An outbreak of brucellosis in a hog slaughtering plant is reported. Epidemiological findings indicate that air-borne infection may have been a factor. Attack rates were related to the area of the plant rather than to the degree of contact of employees with fresh hog tissues.

BRUCELLOSIS OUTBREAK IN AN IOWA PACKING HOUSE

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THIS report discusses some of the epidemiological aspects of an outbreak of 128 human cases of brucellosis which occurred in an Iowa swine slaughtering plant (hereafter identified as Plant A) during the nine-month period November 1, 1959, to July 31, 1960.

Brucellosis has been a serious public health problem in Iowa for many years.[1-3] From 1954 through 1958, an average of 322 cases were reported per year with a large majority of the cases occurring in farmers and 27 per cent in packing house employees. The cases among packing plant employees have been sporadic in nature and distributed among various departments in a number of packing plants but with no definite seasonal variation.

During the period January through October, 1959, six cases of brucellosis were reported from the county in which Plant A is located. This is not an unusual number. One was an aluminum plant worker and part-time farmer, one a rural housewife, and four were packing house employees. A delayed report of brucella infection in a United States government meat inspector raised the total for this period to seven. Beginning in November there was a marked increase of cases among employees of Plant A. The outbreak continued through the winter and spring months, resulting in 128 cases among the 1,627 plant employees by July 31, 1960.

Factors that may have been involved in causing the epidemic such as changes in physical facilities, employment practices, general sanitation procedures, and sources of swine were studied. Plant medical records were reviewed and each patient was interviewed about his illness and medical history. Blood specimens for culture and serology were taken by plant medical department personnel. Blood specimens were also collected from hogs. Air samples and swabs of fomites for bacteriological studies were obtained.

Plant Operation

The establishment, consisting of several large adjoining buildings, slaughters and processes only swine. Of the several thousand killed daily, about 95 per cent are butcher class hogs and 5 per cent are sows. No boars are killed. For administrative and operational purposes, the plant is divided into various departments. With some exceptions, the employees of a department work in a circumscribed geographic area of the plant. Under a policy of several years standing, the plant has hired no workers

