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An Epidemiologic Study of Brucellosis in Minnesota

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While working with the Mediterranean Fever Commission on the Island of Malta in 1905, Zammit (*1*) discovered that goats were a natural reservoir for undulant fever. Other members of the Commission confirmed this observation and incriminated the milk of these animals as the important medium of transmission of the disease to human beings (*2*). Following an order issued in June 1906, prohibiting the use of raw goat's milk by personnel of the Royal Army and Navy stationed at Malta, the incidence of undulant fever in the military forces dropped precipitiously. Effective control of this disease, thought to be largely a local problem in the Mediterranean, appeared to be at hand, yet today brucellosis ranks as the most prevalent disease of animals transmitted to man.

Recognition of the disease in the United States was slow and scattered. Although it now appears highly probable, as proposed by Craig (*3*) in 1905, that many febrile cases formerly diagnosed as atypical typhoid and typho-malarial fever were actually undulant fever, the latter was considered to be a rare imported disease found only in individuals from tropical areas who had had contact with goats. Evidence that the disease was endemic in the United States slowly accumulated as isolated cases from goat-raising areas were reported in 1911 by Gentry and Ferenbaugh (*4*, *5*) from Texas and by Yount and Looney (*6*) from Arizona in 1913.

While undulant fever was being viewed with desultory interest as a disease solely of caprine origin, an apparently unrelated series of observations on contagious abortion of cattle and its etiologic agent were in progress. Bang (*7*), in 1897, succeeded in isolating a small bacillus from the uterus of a cow with threatened abortion and established that this organism was the etiologic agent of bovine contagious abortion. A number of other workers confirmed these observations

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and the organism became widely known as *Bacillus abortus* (Bang) (*8, 9*).

Schroeder and Cotton (*10*) discovered in 1911 that milk obtained from certain cows, when injected into guinea pigs, produced lesions resembling tuberculosis. The same observation was made independently by Smith and Fabyan (*11*) in 1912 who called attention to the similarity of these "milk injection" lesions to those produced by *B. abortus* in guinea pigs. Both groups subsequently isolated the organism from cow's milk and identified it as *B. abortus* (*10, 12*). These findings caused Schroeder and Cotton (*10*) to propose that *B. abortus* might well be pathogenic for man. The question of human pathogenicity was further stimulated by Larson and Sedgwick (*13*) who demonstrated complement-fixing antibodies against *B. abortus* in the blood of children who drank raw milk. Cooledge (*14*) fed viable organisms in milk to several human volunteers without any evidence of clinical illness resulting. He was able to demonstrate *B. abortus* agglutinins in these individuals but concluded that they were absorbed from the ingested milk. The isolation of a similar organism from swine and its association with infectious abortion in sows was first reported in 1914 by Traum (*15*).

The link between these diverse observations was furnished in 1918 by Alice Evans (*16*) who found that *Micrococcus melitensis*, the known etiologic agent of undulant fever which had first been isolated at autopsy by Bruce in 1887, was morphologically, culturally, biochemically, and serologically related to *B. abortus*. Following the suggestion of Meyer (*17*) in 1920, the generic name *Brucella* found general acceptance, and after several years of confused terminology the caprine, bovine, and porcine organisms were designated, as proposed by Huddleson (*18*), as separate species: *Br. melitensis*, *Br. abortus*, and *Br. suis*.

Following the disclosure of the true relationship between *Micrococcus melitensis* (Bruce) and *Bacillus abortus* (Bang), Keefer (*19*) reported the first proved case of human brucellosis in this country of non-caprine origin. Other cases of non-caprine origin in the United States were soon reported by Gage and Gregory (*20*), Huddleson (*21*), and Carpenter and Merriam (*22*). Concurrent observations appeared in other countries (*23*).

Although several of these early case reports indicated that contact with infected animals was a probable means of infection, and the original reports of the Commission on Mediterranean Fever pointed out that infection may occur through small wounds of the skin, attention in this country centered on contaminated milk as a source of human disease. Evans (*24*), Fleischner and Meyer (*25*), Carpenter and Baker (*26*), and others (*27, 28, 29, 30, 31*) pursued the problem and demonstrated the widespread occurrence of *Br. abortus* in raw milk and dairy products. These observations proved that viable *Brucella* were being ingested regularly in raw market milk, including milk from certified herds.

The relatively low incidence of recognized infection despite established proof that viable organisms were commonly ingested led a number of workers to doubt the pathogenicity of the bovine organism. Both Cooledge (*14*) in 1916 and Morales–Otero (*32*) in 1929 were unable to produce demonstrable disease by feeding viable *Br. abortus* in milk to a small number of human volunteers, although Morales–Otero did produce illness in 2 individuals who had ingested *Br. suis*. Nicolle, Burnet, and Conseil (*33*) failed to produce evidence of infection following subcutaneous inoculation of *Br. abortus* in 5 individuals. Huddleson (*34*), working with monkeys, observed that *Br. suis* produced a severe disease ending in death, whereas *Br. abortus* induced a mild infection from which the animals readily recovered. In 1930, Hardy and co-workers (*35*) reported data on 14 patients from whom *Br. abortus* had been isolated. Illness in the group ranged from a mild ambulatory form of the disease to severe, protracted disability. They observed that while, in general, *suis* infections tend to be more severe than those due to *Br. abortus*, this difference was not sufficiently consistent to permit a clinical differentiation in an individual case. This evaluation of the relative pathogenicity of the two species of *Brucella* is now generally accepted. A number of cases of fatal *Br. abortus* infection have been reported (*36*, *37*).

