fever, and shock within three to five days. Death follows shortly thereafter.[3]

Gastrointestinal anthrax infection can develop after the consumption of anthrax-contaminated meat. Once ingested, the organism penetrates the intestinal wall, multiplies, produces a toxin, and causes ulcerative lesions and severe gastroenteritis. While cases of gastrointestinal anthrax have been documented in the past in the United States, disease control regulations in the meat industry have eliminated this form of infection.

When a prompt diagnosis is made and followed by immediate treatment, with penicillin (preferably) or certain other antibiotics, individuals with anthrax usually experience rapid recovery. Antibiotic therapy should be administered every six hours for a period of five to seven days.[5]

IV. EVALUATION METHODS

To enable comparisons between those who had infected livestock and those who didn't, producers from all seven affected farms were interviewed, as were neighboring but unaffected producers—those whose herds had potential or actual fence-line contact with affected herds, according to the affected producers. Additional interviews were conducted with local veterinarians, the county health officer, and the necropsy and bacteriology staff at the NDSU Laboratory, each of whom had potential occupational exposure to anthrax. Interviews addressed facility management practices, pasture characteristics, work practices (including disposal and handling of animal carcasses and disposal of potentially contaminated soil and clothing), a personal health history, and the producer's experience with notification and dissemination of pertinent epizootic information. Information regarding potential but unconfirmed livestock anthrax cases was obtained by review of

records from the NDSU laboratory, from local veterinarians, through contact with county extension personnel, and from affected and unaffected producers.

Medical Evaluation

The medical evaluation included interview questions pertaining to recent symptoms and personal health history. Blood testing for antibody titer to anthrax was offered to those producers, veterinarians, and laboratory personnel who reported respiratory or skin symptoms, received post-"exposure" antibiotics, or had unprotected direct exposure to any dead or infected livestock during the outbreak period. Participation was completely voluntary, and participants gave written informed consent.

Blood specimens were collected in serum separator tubes according to standard phlebotomy technique, centrifuged on-site, immediately refrigerated, and sent for analysis to the United States Army Medical Research Institute for Infectious Diseases **(USAMRIID)** on October 4, 1993. Serum samples were analyzed using both Western Blot and enzyme-linked immunosorbent assay **(ELISA)** tests to identify serum precipitins to *B. anthracis*.

Environmental Evaluation

Occupational and environmental evaluations included personal interviews regarding the work practices of each producer and veterinarian, observation of affected farm pastures and facilities, an inspection of livestock death and disposal sites, and environmental bulk sampling of soil, water, bedding, and feed. Walk-through investigations were conducted at facilities where the producer knew of potential exposure or death sites. Bulk samples were obtained primarily as a service to producers and in cases where positive results were strongly suspected. Work-practice evaluations included questions regarding the general handling of sick and dead livestock; the handling of carcasses potentially contaminated or diagnosed with anthrax; personal protective equipment **(PPE)** use during handling; disinfection or disposal methods for PPE and other potentially contaminated equipment; and each producer's methods for disposal of suspected or confirmed anthrax-contaminated carcasses and surrounding soil.

Thirteen bulk environmental samples were collected from five of the seven affected farms to include seven water samples, four soil samples, one combination used-bedding and soil sample, and one swine feed sample
(Table I). Eight samples (four each of soil and water) were collected in Barnes County from both beef and dairy operations; four samples (one bedding/soil, one feed, and two water) were collected from La Moure County and included beef and swine operations; and one water sample was collected from a beef operation located in Ransom County. Sample site selection criteria included livestock drinking ponds, death sites, especially those where there had been no soil remediation, burial sites, and areas where producers felt most

strongly that there were potential exposures to *B. anthracis* before and during the epizootic.

Seven water samples were obtained from four farm operations (Table I); two from a pond in a beef cattle pasture (site visit 2 in Figure 2); two from a dairy cattle pasture where this particular section of pasture is usually dry (site visit 3); two samples from a beef pasture pond (site visit 5); and one other sample from pasture water at a third beef production facility (site visit 6). Four soil samples, one bedding/soil sample, and one feed sample were obtained from three different affected farms. One sample was collected from the burial site of a confirmed anthrax-infected cow where no soil remediation had been conducted (site visit 2). Three samples were collected in a pasture where a dairy heifer had died approximately 3 weeks earlier (anthrax was suspected but not confirmed); no soil remediation had been conducted and there were visible traces of hair and exudate mixed with the soil (site visit 3). One feed sample and one bedding/soil sample were collected from the swine operation (site visit 4), where three hogs kept in confinement died, but only one carcass was submitted for testing; the bedding/soil sample was collected from the approximate site of death in an old dairy barn where the pigs were kept, and included straw and potentially contaminated soil (no remediation had been conducted, and fresh straw had been placed on top of the soil).