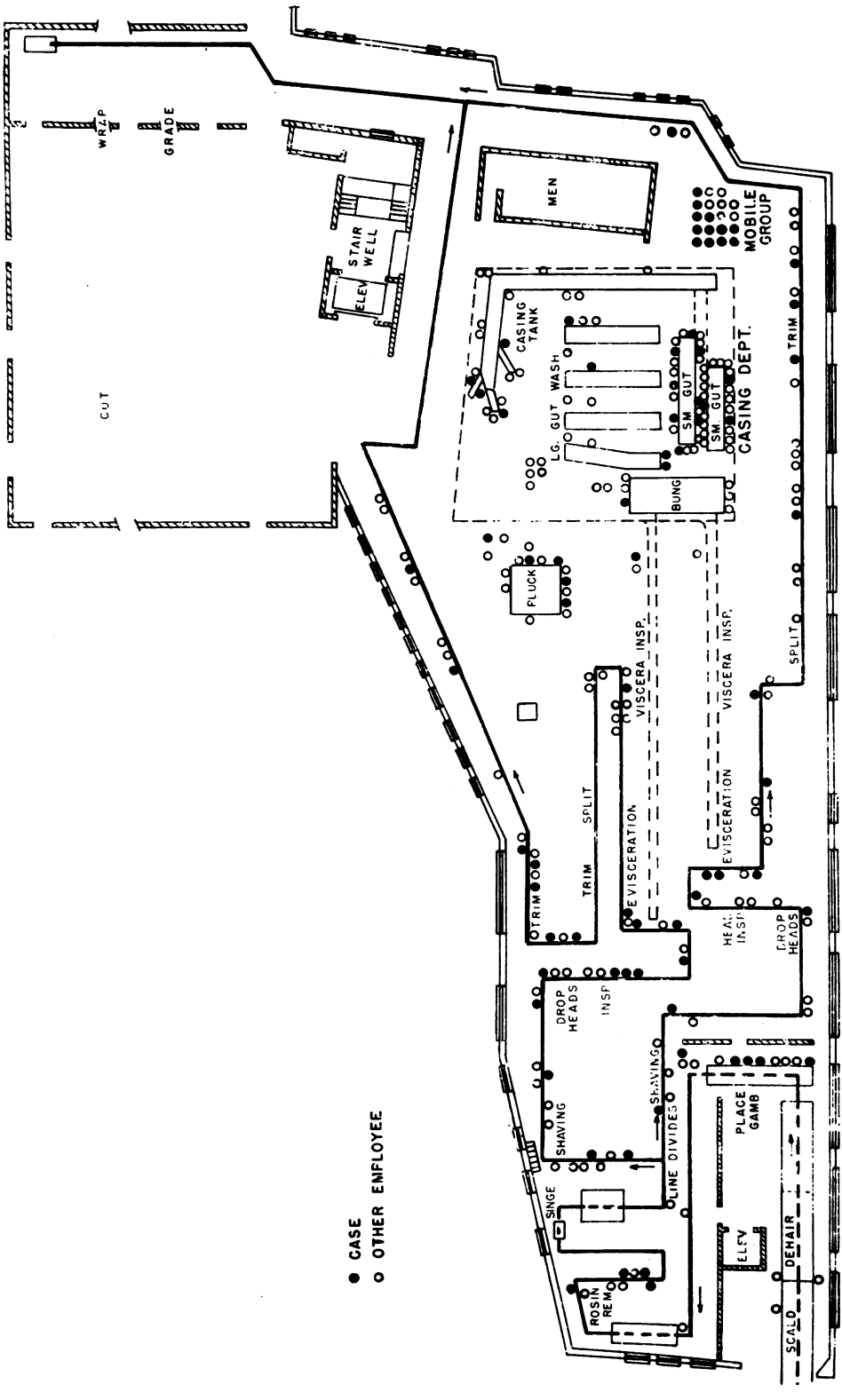

Figure 1—Killing Floor with Casing Department and Cutting Floor

Table 1—Month of Onset by Department

Department	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	*	Total
Kill	4	19	11	4	7	7	4	1		3	60
Casings	3	1	3	4	4		2			3	20
Cut	3	1	2	4	3	5	1	2		3	24
Freeze	1	1						1			3
Boning	1										1
Maintenance		1		2							3
Curing		1	1								2
Inedible			3								3
Pork pack				1			1				2
Head trim					1	1	1		1		4
Night clean-up						1					1
Management and office	1				1		1				3
U. S. insp. (kill)			2								2
Totals	13	24	22	15	16	14	10	4	1	9	128

* Onset indefinite.

with brucella agglutination titers of 1:40 or higher at time of pre-employment physical examination. The annual medical examination of employees included brucella agglutination tests.

The main hog dressing operations are performed on the fourth floor by employees of the "kill" department in an area shown in Figure 1 as the killing floor. While the term "killing floor" implies that the hogs are killed in this area, they actually are immobilized with CO_2, stuck and bled in a large room adjacent to the west end of the killing floor. They are moved by conveyor to the scalding tank shown in Figure 1,