The importance of the skin as a portal of entry was emphasized by Hardy, Hudson, and Jordan (*38*). Noting the frequency of infection in employees in meat-packing plants and farmers, they concluded that the intimate types of contact with infectious materials common to these occupations resulted in infections through the skin. They demonstrated that 100 percent infection in guinea pigs was obtained by applying *Brucella* to the shaved and abraded skin. Eighty percent infection was obtained similarly in a group of animals in which the hair was clipped without visible trauma to the skin, whereas only 22 percent of the animals were infected by ingestion of the organisms.

Principles of Epidemiology

From the foregoing historical summary, it is apparent that most of the major factors in the epidemiology of brucellosis in the United States were recognized by 1930. It had been established that a large reservoir of infection was present in naturally infected goats, swine, and cattle; that the organisms isolated from each of these groups of animals constitute separate though closely related species which can be differentiated on the basis of cultural and metabolic characteristics and which vary in invasiveness and in the severity of disease produced in animals; and that each of the three species may produce human illness. Subsequently, it has been learned that other domestic animals including horses (*39, 40*) and dogs (*35, 41*) may be naturally infected, and that even chickens may be susceptible (*42*).

Discovery of cross infections in animals by each of the three species has added to the problem of ultimate control. Huddleson (*18*) first isolated *Br. suis* from cattle in 1929. Epidemiologic studies in Iowa indicated that transmission of the more virulent porcine strains from cattle to man may occur. Dramatic confirmation of this means of spread subsequently appeared in several milk-borne epidemics of brucellosis due to *Br. suis* (*43, 44, 45*). Cattle may also become infected with *Br. melitensis*, which has been isolated from cow's milk, but this type of cross infection appears to be uncommon in the United States (*46, 47*). For years it was believed that human infection with *Br. melitensis* in the United States was confined almost exclusively to the goat-raising areas of the South and Southwest. However, in 1946, Jordan and Borts (*48*) reported the occurrence of human *melitensis* infections in Iowa with evidence that hogs were the immediate source of infection. Isolation of *Br. melitensis* from the tissues of sows in Iowa followed shortly (*49*). Human *melitensis* infection derived from contact with hogs in Minnesota has also been reported (*50*). It now appears that all three species of *Brucella* may infect cattle, hogs, sheep, and goats. Natural infections of hogs with *Br. abortus* have been recently reported (*51*). Apparently goats have not been encountered that are infected with *Br. abortus* or *Br. suis*.

Brucellosis may be transmitted to man from the animal reservoir by two well-established routes: (1) contact with an infected animal, its tissues, blood, secretions, or products of abortion and (2) the ingestion of contaminated milk, cream, cheese, or other dairy products. Air-borne infection by dust or droplets has also been suggested (*52, 53*). Documented cases of inter-human transmission are rare, but references to infection via coitus and maternal milk have appeared in the literature (*52*). There are indications that the disease can be accidentally transmitted as a result of blood transfusions (*54*).

The portal of entry is dependent upon the mode of transmission. Since the early experimental and epidemiologic observations of Hardy and his associates (*35, 38*), it has been generally accepted that invasion through the skin is the most probable portal of entry following direct contact with infected animals or tissues. Small cuts or abrasions on the skin undoubtedly facilitate this mode of infection, but the possibility of entry through the unbroken skin cannot be excluded. Following ingestion of infected materials, the oropharynx is presumed to be the site of invasion. Little precise information is available concerning the ability of *Brucella* to survive the gastric barrier and invade through the stomach or intestine. The probability that the respiratory tract may serve as a portal of entry in human brucellosis is supported by successful experimental infection of guinea pigs (*52*) and monkeys (*55*) via this route. Cattle are readily infected by inoculation of *Brucella* into the conjunctival sac which suggests that the conjunctiva may also serve as the portal of entry in some human infections, particularly of laboratory personnel (*56*).

With this complexity of possible sources of infection and means of its transmission from animals to man, it is apparent that major factors in the epidemiology of brucellosis may vary widely in different localities. An over-all picture of brucellosis in the United States can only be completed by careful regional studies. Relatively few studies of local epidemiologic factors have appeared in the literature. Carpenter and King (*57*), Orr and Huddleson (*58*), and Simpson (*59*) have reported observations from certain geographical areas dealing primarily with milk-borne infections. These authors found bovine sources to be of primary importance in the areas studied in New York, Michigan, and Ohio, respectively. In Indiana, a broad cooperative study to determine the incidence of brucellosis and types of infection in both the livestock and human population of representative rural areas was initiated in June 1946, but only preliminary reports have appeared (*47*). The most notable contributions to the epidemiology of brucellosis have been the detailed studies from Iowa by Hardy, Jordan, and Borts continued over a period of 20 years. Their first survey, appearing in 1930, was based on a study of 300 patients, from whom *Brucella* was isolated in 48 cases (*35*). The sources and routes of infection in Iowa were detailed and showed a predominance of infection due to *Br. suis*. A number of subsequent reports have supplemented the intial study (*60, 61*). These workers emphasized the need for intensive studies in other areas to contribute to the general knowledge and pointed out the likelihood of error in assuming that the factors which have proved to operate in the transmission of brucellosis in one locality are of equal importance in all areas. It is with this view in mind that the present report was prepared on brucellosis in Minnesota.