All soil, bedding, and feed samples were collected using sterile wooden tongue depressors, and were placed into sterile plastic whirl bags. Water samples were collected in sterile plastic containers. Both sample types were then sealed and hand-carried to the NDSU Veterinary Diagnostic Laboratory for analysis.

Soil specimens were initially prepared with 1 gram of soil in 9 milliliters **(ml)** of sterile, distilled water. This solution was heat shock-treated in a 62.5°C water bath to select for spore-forming bacteria. Ten-fold serial dilutions (using distilled water) were prepared, up to a maximum of 10^6. At each stage of dilution, 0.1 ml of solution was streaked onto each of the following—blood agar plates, PLET agar plates, and pour plates—with 40 micrograms **(µg)** of lysozyme added to a nutrient agar base. Water samples were prepared by filtration through a 1.2 micron filter. The filtered specimen was then centrifuged, and the sediment was cultured as a soil sample. A control was developed using a known *B. anthracis* culture also streaked on agar plates, and conditions for the control were identical to the corresponding bulk soil samples at all stages of plating. Growing colonies were then analyzed for morphology, coliform characteristics typical of *B. anthracis*, gram stain, penicillin sensitivity, and uniformity of colony lift with an inoculating loop.

Experts at the National Center for Infectious Disease **(NCID)**, Division of Bacterial and Mycotic Diseases, Centers for Disease Control and Prevention **(CDC)**, recommended that additional soil samples be collected from the swine facility. The purpose was to attempt to determine the extent of soil contamination within this facility. Seven additional soil samples were collected on November 8, 1993, by the state's regional OHNAC investigator

(Table I). The sample set collection and analysis methods were identical to those utilized during the NIOSH investigation. A repeat sample was taken from the floor of the swine facility where the three carcasses were found. The remainder of the samples included soil from additional areas within the barn, roots of weeds fed to the pigs, and soil immediately adjacent to the barn.

Surveillance Notification

Anthrax epizootic notification data were collected from memoranda issued by the state extension veterinarian, newspaper articles, notices of herd quarantine, NDSU specimen submission records and laboratory reports, and personal interviews with producers and veterinarians. Notification methods were evaluated primarily for timeliness, content, and availability to intended readers.

V. RESULTS AND DISCUSSION

Medical Evaluation

Despite numerous producer and veterinary accounts of direct contact with anthrax-contaminated livestock and carcasses, there were no confirmed cases of anthrax infection reported for any of the residents of the Sheyenne River valley. Of five individuals considered eligible for blood testing, samples were collected from four (Table II). Two samples were collected from producers, both of whom had experienced respiratory symptoms and one who had systemic illness and skin lesions; one was obtained from a local veterinarian who had conducted a postmortem exam on an anthrax-infected cow; and, the fourth was collected from a laboratory worker who had necropsied a subsequently culture-confirmed anthrax-infected swine carcass. The blood was collected from all individuals three to five weeks after the potential exposure or onset of symptoms, and in one producer, a second sample was collected nine weeks following his potential exposure to the organism. None had antibodies to *B. anthracis*. At the recommendation of USAMRIID, a second blood specimen was collected on October 19, 1993, from the producer who reported lesions on his left arm and hands beginning about August 20, 1993, and a systemic illness about 12 days later. This repeat sample was collected to determine whether there may have been a delayed rise in antibody titer. This test result was also negative.

Of the 26 people interviewed by NIOSH investigators, 3 producers (all with affected livestock), 4 of their family members, and 3 veterinarians took antibiotics either as a prophylactic measure or as a result of the symptoms they had experienced. In all cases, the antibiotics were taken from one to six days following exposure or development of symptoms (Table II). About August 20, 1993, one producer noticed reddened fluid-filled sores on the backs of both hands and on his left forearm and elbow. He said the sores ruptured, oozed, and eventually scabbed over while gradually turning dark brown to black. He also reported a systemic illness beginning about September 1, 1993, following direct contact with ill or deceased livestock during the previous week. On September 8, he sought medical care from a local physician, but because of timing conflicts was not examined. Later that day, the physician called the producer and prescribed penicillin. It is unclear as to whether the producer started the therapy prescribed for him, but he did report taking injectable penicillin September 5-6, and he reported full recovery from his illnesses. The producer had a physical examination September 9. The medical records described the sores as 'small punctate healed lesions', and the physician decided that a specimen for culture could not be obtained from them. At the time of the evaluation, NIOSH investigators observed light brown to dark pink depressions in the areas described by the producer of approximately 0.5 to 1 centimeter in size. These appeared to be newly-healed lesions. Two post-exposure blood serum titers for *B. anthracis* collected from this producer by the investigators were negative.