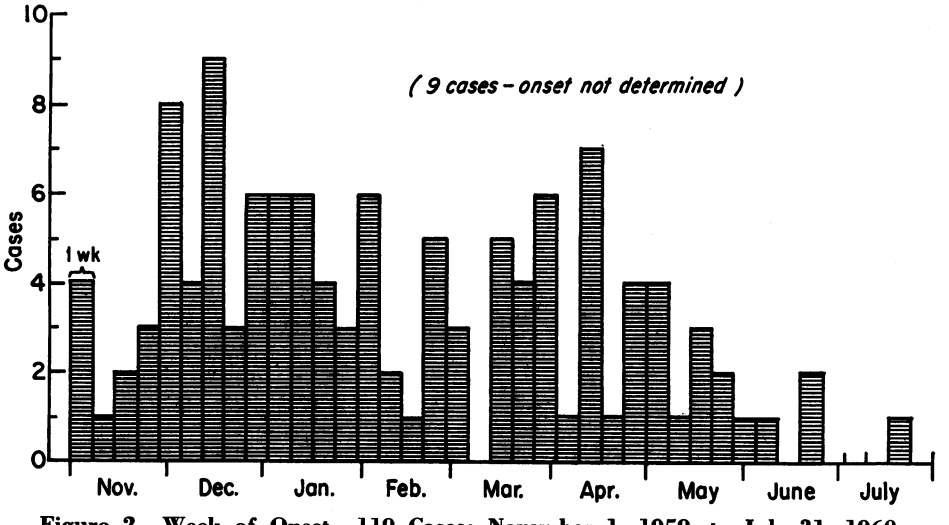

Figure 2—Week of Onset—119 Cases: November 1, 1959, to July 31, 1960

through the dehairing machine, and to the gambrel conveyor where gambrels are placed beneath the flexor tendons of the hind legs. The gambrels are attached to an overhead conveyor system. The hogs are immersed in a rosin bath at 310° F for five to seven seconds. The plastic, semisolid, adherent rosin is then peeled off the hog by manual pulling by employees, some of whom wear cotton gloves. The carcasses then pass through a bank of gas torch flames, and through a mechanical polisher consisting of several revolving rubber paddles and water spray. At this point the conveyor separates into two lines. Remaining hairs are shaved from the carcasses by men with knives. To this point the carcasses have not been opened except for the bleeding wound in the neck. The head is then dropped (disarticulated and left hanging from the carcass by a small skin attachment), the viscera are removed, the carcasses are split, final trimming is done, and the split carcasses move to the east end of the killing floor and to the coolers. Government inspectors inspect the cervical lymph nodes immediately after the heads are dropped, the viscera during evisceration, and the carcasses during final trimming.

The viscera are processed in an area at the east end of the killing floor by a group of workers classified as the "casing department."

Adjacent to the north side of the killing floor is the cutting room in which 137 employees of the "cut" department separate the chilled carcass sides into wholesale cuts. Also adjacent to the north side of the killing floor is an area in which 12 employees from the "curing" department and 12 from the "freezer" department grade and wrap chilled hams and "bellies."

The "head trim" department is located on the third floor, approximately under the casing department. The heads are lowered from fourth floor to third floor where employees of the head trim department remove the soft tissues, including regional lymph nodes, from the bones of the head before cooling.

The "boning," "trim," and "pork pack" departments are located on third floor in an irregularly shaped room directly under the fourth floor cutting room. In addition, 60 employees from the "cut" department work in this room. These employees trim, bone, wrap, and pack chilled cuts of meat that are dropped through chutes from the fourth floor cutting room.

Table 2—Attack Rates (%) by Age Groups and Sex*

Age Groups	Male			Female			Total		
	E	C	A/R	E	C	A/R	E	C	A/R
Under 21	27	9	33.3	0	0	0.0	27	9	33.3
21-30	260	59	22.7	7	1	14.3	267	60	22.5
31-40	175	30	17.1	37	2	5.4	212	32	15.1
41-50	69	5	7.2	46	5	10.9	115	10	8.7
51-60	45	2	4.4	25	3	12.0	70	5	7.1
61 and over	20	1	5.0	1	0	0.0	21	1	4.7
Total	596	106	17.8	116	11	9.5	712	117	16.4

* In departments in which there were cases except freezer, curing, night clean-up, management and office, and U. S. inspectors.
E = total employees. C = cases. A/R = attack rate.

Table 3—Attack Rates by Years of Employment*

Years of Employment	Number of Employees	Cases	A/R(%)
1 or less	264	47	17.8
2	6	1	16.6
3	36	5	13.8
4	44	6	13.6
5	66	15	22.7
6	42	10	23.8
7	43	6	13.9
8	73	9	12.3
9	80	4	5.0
10 or more	205	20	9.7
Total	859	123	14.3

* In all departments in which there were cases except management-office and U. S. inspectors.

Time of Onset

The probable dates of onsets by weeks as determined by medical histories, personal interviews, and rising blood agglutination titers are shown in Figure 2. It was impossible to ascertain the date of onset of nine cases because of the gradual and insidious nature of the disease. Figure 2 also illustrates the biphasic nature of the epidemic curve seemingly with a decrease in cases in mid-February. Table 1 shows that the cases were scattered over the entire period of the outbreak.

Attack Rates by Age Groups and Sex

Except for females in the 41-50 and 51-60 age groups, the attack rates decreased as the ages of the workers increased (Table 2). This exception may be related to the type of contact and the place of work since a high proportion of the females in these age groups worked in the casings department in which the attack rates were high for both sexes (Table 4). Persons in the lower age groups had various jobs. Their lower seniority did not appear to result in assignment to jobs with a higher degree of exposure to tissues more likely to be infectious.

Attack Rates by Years of Employment

Table 3 indicates the attack rates were higher among new employees. However, the attack rate was 9.7 per cent in the group of 205 employees who had worked in the plant ten years or longer. The factors responsible for higher attack rates among persons employed five and six years versus those employed four and seven years are unknown. They were proportionately distributed in various departments. The incidence of cases according to years of employment is related to the attack rates by age since 71 per cent of the persons employed one year or less were under 31 years of age. The attack rates by department are not influenced greatly by the years of employment or ages of workers since the newer or younger employees were working in all departments (see Table 4).