Methods of Study

This report represents a joint study made possible through the collaboration of the Sections of Preventable Diseases and Medical Laboratories of the Minnesota Department of Health, the University of Minnesota Hospitals, and practicing physicians throughout the State. The data were derived primarily from a study of 268 patients from whom *Brucella* was isolated by the Medical Laboratories of the Minnesota Department of Health and the University Hospitals from January 1, 1945, through June 30, 1948. Duplicate isolations from both laboratories were obtained in a number of cases making a total of 333 strains.

The technique of blood culture employed was as follows: Five milliliters of blood, drawn aseptically, were inserted by needle into a 2-ounce rubber diaphragm screw-capped bottle containing 25 milliliters of sterile bacto-tryptose broth, pH 6.8, and one percent sodium citrate. Prepared culture outfits were mailed on request to physicians who then inserted the blood and returned the bottle to the laboratory by mail. Upon receipt of the culture in the laboratory, approximately 10 percent of the air was aseptically removed and replaced by an equal volume of CO_2. After incubating the broth culture for 5 days at 37° C., four tubes of bacto-tryptose agar, pH 6.8, were inoculated with 1 milliliter each from the broth culture. Two of the tubes were incubated aerobically and two under 10 percent CO_2 at 37° C. The original broth culture was returned to the incubator for an additional 10 days at the end of which time a second set of four subcultures was inoculated. Each set of subcultures was observed every other day for 2 weeks. No blood cultures were discarded before 30 days of observation.

Identification of the species of *Brucella* was carried out with every freshly isolated strain in the Department of Health laboratories based upon the requirement of carbon dioxide for growth, growth characteristics on dye plates and the production of hydrogen sulfide (*18, 62*).

By focusing the study on this group of proved cases all speculation about the diagnosis in the individual case was removed and the particular species of *Brucella* was established and correlated with the source of the infection. A complete study of all phases of the illness at the university hospitals was possible in 41 of the patients. In the remaining cases, data were obtained from individual reports submitted by attending physicians throughout the State. These included information on occupation, use of raw milk products, contacts with animals, any known abortions or other evidence of brucellosis in livestock, and a brief statement of symptoms and date of the onset of illness. In only 13 of the 268 cases were reports lacking or grossly incomplete, a fact which emphasizes the interest and cooperation of Minnesota physicians in the study of this disease. Further study was made in a number of cases through visits to the homes of patients by physicians from the State Department of Health. In addition to this information, data are presented on the cases of brucellosis reported annually to the Minnesota Department of Health since 1927 on which less detailed information is available.

Incidence of Human Brucellosis

The first cases of human brucellosis in residents of Minnesota were reported in 1927. The number of reported cases increased from 12 in 1928 to 62 in 1932 and to 113 in 1935. During the following 4 years, the number varied from 77 to 92 cases annually. A steady increase in the number of reported cases began in 1940 and continued to a peak of 403 cases in 1946. In the period of 11 years from 1927 through 1937, 710 cases were reported. In the following 10-year period the number increased to 2,605, a total of 3,315 cases having been reported by January 1, 1947. It is difficult to determine how accurately these figures represent the actual incidence of active brucellosis in this State, but it may be reasonably assumed that the addition of all diagnosed but unreported cases, plus unrecognized mild or ambulatory cases would appreciably increase the incidence. During 1947, when 378 cases of brucellosis were reported in Minnesota, *Brucella* agglutinins were found to be present in a titer of 1:40 or higher in 1,201 human sera submitted for this examination to the laboratories of the Minnesota Department of Health.

The annual morbidity rate for brucellosis in Minnesota increased markedly during World War II and the immediate post-war period. For the 5-year period 1937–41, the average annual morbidity rate per 100,000 population was 4.1. In contrast, the estimated average annual rate for 1942–47 was 12.9. A similar increase has been reported in Iowa and undoubtedly has occurred in other States (*61*). It is apparent that brucellosis is a problem of growing concern in the North Central States region.

Reservoir of Brucellosis

The major animal reservoir of brucellosis in Minnesota resides in cattle. Swine, though numerically equal, are raised on fewer farms and contribute to fewer human contacts than do cattle. Horses and sheep comprise a significant number of domestic animals and should not be overlooked in any census of the animal reservoir. Agglutination tests for Bang's disease among horses in Minnesota revealed 2.9 percent reactors in one study (*63*).

A sharp increase in bovine brucellosis has occurred in Minnesota since 1942 as indicated by agglutination tests on cattle. From 1934, when the Federal–State Bang's disease program was first initiated in Minnesota, through 1939, over 870,000 cattle distributed in 58,473 herds were tested at least once (*63*). In subsequent retests of the same herds, 537,000 animals were investigated. On the initial test 11.4 percent of the animals were found to be positive. On the first retest the number of reactors had been reduced to 3.9 percent of the group. Of the herds tested, 61.3 percent were completely negative initially and 71.7 percent were negative on retesting. The over-all incidence of reactors continued to decline until 1942 when only 1.48 percent reactors were found in over 1,700,000 cattle tested. From that year, however, the incidence of infection steadily increased to 8.2 percent in 1946. The total number of cattle on Minnesota farms in 1947 was estimated to be 3,527,000 (*64*).