Two additional producers and their immediate family members were treated with penicillin. Both producers reportedly had direct contact with anthrax-infected carcasses, but none of the family members had any contact with either sick or dead livestock. One producer and his family members were given prescriptions for penicillin, and according to the physician's records, this was based upon family members' respiratory symptoms and the producer's exposure to infected carcasses one day preceeding the onset of symptoms and three days before penicillin was prescribed. The second producer, exposed twice to infected livestock, experienced respiratory symptoms and took penicillin for five days, starting four days after his first exposure. Approximately two weeks later, although he had no symptoms, he began taking penicillin one day after his second exposure. Using a front-end loader, he had removed three swine carcasses from his confinement facility, blanketed one, and placed it in the trunk of his car. He then transported the carcass to the NDSU diagnostic laboratory, where anthrax was determined to be the cause of death. The producer reported that he wore long-sleeved clothing and cotton gloves to protect himself while handling the carcasses.

Three additional individuals were treated with antibiotics during this time period. Two veterinarians, neither of whom had symptoms, treated themselves with ampicillin. One did so a day after vaccinating livestock on
an affected farm, and the other, a day after conducting a postmortem examination on a cow subsequently found to have anthrax. Anthrax was not suspected at the time because the carcass did not display any of the characteristics typical of an anthrax infection. Although not his usual procedure when conducting postmortems, the veterinarian reportedly wore coveralls, boots, and rubber gloves during the examination. A blood sample collected from this individual was negative for antibodies to *B. anthracis*.
A postmortem room technician at NDSU Veterinary Diagnostic Laboratory reported that he was sprayed with blood from the head of a swine carcass as it was opened. The technician reportedly wore the usual PPE provided by the employer for standard necropsy, including latex rubber gloves and a three-quarter-length cotton laboratory coat. Anthrax infection was not suspected, but the animal subsequently tested positive. Although the technician had no symptoms, he took ampicillin beginning two days after his exposure.

Environmental Evaluation

Of the environmental samples collected, all seven water samples were negative for *B. anthracis*, while two of the four soil samples cultured positive for *B. anthracis*. Both of these soil samples were obtained from the north pasture of the dairy producer (site visit 3). The third positive sample, a combination of used bedding and soil, was obtained from the barn floor of the swine production facility. The feed sample, also obtained from the swine facility, was negative. Seven additional soil samples, collected from the swine farm on November 8, 1993, were negative for *B. anthracis*.

Each of the affected producers was asked to define their usual work-practice procedures when handling dead livestock, and about work practices generally followed when confronted with a potentially contaminated carcass. They were further asked to identify where herds with affected animals had been pastured, where dead animals had been found, and where they had been buried. Interviews conducted with each of the seven affected producers indicated that when confronted with any dead livestock 57% (four of seven), without handling the animal, immediately contact their veterinarian to conduct postmortem investigations; if the death of the animal is suspect in any way, two of those four producers usually transport the carcass directly to the NDSU laboratory for necropsy, as they did during the epizootic; the other two producers either begin a postmortem themselves or simply dispose of the carcass, usually by burial but potentially by using it for feed for other livestock, depending upon factors such as the condition of the carcass, the weather, etc.

When confronted with a potential anthrax-infected carcass, five of the seven affected producers reported that they usually contact a veterinarian to conduct testing, then bury the carcass approximately six feet deep; 29% (two of seven) of producers usually burn the carcass before burial; one of those two producers adds quick-lime to the grave. None of the producers initially removes the potentially contaminated topsoil; however, upon veterinary or laboratory confirmation of anthrax infection, 43% (three of seven) of producers return to the death site to remove and bury the topsoil where the affected animal died or was necropsied.