Cases by Department

The cases and attack rates by department and sex are shown in Table 4. The

rates were highest in the kill and casings departments in which the contact with fresh warm tissues was intimate. Contact in the head trim department was similar but the attack rate was considerably lower. The seemingly great variation in attack rates for men and women in the kill department is not statistically significant. The absence of cases among females in the cut department appears to be related to the fact that all women in that department worked on third floor (see Discussion 3c). The large number of employees listed under "other departments" included those from smoked meats, sliced bacon, sausage, canning, lard, livestock, luncheon meat, warehouse and shipping departments, delivery truck drivers, cafeteria workers, and others. The three cases among the "management and office" group included the supervisor of slaughtering operations and two industrial (time study) engineers, all of whom spent considerable time in the kill, cut, casings, and other departments and occasionally came in contact with swine carcasses, fresh carcass parts, and viscera. There were two cases among the 11 United States government post-mortem inspectors who worked continuously on the killing floor. The other seven inspectors were assigned to other departments in the plant.

Killing Floor Cases

The attack rates in various areas of the killing floor as shown in Table 5 are of interest. Cases occurred on both processing lines. For discussion purposes the jobs are placed in groups. There were no cases among Group I employees, many of whom had direct physical contact with live hogs by grasping ears, legs, and tails, with fresh feces and urine, and with fresh blood. In

Table 4—Per cent of Employees Who Had Been Employed One Year or Less (Column 2), Cases and Attack Rates by Department and Sex (Columns 3-11)

Department	% Employed 1 Yr or Less	Male			Female			Total		
		E	C	A/R(%)	E	C	A/R(%)	E	C	A/R(%)
Kill	34.2	165	58	35.1	13	2	15.3	178	60	33.7
Cut	28.4	166	24	14.5	31	0	0.0	197	24	12.2
Casings	36.5	44	11	25.0	38	9	23.6	82	20	24.4
Head trim	29.6	42	4	9.5	12	0	0.0	54	4	7.4
Freezer	36.7	57	3	5.3	0	0	0.0	57	3	5.3
Inedible	50.0	32	3	9.4	0	0	0.0	32	3	9.4
Maintenance	11.5	69	3	4.3	0	0	0.0	69	3	4.3
Pork pack	22.2	44	2	4.5	1	0	0.0	45	2	4.4
Curing	36.9	41	2	4.9	5	0	0.0	46	2	4.3
Boning	24.0	30	1	3.3	24	0	0.0	54	1	1.9
Night clean-up	37.7	45	1	2.2	0	0	0.0	45	1	2.2
Other departments		350*	0	0.0	100*	0	0.0	450*	0	0.0
Management and office		100*	3	3.0	200*	0	0.0	300*	3	1.0
U. S. insp. (kill)		11	2	18.1	0	0	0.0	11	2	18.2
U. S. insp. (other)		7	0	0.0	0	0	0.0	7	0	0.0
Total		1,216	117	9.6	426	11	2.5	1,627	128	7.8

* Approximate.
E=employees. C=cases. A/R=attack rate.

Table 5—Attack Rates by Job and Area of Killing Floor for Kill Department and Casing Department

Group	Area of Killing Floor	Job	Employees	Cases	A/R(%)
I	*	stickers, helpers, et al.	11	0	0
II	west third	gambrel placers, et al.	13	5	38
III	"	rosin pullers, et al.	8	4	50
IV	"	shavers, et al.	22	7	31
V	middle third	headers, openers, et al.	27	10	37
VI	"	eviscerators, et al.	15	5	33
VII	"	splitters, trimmers, et al.†	44	12	27
VIII	"	pluck processors	16	5	31
IX	entire floor	mobile group	22	12	54
	total	kill department	178	60	33
X	east third	casing department, all jobs	82	20	24

* Group I employees, except three dehairing machine feeders, work in room adjacent to killing floor.
† Twelve employees of Group VII work in east third.
Et al.=and other persons working in close proximity and having contact with carcasses in the same stage of processing.

sharp contrast, there were many cases among persons (Group II) who had contact with the hogs immediately after they passed through the dehairing machine. In addition, attack rates were high in Groups III and IV. It should be remembered that the hogs passed through a cleansing process consisting of a scald at 140° F (pH 11.9) for six minutes and a clean water rinse at 140° F in the dehairing machine before coming in contact with Group II employees. In addition, the animals were immersed in a rosin bath at 310° F for five to seven seconds before they were contacted by Groups III and IV. Bacterial swab counts of the skin of hogs after removal of the rosin were very low. (Additional information on bacteria counts will be published as a separate report.) Groups I through IV had contact with carcasses that were unopened except for the bleeding wound in the neck.