There is little available information on the incidence of brucellosis in other livestock in Minnesota, although it is highly probable that the same conditions existing in cattle have operated to bring about an increase in swine brucellosis. It is to be emphasized that in Minnesota, swine constitute the reservoir of *Br. melitensis* as well as *Br. suis*. Although these two species together were found to represent less than 15 percent of the human infections in the present study, they produce a more severe disease than *Br. abortus* in most cases. Since it is already well recognized that *Br. suis* may spread from infected swine to dairy cattle on the same farm, the potential danger of widespread dissemination of both of the more virulent species of *Brucella* from swine to other farm animals is apparent.

Analysis of Proved Cases of Human Brucellosis

Species Distribution

Grouping of bacteriologically proved cases according to the species of *Brucella* isolated shows a striking predominance of *abortus* infections in Minnesota. It is of interest that the first 36 strains isolated from human cases up to 1935 revealed only 12 strains of *Br. abortus*,

Table 1. *Species distribution of* Brucella *isolated in Minnesota from 268 patients (January 1945 to June 30, 1948)*

Year	*Brucella abortus*		*Brucella melitensis*		*Brucella suis*		Total patients
	Number of patients	Percent	Number of patients	Percent	Number of patients	Percent	
1945	51	76.1	9	13.4	7	10.5	67
1946	76	90.5	4	4.7	4	4.7	84
1947	71	86.6	6	7.3	5	6.1	82
1948 (to June 30)	32	91.4	3	8.6	0	0.0	35
Total	230	85.8	22	8.2	16	6.0	268

whereas 24 were identified as *Br. suis* (*62*). The discrepancy between these findings and those of recent years can probably be accounted for by the large proportion of packing plant workers in the early sample and the probability that cultural studies during those years were attempted only in the more severe and obvious cases. The combination of these factors could readily have resulted in selecting a group of cases that was poorly representative of all *Brucella* infections in the State. It is also possible that there has been an actual increase in the proportion of *abortus* infections, or that the *abortus* variety has acquired greater invasiveness for man.

Table 1 summarizes the species distribution of *Brucella* isolated from 268 patients from January 1945, through June 1948. *Brucella abortus* was the etiologic agent in 230 cases, or 85.8 percent. Of the remaining 38 cases, *Brucella melitensis* was recovered in 22 (8.2 percent) and *Brucella suis* in 16 (6.0 percent). A similar predominance of *abortus* infections has been found in Wisconsin and Michigan (*65*). Like Minnesota, these states engage in extensive dairy farming. In contrast, *Br. suis* has consistently been the most common species isolated from patients in Iowa. In a recent summary of 420 strains isolated by the Iowa State Hygienic Laboratory, 259 were *Br. suis;* 112, *Br. abortus;* and 49, *Br. melitensis* (*66*). It is remarkable that recognized *Br. suis* infection remains relatively uncommon in Minnesota even in the southern portion of the state bordering on Iowa where there are considerable numbers of swine.

Sex and Age Distribution

Slightly over three-fourths (77.5 percent) of all the reported cases of brucellosis in Minnesota have occurred in males. This ratio of males to females has remained quite constant. Of 710 cases reported from 1927 through 1937, 77.2 percent were males. In the following decade 2,605 cases were reported of which 77.6 percent were males. In the present study of 268 proved cases, males constituted 78.4 percent of the group (table 2). A similar preponderance of males has been

Table 2. *Distribution of 268 cases of proved brucellosis in Minnesota according to sex (January 1945 to June 30, 1948)*

Age group	Males		Females	
	Number	Percent	Number	Percent
Children 12 and under	10	50.0	10	50.0
Adults 13–54	188	83.5	37	16.5
Adults 55 and over	12	52.2	11	47.8
All cases	210	78.4	58	21.6

noted in reports from various other parts of the country. Hardy and his group (*60*) reported 76 percent males in Iowa. Smaller series from Alabama (67) and Indiana (*47*) gave the incidence of males as 79.1 and 87.3 percent, respectively. As pointed out by Hardy in 1930, it need not be assumed that males are more susceptible to brucellosis than females. The unequal distribution is readily explained by a much greater opportunity among males for occupational contact with infectious materials. In the present study the sex incidence was approximately equal in children under 13 years of age and in adults over 55, groups which have infrequent contact with animals. Of the 74 cases of all ages who gave no history of contact with animals, only 38 or 51 percent were males. Similar observations have been made in Iowa (*35, 68*). Thus under the same conditions of exposure, both sexes appear to be equally susceptible.

The age of the patients in the present study ranged from 2 to 74 years. The great majority were between the ages of 12 and 60, but

Table 3. *Distribution of 268 proved cases of brucellosis according to age and sex in Minnesota (January 1945 to June 30, 1948)*

Age in years	*Br. abortus*		*Br. suis*		*Br. melitensis*		Total	
	Male	Female	Male	Female	Male	Female	Male	Female
2	0	2						2
4	0	2						2
5	0	1						1
6	1	2					1	2
9	1	0					1	0
10–14	11	4			1		12	4
15–19	12	2		1	1		13	3
20–24	14	3	1		1		16	3
25–29	20	7	2		4		26	7
30–34	42	4	5		5		52	4
35–39	21	5	3		2		26	5
40–44	18	2		1	2	1	20	4
45–49	14	5	1		1		16	5
50–54	10	5	1		4		15	5
55–59	6	4					6	4
60–64	4	3					4	3
66	0	1					0	1
67	0	2					0	2
72	0	1	1				1	1
74	1	0					1	0
Total	175	55	14	2	21	1	210	58

33 of the 268 cases were outside of this age bracket. The incidence in males rose rapidly during young adulthood, reached a peak in the 30- to 34-year age group, and thereafter declined gradually (table 3, fig. 1). Three-fourths of the males were in the third, fourth or fifth decade of life, the remaining fourth being scattered through the first, second, sixth and seventh decades. The female cases, on the other hand, showed an almost uniform distribution throughout all age groups. The age distribution of females parallels that of all cases having no history of animal contact (fig. 2).