During this epizootic, three of the producers (43%) and at least one of the four veterinarians interviewed (lack of data is due to conflicting reports) were involved with direct handling of both sick and dead livestock and were unprotected (did not use any PPE). Also during the outbreak, all producers with anthrax-infected or suspect carcasses reported that they eventually buried them, but only one used quick-lime, which kills any remaining anthrax organisms, during burial. Two of the seven affected producers directly handled anthrax-suspected or -confirmed carcasses, and neither of these producers wore protective clothing, rubber gloves, or shoe covers while handling the carcasses. Furthermore, none of the producers wore personal protective gear during animal burial,

soil removal, or soil treatment with quick lime. At least one veterinarian conducted postmortems on livestock without using any protective clothing.

Producers were asked to comment on any changes they made in herd management practices during the epizootic. Upon confirmation of anthrax infection in their herds, all seven of the affected producers increased the frequency of herd observation. In addition, three of the affected producers, all with beef cattle, moved their herds to different pastures: One producer moved his herd within a day after confirmation; another within one week; and the third producer, who experienced multiple beef cattle deaths, moved his herd to three separate pastures within two days after receiving two positive anthrax test results in two days. All of the producers subsequently vaccinated their herds against anthrax. Two of the local veterinarians used Thraxol - 2, which is administered as a single dose, to vaccinate against anthrax on five of the seven affected farms; at the time of this investigation, three of those five (60%) herds had received the recommended booster three to four weeks after the initial dose. The two remaining affected herds were vaccinated with the Colorado System, a two-dose vaccine, by local veterinarians.

In comparison, six of seven neighboring but unaffected producers, once notified, increased their frequency of herd observation during the outbreak period. After being informed of infected cattle in a neighboring pasture, on land with potential for fence-line contact, one unaffected producer relocated his herd; one other producer reported that he would have relocated his herd if he had been informed of infected neighboring cattle. As a precaution, one of the seven unaffected producers vaccinated but did not booster his herd against anthrax.

Potential Anthrax Sources for the North Dakota Epizootic

In general, an anthrax epizootic can occur as, 1) a result of introducing the *B. anthracis* organism into the area, 2) through re-emergence of the organism from a previously established soil source, or 3) by mechanical transmission, such as through insect bites. Results of this investigation showed that 2 of the 14 interviewed producers added new livestock during the epizootic; five Holstein cattle were added to a herd which ultimately remained unaffected, and an additional three head of cattle were introduced into a beef facility, but pastured separately from cattle that ultimately became infected with anthrax. Most of the affected and unaffected producers used feed supplements; however, none were used that contained any animal by-products. Only one producer used fertilizer on his pasture; however, the fertilizer was of inorganic origin and his herd remained unaffected throughout the epizootic.

Because of the potential for transmission of the anthrax organism through biting insects, producers were asked to comment on this year's fly and mosquito populations. Many of the producers (8 of 14) felt that the number of flies remained about the same when compared to past years, while two producers felt that there were more flies than usual.

The other four producers had no comment. When questioned about the mosquito population, 8 of the 14 producers felt that there had been a definite increase—4 of those 8 were affected producers.

Six of the affected producers pastured their livestock, as did all seven of the unaffected producers. The single exception was the affected swine producer who kept his animals in a partially-enclosed confinement facility (a converted dairy barn). All of the pastured livestock had access to ponds or streams. No new water supplies were created as a result of the flood; however, some of the pasture ponds, which are usually dry by late summer, contained standing water at the time of the investigation in September 1993. One producer reported increased wildlife deaths (foxes and coyotes) in his pastures where anthrax-infected cattle were found.

Quarantine and Notification

Six of the eight specimens submitted to the NDSU laboratory were collected from the carcasses by veterinarians at the death sites. Two of the carcasses, a pig and a cow, were transported by their owners to the laboratory for necropsy. All of the individuals who submitted specimens for culture were notified by laboratory staff of an anthrax-positive result within 24 hours of confirmation; the state veterinarian was also notified of positive results the day of confirmation for all eight cases.

The state veterinarian issued quarantine notices to producers with confirmed anthrax within 12-24 hours following laboratory notification. Each producer was then required by the state of North Dakota to vaccinate all remaining farm livestock and to place the entire herd under immediate quarantine for either 30 days after the last death loss or 30 days following vaccination. According to the North Dakota State Board of Animal Health, the vaccination must consist of at least two doses. The quarantine starting dates for each affected herd were from August 17 to September 17, 1993. As no further anthrax-confirmed deaths occurred in any of the herds, all quarantined herds were released by November 1993.