Persons in Groups V and VI had continuous and very intimate contact with freshly opened animals. Their hands were continuously bathed with blood and other tissue fluids as a result of grasping freshly cut tissues. Despite this close contact, the attack rates were no higher than in Groups II, III, and IV.

The degree of contact among persons in Group VII varied. Splitters had less contact than kidney removers and leaf lard removers. Persons in Group VIII who processed (separate, trim, and wash) lungs, liver, spleen, stomach, esophagus, and gall bladder had very intimate, continuous, contact since they grasped these organs with bare hands. In addition, moving of these organs on tables caused much spattering of employees' clothing and faces with blood, other tissue fluids, water, and mixtures thereof.

Group IX includes foremen, janitors, and utility workers whose duties required them to move about to all areas of the killing floor.

Group X, classified as the casing department, occupies a large portion of the eastern third of the killing floor. These workers grasped the large and small intestines thereby resulting in continuous contact with intestinal and mesenteric tissue. Operations of this department created considerable aerosols of water that most likely contained tissue fluids. The attack rate for this

group was similar to that of other groups on the killing foor.

Titer Histories of Cases

Because of the excellent plant medical program and management co-operation, records of pre-employment and annual blood agglutination tests were available for study. As indicated in Table 6, many of the cases had negative brucella titers (less than 1:40) for years. Almost all of the 35 with negative titers for one year or less had been employed at the plant during the fall of 1959. Specimens from nine cases had shown transient titers of 1:160 or less in previous years. Two cases had known positive titers previously. Case D.E. was negative in 1952 and 1954. Since 1954, his titer ranged from 1:160 to 1:640 and did not go above 1:640 during the 1959-1960 episode. He had typical clinical manifestations of brucellosis in February, 1960, and was treated accordingly. Case L.E.L. was negative in January, 1956, and on June 13, 1956. On June 20, 1956, his titer was 1:640 and he was treated for brucellosis. Since 1956, his titer has fluctuated between 1:160 and 1:320. He became severely ill with typical symptoms of brucellosis in April, 1960, again was treated and recovered. His titer on April 11, 1960, was 1:320 and 1:160 on August 26, 1960.

Subclinical Infections

A mass blood agglutination survey was done in December, 1959, and again in March, 1960. Specimens were obtained from all persons working in departments in which brucellosis cases were occurring. A number of specimens from persons who were not sick were positive in dilutions ranging from 1:320 to 1:40,960. Some of these became clinically ill later. However, 21 persons who were observed to have rising titers were not classed as cases and required no treatment for brucellosis. Some had minor clinical illness for varying lengths of time and others reported no illness whatsoever. During the period of the outbreak these 21 persons lost an average of 3.1 days of work due to illness. In most instances the reason for their absenteeism was listed as "cold," "flu," "upset stomach," or "URI." One person in this group was absent from work 15 days in March, 1960, and during this time had high titers for leptospirosis. His brucella agglutination tests on March 28 and April 7 were negative, but tests performed on June 20 and June 27 were positive through 1:1,280.

Blood tests conducted from April 1 through July 31, 1960, as part of the routine annual medical examinations revealed ten additional subclinical infections. The department distribution of the 31 subclinical cases was as follows: kill 15, cut six, casings four, freezer two, night clean-up one, livestock one, maintenance one, management and office one.

Other Pertinent Facts

During the summer of 1959, there was a gradual modification of killing floor facilities for greater capacity. The change was completed and the slaughter rate was increased considerably the first

Table 6—Titer Histories of Cases

2	Cases Negative for 10 Years
4	" " " 9 "
4	" " " 8 "
5	" " " 7 "
9	" " " 6 "
13	" " " 5 "
9	" " " 4 "
3	" " " 3 "
3	" " " 2 "
35	" " " 1 year or less
30	" " (length of time undetermined)
9	" with transient titers of 1:160 or lower
2	" with multiple titers of 1:640 previously
128	total