The question has frequently been raised as to the relative susceptibility of children to brucellosis. In this series, organisms were isolated from 9 children under the age of 10, including four cases under 5 years of age, a total of 3.4 percent of the entire group. Of the 3,315 cases of brucellosis reported in Minnesota since 1927, 102, or 3.1 percent, were children under the age of 10. If consideration is limited to the group of cases having no contact with animals, the proportion of children is increased but still lags considerably behind the incidence in young and middle-aged adults. In the 74 proved cases with no animal contacts nearly 10 percent were children under 10 years of age. In Iowa, Jordan (*69*) found the specific annual rate of reported cases to be 0.9 per 100,000 in rural children under 12 years of age and 0.4 in urban children as compared with 1.4 in urban housewives. It appears that even in selected groups of cases in which infection is presumably contracted from raw milk, recognized infections in children are significantly less than in adults.

Distribution of 268 Culturally Proven Cases of Brucellosis

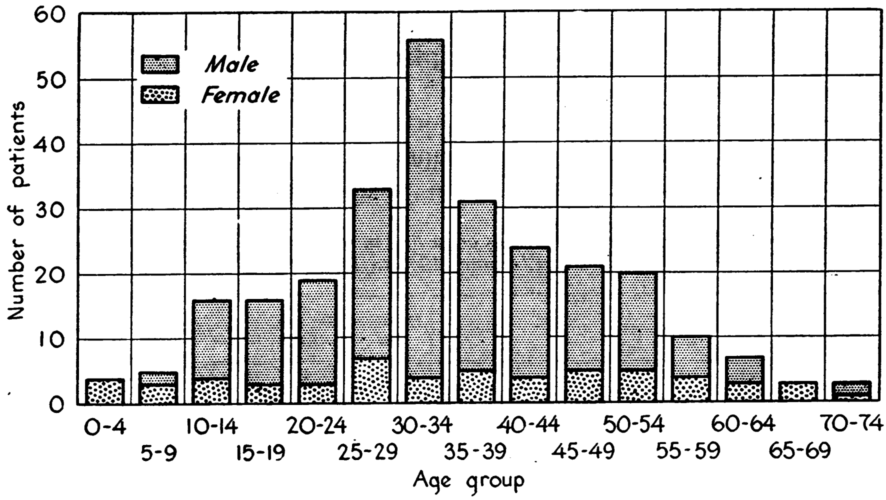

Figure 1.

Comparison of 253 Culturally Proven Cases of Brucellosis
With and Without Farm Animal Contact

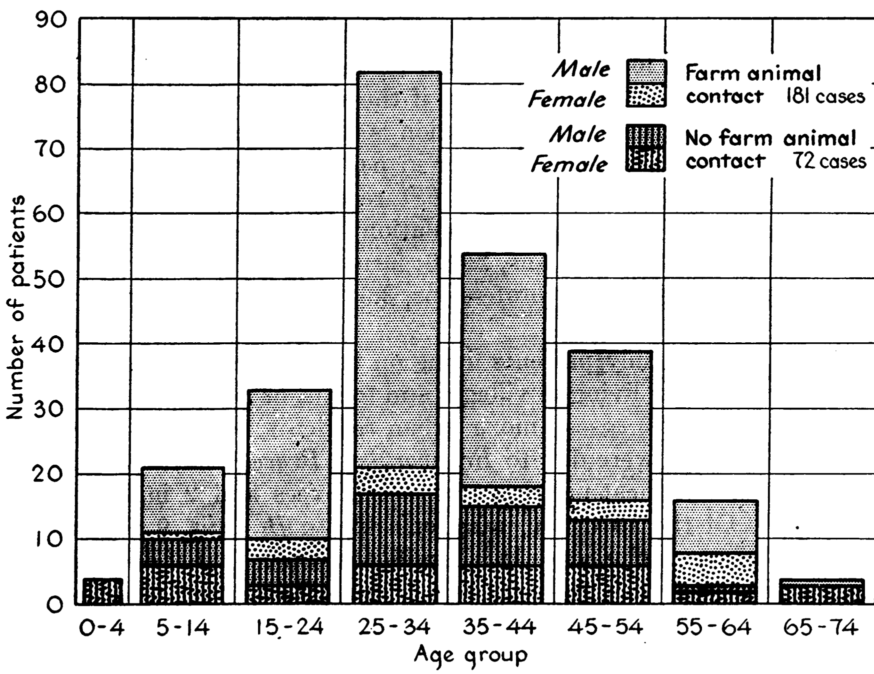

Figure 2.

Occupation and Residence

At least 60 percent of the proved cases in this study may be classified as occupational in origin. Farmers constituted the largest single group, followed by meat-packing plant employees (table 4). Retail butchers, stockyard workers, veterinarians, and laboratory workers were also involved. Of all cases reported to the Minnesota Department of Health through 1947, approximately one-third were farmers or farm workers and one-sixth were meat-packing plant employees.