On September 3, 1993, a memorandum regarding the anthrax epizootic was issued by the state extension veterinarian and was distributed to all county extension staff. Although labeled as information only for extension staff and not for publication, it was prepared by the same office that same day as a press release and was printed September 5, 1993, by one local news publication. The memorandum included confirmation of five livestock deaths due to anthrax and included a description of its symptoms and the potential for infection in cattle. The memorandum also stated that anthrax could present a public health risk to those working with infected animals and that unnecessary contact should be avoided. Although the memorandum recommended that producers contact their veterinarians immediately if anthrax was suspected, it did not instruct the recipients (extension staff) to actually notify area producers or veterinarians of either the affected livestock or the risks associated with exposure to anthrax.

Following confirmation of an additional livestock anthrax death in the Sheyenne River basin, a second memorandum was issued September 9, 1993, by the state extension veterinarian. This memorandum, again issued to all extension staff, contained recommendations for area producers to check herds daily and to report to the herd veterinarian any sudden livestock deaths. The memorandum also stated that prompt diagnosis and correct handling of infected tissue were important for preventing disease spread and human exposure. At this time, staff was advised to use information from either memorandum "as you see fit," but again were given no specific information on making contact with those potentially at risk.

Two announcements regarding the anthrax outbreak were distributed via newsprint to the public in the Sheyenne River valley region. The first published article was written by a local veterinarian and was based upon information contained in the first memo released by the state veterinary office. The article appeared in a local newspaper on September 5, 1993, and suggested that producers closely monitor herds; it also warned against moving any animal carcass because of potential human health risks. The second article, appearing in another local paper on September 10, 1993, was written by the state's regional OHNAC nurse and a local physician. The article provided recommendations on avoiding exposure to anthrax and described the symptoms of anthrax infection in humans.

Only two of the affected and four of the unaffected producers recalled having read one of the two published newspaper articles written during the outbreak period. One unaffected producer reportedly read an article in a cattle producer's magazine. Three of the affected producers first learned of the anthrax outbreak after being informed of positive laboratory results by their veterinarians; three of the remaining four affected producers reportedly learned of the outbreak from a neighbor, and one producer was first informed by reading one of the newspaper articles. Three of the seven unaffected producers first heard of the anthrax outbreak from their affected neighbors, while a fourth received the information from another unaffected neighbor. The remaining three did not recall how they were informed.

VI. CONCLUSIONS

Ten (all with potential exposure to anthrax) of the 26 individuals involved with the NIOSH survey received antibiotic therapy during the anthrax epizootic; 6 were treated for URI symptoms, 3 as a result of direct contact with infected livestock, and 1 individual, who also had direct contact with infected livestock, treated himself as a result of systemic illness and skin lesions he thought to be anthrax-related. While the URI symptoms were most likely not related to the epizootic, his description of the lesions that developed on his hands and left arm suggest the possibility of cutaneous anthrax, and he had several wounds and much scarring (presumably from prior injuries, due to the nature of his occupation), which is indicative that there may have been open wounds that could have provided entry for the anthrax organism. Unfortunately, certain diagnostically important details about the

skin lesions are not available, and the negative serologic tests argue against the skin lesions being anthrax-related.

Although the investigation was not designed to evaluate risk factors for herd or animal infection with anthrax, results yielded a few conclusions regarding the potential etiology of this anthrax epizootic. No fertilizers or feed supplements containing animal products were used, no recent soil disturbances (such as plowing) were reported, no infected cattle were introduced into any of the herds, and with one exception, all of the affected herds were pastured during the outbreak. One group of affected swine was kept in confinement inside a dairy barn prior to and throughout the epizootic, and it is likely that the anthrax organism was introduced to them from an outside source. At the time of the NIOSH investigation, however, the producer assured us that he knew of no potential sources, and a sample of his feed was culture-negative for anthrax. Hypotheses included the potential for contamination from the prior inhabitants of the barn, and that because the producer neighbored his son's anthrax-affected beef facility, he had inadvertently introduced the organism to his barn by entering with contaminated boots. Approximately six months after the NIOSH investigation, the producers were interviewed by a state employee about their experiences with the outbreak. At that time, the swine producer remembered he had fed his pigs a beef cattle carcass which was probably contaminated with anthrax. Originally, this carcass was not suspected to be infected with anthrax and was never tested; however, the producer of the herd from which this carcass originated subsequently lost an additional six head of cattle; blood samples from two of those were submitted and tested positive for anthrax. It is therefore likely that this epizootic was a result of pre-existing soil-borne anthrax spores which germinated during the flood. It is not known why outbreaks of this nature occur as inconsistently and infrequently as they do, nor why livestock grazing similar pasture and separated only by a fence line can remain unaffected. Although anthrax in this region of the state is not known to be endemic, and affected producers did not report prior knowledge of anthrax on their property or surrounding area, many of these producers related similar stories about a massive buffalo herd that had died many years ago in the Sheyenne River valley, reportedly of anthrax.