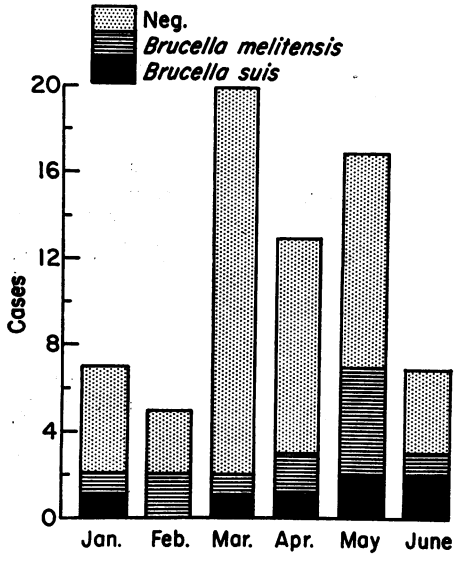

Figure 3—Blood Cultures (the Brucella melitensis Strain in March Was Recovered from a Clot)

week in September. The alteration required relocation of certain operations on the killing floor. The principal change was moving the rosin bath and rosin removal area from the south central area to the west end of the killing floor. The various rooms of the plant were well lighted, had high ceilings, and appeared to be well ventilated. Sanitation throughout the plant was excellent. There were 26 hand washing facilities (foot operated water faucets, soap, and towels) on the killing floor. Water specimens taken from 12 different outlets on the killing floor on February 22, 1960, and tested at the State Hygienic Laboratory were found to be "bacteriologically satisfactory." Swab cultures of fomites were negative for brucella organisms. A seasonal increase in operations resulted in a 60-hour work week from September through November, 1959. A review of plant first-aid records revealed no apparent relationship between lacerations or other skin wounds with the development of brucella infection.

The cases lived in 13 different cities and towns within a 30-mile radius of the plant. Their homes were supplied with pasteurized milk from 17 different dairies. Only two said they had consumed raw milk on occasions within the last year. Three used some homemade dairy products supposedly made from pasteurized milk. There was no instance of more than one brucellosis case per family. During the period of the outbreak, there were no reported cases of brucellosis among nonpacking house workers in the county.

Influenza was reported from the county in January and February, 1960. Seventy-nine cases of infectious hepatitis, concentrated in two parochial schools, were recorded in the county during the period of the brucellosis outbreak. Two of the brucellosis patients were reported as having had hepatitis before brucellosis. One brucellosis patient developed hepatitis after her brucella infection at a time during which other members of her family had hepatitis.

Etiologic Agent and Reservoir

Sixty-nine specimens of blood from 65 patients were cultured for brucella. In most instances, the blood was taken at the time of diagnosis and just before treatment was started. Eleven strains of Brucella melitensis and seven strains of Brucella suis were recovered from 18 of the 69 blood cultures. In addition, one strain of B. melitensis was recovered from one of 141 blood clots that were cultured (Figure 3). Two isolates of B. melitensis and one of B. suis were injected into guinea pigs and found to be highly virulent.

A large majority of the hogs slaughtered at this plant are raised within a radius of 100 miles. About 80 per cent are from Iowa and 20 per cent from a neighboring state. It is estimated that three to five other packing companies

purchased hogs in the same area during this period. During the fall of 1959, some hogs were procured from outlying areas not previously serving as a source for Plant A.

Studies as early as 1930 indicated the presence of brucellosis in Iowa hogs.[1] Brucella melitensis associated with bacteriologically proved human cases was first recovered from hogs in Iowa in 1946.[4] However, the incidence of brucellosis in Iowa swine is unknown largely due to the lack of a satisfactory practical test. Despite the limitations of the agglutination test as applied to swine brucellosis,[5] agglutination surveys provide the best available indicator of the extent of brucella infection in hogs. In a survey of hogs slaughtered in Plant A, done as a part of this study, 0.9 per cent of 1,156 butcher hogs and 2.2 per cent of 405 sows reacted positively in dilutions of 1:160 or higher. A similar survey of hogs slaughtered in a plant in another section of Iowa revealed 0.5 per cent of 1,447 butcher hogs and 0.9 per cent of 337 sows positive in the same dilutions. This compares with 1.4 per cent of 40,786 selected swine specimens, tested in 1959 at the State-Federal Brucellosis Laboratory at Iowa State University,[6] which had titers of 1:100 or higher.

In March, 1960, replies from 359 of Iowa's 800 veterinarians engaged in large animal practice indicated none had noted any unusual clinical incidence of swine brucellosis. The U. S. Department of Agriculture veterinarian in charge of inspection in Plant A reported no unusual condemnations of carcasses or carcass parts during the period of the human brucellosis outbreak.