Table 4. *Analysis of 255 proved cases according to residence and occupational groups in Minnesota (January 1945 to June 30, 1948)*

Occupational group	*Br. abortus*	*Br. melitensis*	*Br. suis*	Total	Percent
Urban:					
Business, trades, workers (male)	32	0	1	33	12.94
Packing plant, stockyards, butchers	30	15	9	54	21.17
Veterinarians	2	0	0	2	.78
Housewives, teachers, clerks (female)	20	0	0	20	7.85
Laboratory workers	0	2	0	2	.78
Children under 15	9	0	0	9	3.53
Total urban cases	93	17	10	120	47.05
Rural:					
Farmers, farm workers	91	4	2	97	38.04
Farm women	20	0	2	22	8.62
Farm children	15	1	0	16	6.28
Total rural cases	126	5	4	135	52.94
Total all cases	219	22	14	255	99.99

Accurate figures for the calculation of specific rates of infections in occupations are not available, but if the proportion of these occupational groups to the entire population is considered, it is evident that the rate of infection is far greater in packing-plant workers than in any other occupation. Jordan (*69*) recently reported the specific rates in Iowa (per 100,000 population) as follows: packing-house workers, 271.5; veterinarians, 250.0; farmers and farm workers, 43.0; urban merchants, trades, professions, 3.3; farm wives, 2.2; and urban housewives, 1.4.

In this study, only patients living on farms were classified as rural residents. Those living in villages and towns, or cities, were classified as urban. Of 120 cases among urban residents, 93, or 77.5 percent, of the infections were due to *Br. abortus*. *Brucella melitensis* caused 15 infections in meat-packing plant employees and 2 in laboratory workers. Of the 10 urban infections due to *Br. suis*, 9 occurred in packing plant employees. It is significant, then, that if occupational contacts are excluded, brucellosis in urban areas was due to *Br. abortus* with a single exception. Turning to the 135 rural cases, 126, or 93.3 percent, were due to *Br. abortus*. It is remarkable that among farm residents only five cases were caused by *Br. melitensis* and four by *Br. suis*, although over half of the farmers gave a history of contact with swine and many were residents of southern Minnesota living only a few miles from Iowa where *Br. suis* is the predominant organism.

Source of Infection

The relative importance of various sources of infection as they appear in Minnesota is indicated in table 5, which summarizes the probable origin of infection in 255 cases. It is significant that 181, or 71 percent, gave a history of contact with farm animals or their carcasses. This group, composed mainly of adult males under the age of 55, dominated the age and sex distribution of the entire series. In Iowa over 70 percent of the reported cases had direct contact with livestock or fresh meat. Thus, a marked disparity is seen in the incidence of brucellosis in individuals and occupation groups who handle infectious materials as compared with a much larger population group ingesting raw milk. The conclusion appears justified that direct contact with infected animals and tissues is much more likely to result in illness than is the ingestion of the organisms in raw milk.

Table 5. *Analysis of 255 proved cases according to probable sources of infection in Minnesota (January 1945 to June 30, 1948)*

Possible source of infection	*Br. abortus*		*Br. melitensis*		*Br. suis*		Total		Percent
	Male	Female	Male	Female	Male	Female	Male	Female	
Contact with cattle (and hogs) plus use of raw milk	96	16	[1] 5	------	[1] 2	[2] 2	103	18	47.45
Contact with hogs only plus use of raw milk	------	------	2	------	------	------	2	0	.78
Contact with hogs only	3	------	8	------	4	------	15	0	5.86
Contact with cattle only	11	------	------	------	1	------	12	0	4.71
Contact with cattle and hogs	12	------	4	------	1	------	17	0	6.66
Packing employees—no known animal contacts	8	2	1	------	3	------	12	2	5.49
Total cases with animal contacts	130	18	20	0	11	2	161	20	70.95
Raw milk and/or cream	32	30	------	------	1	------	33	30	24.72
Laboratory infections	------	------	1	1	------	------	1	1	.78
Source unknown	4	5	------	------	------	------	4	5	3.54
Total cases with no animal contacts	36	35	1	1	1	0	38	36	29.04
Total	166	53	21	1	12	2	199	56	99.99

[1] Contact with cattle and hogs.
[2] Only animal contacts were cattle.

The data in table 5 also indicate that there was a fairly consistent correlation of the source of infection with the species of *Brucella* isolated. The largest single group, consisting primarily of rural residents, were patients who had had contact with cattle (frequently also with swine) and who drank raw milk. In this group, 112 out of 121 cases were due to *Br. abortus*. The herds of cattle of 68 farmers in this group showed evidence of Bang's disease as indicated by the occurrence of abortions or positive reactors to the agglutination test. Thirty-four of these farmers and one farm wife had handled aborted material. Five rural males, one a 10-year-old farm boy, developed *melitensis* infection. These five had contact with hogs as well as with cattle, and abortions had occurred in the swine herds on four of the farms.

Br. suis was isolated from four patients in the group who had animal contact and drank raw milk. Two were farmers having contact with swine and cattle. The other two cases were farm women whose only animal contact was with milch cows. The suspected cows in each instance were found to be positive reactors. In these two cases, *Br. suis* was apparently transmitted from infected cows either by direct contact or through the milk. It is of interest that in one case, the husband and a 16-year-old son also had symptoms of brucellosis and agglutinin titers of 1:1280, although blood cultures remained sterile. This family had a single milch cow, subsequently proved to be a positive reactor, whose milk was used only by the family. The entire family had had contact with the animal in milking. The other patient with *suis* infection from a bovine source had a brother who developed an agglutinin titer of 1:320, but manifested no symptoms.