The North Dakota state anthrax surveillance system was observed to be efficient. Timely laboratory notification was observed, as positive culture results were relayed within 24 hours of confirmation to producers, local veterinarians, and to the state veterinary office. The state office, in turn, promptly issued the required notice of herd quarantine, usually on the day confirmation was received from the laboratory. There was, however, observed to be a notification delay to the broader community. Although it is important to avoid causing unnecessary alarm, efforts should be made to disseminate appropriate information to those who need to know, including both affected and unaffected neighboring facilities. Once issued, announcements to the community regarding anthrax were observed to be complete and informative and described risks to livestock and producers, clinical signs in livestock and humans, exposure prevention strategies, and treatment and disposal of suspect or affected carcasses, affected soil, and contaminated clothing.

VII. RECOMMENDATIONS

Those producers with positive soil samples (the dairy and swine facilities), local and laboratory veterinarians and personnel, and the general community may all benefit from information regarding the potential for anthrax infection, although very infrequent, during periods of drought and flooding. The following recommendations provide methods for reducing occupational exposure and infection while conducting treatment of potentially infected livestock, proper burial procedures for known or suspected anthrax-infected livestock, proper methods for soil remediation, and methods for disinfection or disposal of contaminated personal protective equipment. Recommendations for increasing public awareness for future outbreaks follow:

- ✔ If anthrax is suspected, aseptically collect a jugular blood sample for culture: Do not necropsy the animal. If a necropsy is inadvertently performed, autoclave or incinerate all implements. All animals at risk should be promptly vaccinated and annually revaccinated. Symptomatic animals should be treated with penicillin or tetracyclines and then vaccinated.[5]

- ✔ Producers with confirmed anthrax-infected livestock, especially those with anthrax-positive soil samples, should conduct immediate remediation of any soil remaining at and around the death site(s) as follows: Ideally, the first 6 inches of any topsoil contacted by the infected carcass, its exudate (blood, excrement, and hair), and any necropsy waste, should be removed and buried along with the carcass, to a depth of at least 6 feet. The carcass should then be covered with 5% lye or quick lime (anhydrous calcium oxide). Prior to burial, contamination potential can further be reduced by burning the carcass; burning should not be conducted in an open field, where wind could potentially spread the organism. Burning also requires a fire of approximately 700°F for sustained burning. Decontaminate the site by adding quick lime to the grave, the carcass and the contaminated top soil during burial. Additional lime should be mixed in with the replacement top soil to kill any remaining anthrax organisms.[5]

- ✔ Producers should take every precaution to avoid skin contact with the potentially contaminated carcass and soil. Protective, impermeable clothing and equipment such as rubber gloves, rubber or leather apron, and rubber boots, with no perforations, should be used. No skin, especially that which is compromised with wounds or scratches, should be exposed. Disposable PPE is preferable, but if not available, decontamination can be achieved by washing any exposed equipment in hot water and detergent. Disposable PPE should be burned and buried with the carcass.

- ✔ Although the likelihood of an anthrax respiratory infection is small, airborne particulates, including anthrax-contaminated soil, can enter the lungs: Therefore,

producers should wear a NIOSH and Mine Safety and Health Administration **(MSHA)** approved high efficiency-respirator, such as a half-face disposable respirator with a high-efficency particulate air **(HEPA)** filter, when conducting soil remediation and burial and when applying quicklime to soil. High efficency respirators provide protection against particles of 0.3µm or greater in size. *B. anthracis* organisms range from 0.5-5.0µm in size. Veterinarians and producers conducting postmortems should also wear a HEPA-filtered respirator, especially on windy days. Various types and sizes of respirators and filters are usually available through feed, hardware, or industrial supply stores. Respirators should not be worn over a beard, as this greatly reduces the respirator's effectiveness by not allowing a proper seal between the user's face and the respirator.

✔ The appropriate state agency should consider developing an alert, which would include these and any further recommendations, for distribution to producers with confirmed anthrax infection and to any neighboring production facilities, especially those pasturing livestock immediately adjacent to infected animals.