Usual Incidence

Brucellosis in Iowa packing plant workers usually has been sporadic although "waves" of cases in packing houses have been mentioned by Spink.[9] In recent years, the reported incidence in Iowa plants with 1,000 or more employees has ranged from 0 to 15 with little seasonal variation (Table 7). A detailed examination of medical records including agglutination histories of employees in Plant A suggests there have been, in addition to the 16 reported clinical cases, 14 subclinical infections.

Plant F (slaughters cattle, hogs, sheep, and calves) was the only other plant that reported an increase of cases during the period of the outbreak in Plant A. With no more than 15 recorded cases per year during the 1954-1958 period, Plant F reported 16 cases during the nine-month period, November 1, 1959, to July 1, 1960. Twelve of these cases were reported in April and May. While the plants shown in Table 7 are widely scattered in the state, Plants A and F are in the same general region of the state and about 80 miles apart.

Incomplete records indicate that an exception to the sporadic nature of the disease occurred in Plant B in 1943 and 1944 during which time brucella organisms were recovered from 59 cases by one of the authors (Borts), (46 B. suis, eight B. melitensis, five B. abortus). Available records do not show the number of additional cases if any.

Table 7—Reported Brucellosis, Iowa Packing Houses

Plant	Total Employees	Cases	
		Yearly Average	Range
A	1,600	3.2*	2-6
B	1,000	5.0	4-7
C	3,500	2.5	0-5
D	6,500	5.5	4-8
E	2,500	1.8	1-3
F	2,900	7.2*	1-15
G	1,000	2.7	2-4
J	1,200	1.0	0-3

* Plants A and F, 1954-1958, all other plants 1956-1959.

Table 8—Cases and Attack Rates Among Workers on Third and Fourth Floors Having Contact with Carcasses and Viscera Before Chilling

Floor	Department	Employees	Cases	A/R(%)
4	kill	178	60	33.7
4	casings	82	20	24.4
3	head trim	54	4	7.4

Plant B slaughters cattle, swine, and sheep and is located approximately 200 miles from Plants A and F.

Discussion

Agglutination tests of blood specimens from hogs suggest it is likely that brucella infected hogs are slaughtered in each large packing house in Iowa every day. Why then should Plant A experience an outbreak, with a moderately increased incidence in Plant F? Other plants slaughtering hogs raised in the same general area did not have outbreaks at this time nor has Plant A experienced this in previous years. Slaughtering operations in Plant A are essentially similar to those in other plants.

While there is no specific evidence of increased severity of the disease among Iowa swine, the possibility of multiple introductions into the plant of organisms of unusual virulence cannot be ruled out definitely. There is a growing trend among Iowa swine producers to spread their hog farrowings and marketings throughout the year rather than during one or two seasons. It is conceivable that under such a program hogs from a single infected herd could be marketed during each month of the year, thereby introducing infection into the plant repeatedly. However, if such a strain were present in one herd, it is likely that other herds would be similarly affected. The increased incidence of human cases in Plant F would seem to support the hypothesis of higher incidence or increased virulence among hogs.

Early in the outbreak, the possibility of a single exposure of plant employees to a highly infectious lot of hogs was thought likely. When the cases continued to occur beyond normal or long incubation periods, multiple or continuous exposures seemed more probable. Recovery of both B. suis and B. melitensis point toward more than one source of infection, since it is unlikely that the same hogs would be harboring both species of brucella.

An examination of attack rates among various groups reveals several interesting aspects.

1. There were no cases among Group I (Table 5) despite their direct contact with animals and fresh blood. Most of these persons worked in a room apart from the killing floor.

2. The attack rates were as high among Groups II, III, and IV where the contact was only with cleansed unopened hogs as they were among Groups V, VI, VII, and VIII where there was intimate contact with fresh tissues and tissue fluids.

3. The following contrasts are noted in comparing the attack rates among a group of workers in one area with a group with similar contact but in another location in the plant.

a. Among persons having contact with carcasses and viscera before chilling, the attack rates were significantly higher in the kill and casings departments when compared with the

Table 9—Cases and Attack Rates Among Selected Groups from Kill Department* and Head Trim Department

Floor	Department	Employees	Cases	A/R(%)
4	Groups II, III, and IV*	43	16	37.2
3	head trim	54	4	7.4

* See Table 5.