Also included in the group of patients having animal contact and using raw milk were two packing-plant employees with *melitensis* infection. The activities of both were confined to the "hog-kill" division. Neither had had contact with sheep or goats.

A second category of patients includes those having contact with animals or fresh meat products and who denied the use of raw milk. Meat-packing plant employees comprised the majority of this group, although several farmers who denied the use of raw milk or cream were also included. Two veterinarians, two stockyard employees, and a retail butcher brought the total to 56 cases, of whom only two were females. Among the packing-plant employees included in this group were 14 whose work did not involve the handling of live or freshly slaughtered animals. These included such employees as a typist in the general office, steamfitter, pipeshop worker, millwright, carpenter, elevator operator, and a bacon slicer. Because of the possibility of inadvertent contact with infected animals or tissues, they have been tabulated with the animal contact group.

In a number of cases the strain of *Brucella* isolated was not the species that would have been expected from the apparent source. *Br. abortus* was isolated from 3 workers having contact only with slaughtered hogs and from 10 of the workers just discussed who had no definite animal contact. The remaining 22 patients in this category with *abortus* infection, including one retail butcher, had had contact with fresh beef. A consistent correlation between *melitensis* infection and contact with hogs was found, except for one patient who was an elevator operator in a packing plant. A striking feature was that 13 of the 15 cases of *melitensis* infections occurring in meat-packing plant workers were detected in one particular plant. The appearance of swine-borne *melitensis* infection in Minnesota has been observed only in the past 3 years, following the discovery of *melitensis* infection in hogs in Iowa. *Br. suis* was isolated from one patient who worked on the beef-kill and from three packing-plant employees with no known animal contacts.

A third major group of the proved cases consisted of those who had ingested raw milk or cream without any other known exposure to possible infectious sources. There were 63 patients in this group, 30 of whom were females. Only 11 individuals in this group resided on farms and these were women and children. The remainder were urban residents engaged in various occupations, including salesmen, mechanics, merchants, housewives, and students. The causative organism in this group was *Br. abortus* with the single exception of a mechanic from whom *Br. suis* was isolated. The source of the raw milk used by this patient was unknown. The 11 rural patients drank raw milk obtained from their own herds; in 7 of these there was evidence of Bang's disease. Among the 52 urban cases, 20 obtained raw milk directly from friends or relatives on farms. Data on these herds were fragmentary, but evidence of Bang's disease was present in at least five instances. The remaining 32 patients obtained their milk through regular commercial channels. One commercial dairy herd from which two of the patients had obtained milk was shown to contain two animals suspected of having Bang's disease on the basis of agglutination tests.

The degree of exposure to potentially contaminated milk varied widely. Most of the rural patients used raw milk and cream regularly although two farm women stated that they had used only raw cream for coffee and cereal. Five patients were rural children from 2 to 6 years of age. One, a 2-year-old girl, had no symptoms or fever, but *Br. abortus* was isolated from her blood when submitted for culture along with other members of the family who were ill. Eight urban residents who usually drank pasteurized milk developed illness following vacations or brief visits on farms. Several other urban cases were salesmen and truck drivers who drank only milk served across the counter in cafes in small towns or villages. Other urban residents had habitually used raw milk for years before the onset of the illness.

From the public health viewpoint, the cases in which raw milk was the only demonstrable source are perhaps the most important group. These cases, representing 25 percent of the proved cases in the present study, could probably have been avoided if the universal pasteurization of milk had been in force. It is estimated that in 1947 less than 10 percent of the population of Minnesota lived within the confines of municipalities in which the sale of raw milk was forbidden (*64*). The two largest cities, with a combined population of over 800,000

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do not have such an ordinance, although most of the milk is pasteurized. Studies of Fitch and Bishop (*30, 70, 71*) have demonstrated the presence of viable *Brucella* in raw market milk in Minnesota, including that from certified herds.

One must conclude that thousands of individuals are repeatedly exposed to viable *Brucella* in raw milk without any subsequent evidence, clinical or laboratory, of such exposure. Others apparently develop serum agglutinins and dermal sensitivity to *Brucella* antigens, without clinical manifestations of infection. A recent survey of 1,627 healthy donors of the blood bank at the university hospitals revealed an agglutinin titer of 1:20 or above in 12.2 percent as compared with a reported case rate of approximately .012 percent in this State. On the other hand, it is apparent that some individuals develop clinical illness and bacteremia after an occasional or repeated exposure to the organisms in milk.

A small group of patients who had no contact with animals and had not to their knowledge used any raw milk have been classified as "source unknown." Since contact with animals was definitely ruled out, it appears likely that these infections developed from the use of raw milk or milk products. It may be significant that one of these patients frequently ate raw hamburger.

Geographical Distribution

The geographical distribution of the proved cases of brucellosis in Minnesota according to county of residence is shown in figure 3. In 1948, 21 counties, operating under the area plan for control of Bang's disease, were accredited and 8 counties were in the process of accreditation as modified accredited Bang's disease-free areas. These 29 counties represent more than half of the area of Minnesota, but they contain only one-fifth of the cattle and approximately 23 percent of the population.