✔ The state health department, in cooperation with the media, should consider issuing a periodic informational alert any time communities experience environmental conditions conducive to anthrax proliferation, like droughts and floods. The full range of available news media should be used to quickly reach the public. The warning may contain general information on anthrax infection of livestock, including common symptoms, and personal protective measures that can be used by the producer to reduce potential occupational exposure to the anthrax organism.

✔ As soon as positive test results are received from the laboratory, the state animal health department should contact all veterinarians in potentially affected areas, who in turn would contact their clients. Local veterinarians should also alert neighboring veterinary practitioners, should advise the affected producer to notify neighboring production facilities, and should alert other susceptible clients of the potential for infection. Relayed information may include advice as to the potential for infection for each producer's herd and infection prevention strategies. These strategies can include herd relocation and herd vaccination against anthrax. The veterinarian can also provide instruction and supervise proper cleaning, disinfection, and disposal of infected carcasses. These precautionary measures should reduce the potential for occupational exposure to anthrax.

✔ A followup study is planned by the USDA to determine what environmental factors may have contributed to the risk of anthrax infection in grazing animals and also to gain a better understanding of anthrax bacilli and spore-retention in the soil of the floodplain/grassland ecosystem and of the impact of flooding.

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For the purpose of informing affected individuals, copies of this report have been forwarded to:

1. North Dakota State Epidemiologist, Bismarck, North Dakota
2. North Dakota State Veterinarian, Bismarck, North Dakota
3. North Dakota State Animal Board of Health, Bismarck, North Dakota
4. Barnes, La Moure, and Ransom County Health Officers, North Dakota
5. Barnes, La Moure, and Ransom County Agent, North Dakota
6. Barnes, La Moure, and Ransom County Health Unit, North Dakota
7. Valley City Veterinary Hospital, Bismarck, North Dakota
8. Hovland Veterinary Service, Lisbon, North Dakota
9. Barnes, Ransom, and La Moure County participating producers
10. Community Health Center, Fargo, North Dakota
11. North Dakota State Veterinary Diagnostic Laboratory, Fargo, North Dakota
12. Center for Animal Disease Control, Fort Collins, Colorado
13. OSHA Region VIII

TABLE I

DEMOGRAPHICS AND ENVIRONMENTAL SAMPLING RESULTS
SHEYENNE RIVER VALLEY, NORTH DAKOTA

HETA 93-1121
SEPTEMBER/OCTOBER 1993

Site	*County*	*Operation Type*	*Herd Size*	*Total Dead*	*NDSU-Confirmed Anthrax Deaths*	*Sample Type*	*Total Samples*	*Results*
1	**Barnes**	Beef	1,650	5	1	None	None	N/A
2	**Barnes**	Beef	25	2	1	Soil Water	1 2	Negative Negative
3	**Barnes**	Dairy	240	11	1	Soil Soil Water	2 1 2	Positive Negative Negative
4	**La Moure**	Swine	35	3	1	Bed/soil Feed Soil*	1 1 7	Positive Negative Negative
5	**La Moure**	Beef	119	7	2	Water	2	Negative
6	**Ransom**	Beef	249	2	1	Water	1	Negative
7	**Ransom**	Beef	80	3	1	None	None	N/A

* Denotes the seven samples collected on November 8, 1993.

TABLE II

MEDICAL DATA
SHEYENNE RIVER VALLEY, NORTH DAKOTA

HETA 93-1121
SEPTEMBER/OCTOBER 1993

Occupation	*Direct Contact with Infected Livestock*	*Antibiotic Therapy*	*Symptoms*	*Blood Test Results*
Dairy Farmer	Numerous times during burial and treatment of infected animals	Self-treatment with penicillin for 2 days, unknown amount	Skin lesions	Negative*
		250 mg penicillin, 4 per day for 10 days (unknown if taken)	Systemic illness	
Beef Rancher	Burial and treatment of infected animals	250 mg penicillin, 4 per day for 7 days	Upper respiratory	Negative
Swine Farmer	Fed infected carcass to swine	500 mg penicillin, 4 per day for 5 days	Upper respiratory	No sample taken
	Transported dead swine to clinic	500 mg penicillin, 4 per day for 5 days	None	
Veterinarian	Postmortem of infected cow	Self-treatment with 500 mg ampicillin, 3 per day for 7 days	None	Negative
Veterinarian	Vaccination of affected beef herd	Self-treatment with 500 mg ampicillin, 3 per day for 6 days	None	No sample taken
Veterinary Pathologist	Postmortem of infected swine carcass	Yes, details unknown	None	Negative

* A second blood sample, collected approximately one month later, was also negative.