head trim department (Table 8). This seems meaningful since the degree of contact in the kill and casings departments and head trim department was quite similar. Although the contact in these departments was with different parts of the carcass, it does not seem likely that persons having contact with soft tissues of the head including the mandibular (previously sectioned by United States inspectors) and retropharyngeal lymph nodes would be subjected to less exposure. On the contrary, Hutchings[7] reported that these nodes were a common site of B. suis localization in experimentally infected hogs. Likewise, McCullough's[8] findings indicate persons handling these tissues come into contact with high concentrations of brucella organisms in naturally infected swine. An obvious difference in comparing these groups is the fact that the kill and casings departments are on fourth floor while the head trim is on third floor.

b. The attack rate was significantly higher among persons having contact with unopened hogs than it was among workers having intimate contact with fresh, soft, and bony tissues of the head (Table 9). Again this contrast emphasizes the fourth floor and third floor location.

c. Table 10 shows the significantly greater attack rate on the fourth floor as compared with the third floor among workers who had a similar type of contact with chilled carcass parts. This difference in attack rates by floor was reflected in the attack rates by sex in the cut department. While there were 166 males and 31 females in this department, the 24 cases were all males. All the females in this department worked on third floor (Table 4). The comparisons in attack rates noted above would seem to indicate that: (1) The degree or type of contact which the employees had with carcasses, carcass parts, or viscera had little bearing on the attack rates. (2) There are factors associated with the floor or area in which the employees worked that influenced the attack rates.

Direct contact with infected animals or their tissues, with organisms entering the human host through the skin, is recognized as the most common method of transmission of brucellosis from animals to man.[1,9,10] Among other means of spread, Spink[9] has mentioned transmission through the respiratory tract and ocular mucosa as possibilities. In experimentally infecting guinea pigs with B. suis, Elberg and Henderson[11] concluded "that it is probable that the respiratory route of infection is little less effective than parenteral injection." They further state "the regularity with which these infections were produced (by inhalation) makes a reconsideration of the importance of the air-borne route in human and animal infections appear desirable."

Since attack rates in this outbreak do not indicate direct contact played an important role, other means of transmission must be considered. Milk, water, and food do not appear to be involved. The distribution of cases would seem to indicate that air-borne transmission may have been a factor. The isolation of B. suis from the air at two locations on the killing floor in February, 1960, by Harris, et al.,[12] demonstrates that one of the etiologic agents was present in the air during the outbreak. Many operations on the killing floor resulted in considerable small droplet splash and aerosol of water, tissue fluids, or a combination of these two. Aerosols were observed par-

Table 10—Cases and Attack Rates Among Workers on Third and Fourth Floors Having Contact with Chilled Carcasses and Carcass Parts

Floor	Department	Employees	Cases	A/R(%)
4	cut (137) freezer (12)* curing (12)*	161	27†	16.4
3	cut (60) pack (45) boning (54)	159	3	1.8

* Twenty-four employees from freezer and curing departments grade and wrap wholesale cuts in room adjacent to cutting room.

† Two additional cases worked on fourth floor part time.

ticularly in the dehairing, polishing, eviscerating, pluck processing, casing, and neck washing areas.

While these observations offer no proof, they do suggest the possibility of air-borne transmission. The recovery of brucella organisms from the air does not indicate that they were or were not present in the air at times or in selected locations in densities sufficient to cause human infection. The epidemiological data presented should be evaluated in the light of reports of other investigators. The findings of Rosebury[13] emphasize the relative stability of B. suis in experimentally produced aerosols. Elberg and Henderson[11] reported the inhalation ID_{50} for guinea pigs was 36 B. suis organisms.

Summary

1. One hundred and twenty-eight human brucellosis cases occurred in an Iowa swine slaughtering establishment in nine months.

2. In addition, at least 31 subclinical infections occurred during the same period.

3. Twelve strains of B. melitensis and seven strains of B. suis were recovered from 19 of the cases.

4. Epidemiological findings indicate that direct contact with fresh swine tissues was not the primary mode of transmission. The data further suggest air-borne transmission may have been a factor.

5. Limited data suggest the incidence of infected hogs slaughtered in Plant A does not differ markedly with the incidence of infection in hogs killed in other plants. Also, while available information on swine brucellosis does not indicate the presence of highly virulent foci of infection, the possibility of repeated introductions of highly infectious hogs into the plant cannot be eliminated.

Addendum

During the period August 1 to December 31, 1960, five of the persons with subclinical infections developed clinical manifestations of brucellosis. In addition, five new cases were recognized in Plant A. During this same period, 23 new cases were reported from Plant F. The continued high incidence in Plant F tends to support the hypothesis of increased incidence or greater virulence of infection among animals being slaughtered.

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