FIGURE 1 - Precipitation totals for Barnes, La Moure, and Ransom Counties and the state of North Dakota for July, August, and September of 1991-1993.

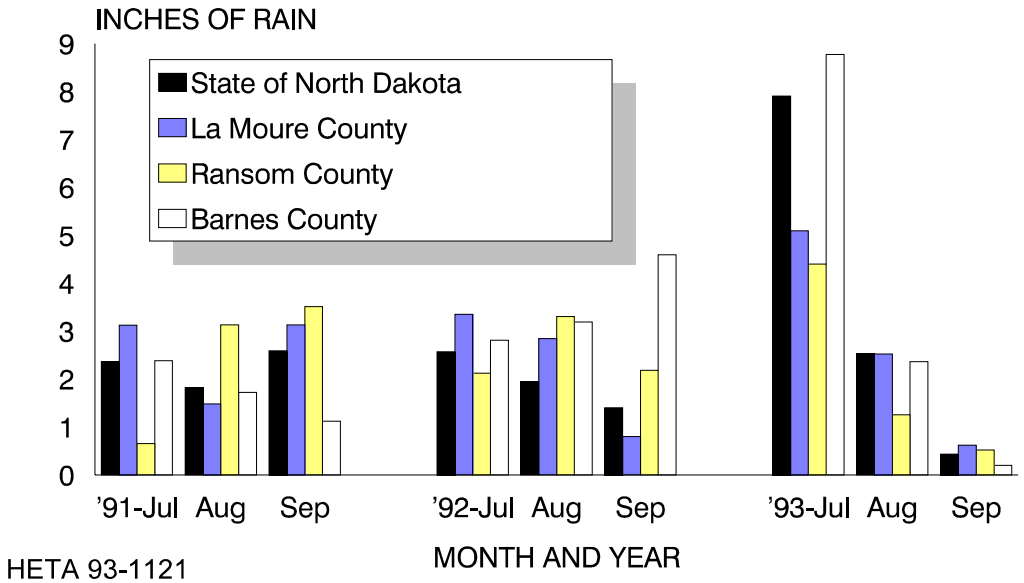

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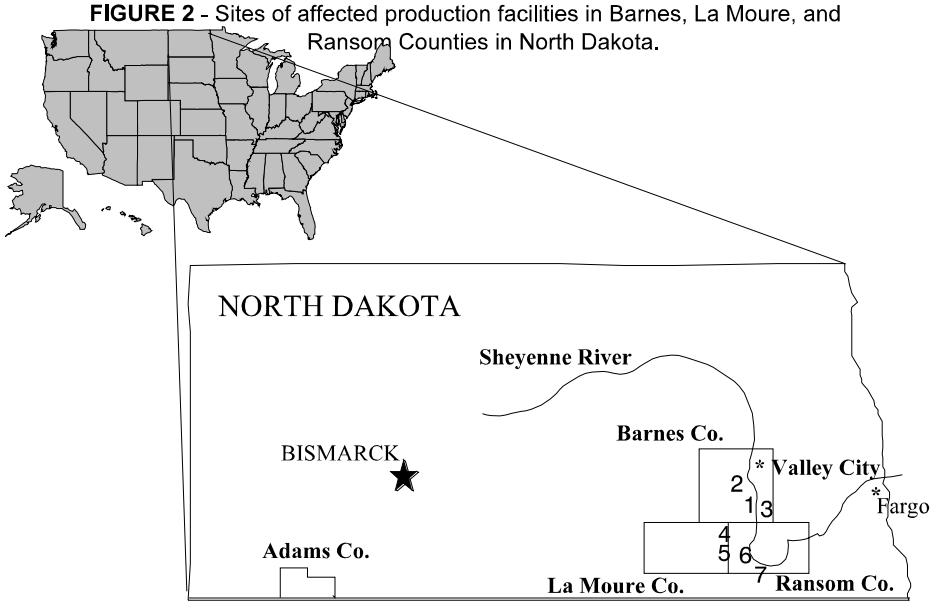
FIGURE 2 - Sites of affected production facilities in Barnes, La Moure, and Ransom Counties in North Dakota.



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SEPTEMBER, 1993