The direct influence on human health of control measures against bovine brucellosis is revealed by data from the 21 counties under the area plan. In 1939, before this program was well established, the 21 counties, which have subsequently become accredited, contributed 13 percent of the reported cases of human brucellosis in the State. In 1946, with bovine infection in these counties reduced to less than 1 percent, they represented only 3.7 percent of the human cases reported in the State (*72*). Analysis of the annual infection rate of human brucellosis, based on reported cases per 100,000 population, discloses that since 1937 there has been a fourfold increase in the rate from counties outside the area plan, whereas there has been no increase in the infection rate during the same period in the controlled area.

Distribution of 254 Culturally Proven Cases of Brucellosis
Minnesota 1945-48

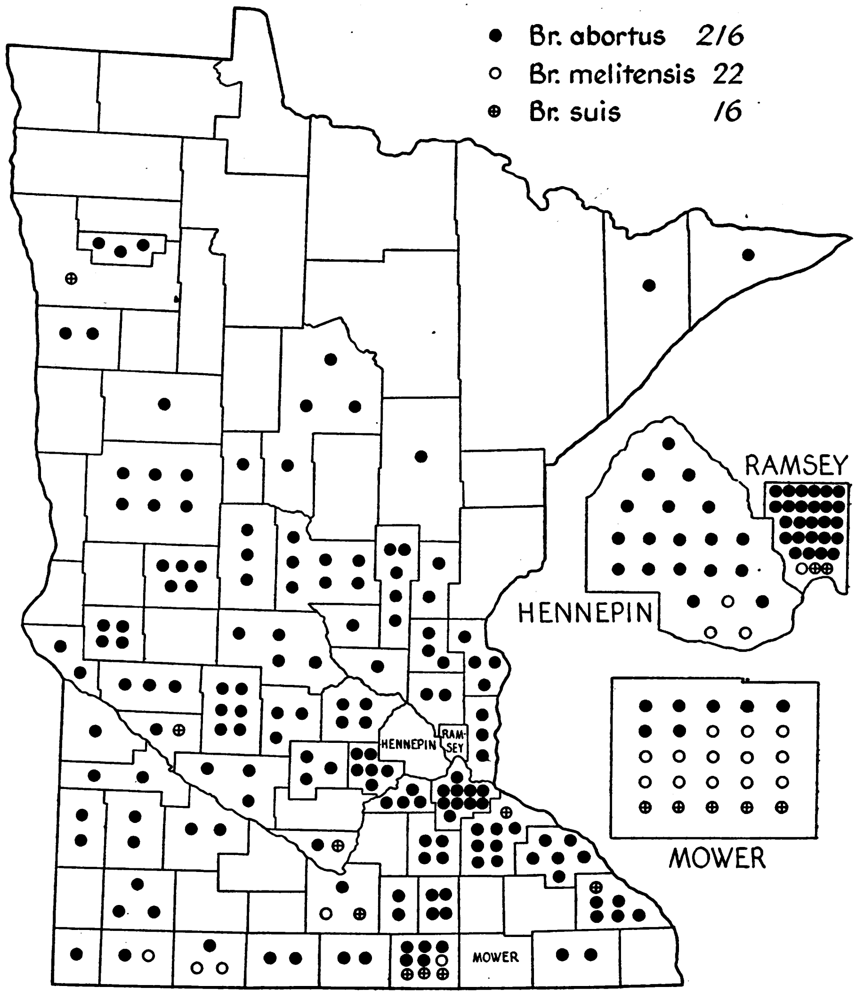

Figure 3.

Approximately 90 percent of the proved cases in this study were residents of nonarea counties. Counties containing the large meat-packing plants showed the greatest number of cases.

Seasonal Incidence

A marked variation in seasonal incidence was not observed in the proved cases in this study. March was most frequently listed as the month of onset. A relatively high rate of onset persisted through July, falling off in late summer and fall. Approximately 60 percent of the patients noted the onset of symptoms between March and August; 40 percent from September through February. Most previous data have shown the highest incidence to be in the summer quarter. In this study, the incidence in the spring quarter was slightly greater.

Laboratory Studies

The laboratory findings in the cases comprising this study are of considerable interest. *Br. abortus* was isolated from the spinal fluid of two patients with symptoms of meningo-encephalitis, whereas repeated blood cultures showed no growth. Cultures of the sternal bone marrow revealed *Br. abortus* in two patients; in one of these, blood cultures were sterile. In the remaining 264 cases, the final diagnosis was confirmed by isolation of *Brucella* from the blood.

The duration of symptoms at the time the organism was first isolated is summarized in table 6. Among the 251 cases from which

Table 6. *Duration of symptoms at time of first positive culture, based on 251 cases*

Species	Under 15 days	15–30 days	31–60 days	61–90 days	3–6 months	7–12 months	1–2 years	Total under 3 months	Total over 3 months
Brucella abortus	20	51	68	36	26	11	7	175	44
Brucella melitensis	4	9	2	3	1	0	0	18	1
Brucella suis	2	3	4	3	1	0	0	12	1
Total cases	26	63	74	42	28	11	7	205	4

this information was obtained, 205 had noticed symptoms for less than 3 months. Twenty-eight patients had been ill for 3 to 6 months, and seven had symptoms for a year or longer at the time of the first positive blood culture. In the majority of cases, only one or two blood samples were submitted, and the duration of symptoms before isolation of the organism represents the delay in sending the blood for examination. In several instances, however, one or more negative cultures were obtained before ultimate isolation.

Agglutinin Titers

The serum agglutinins against *Brucella* antigen were determined, with one exception, in every proved case. The agglutination test employed was a macroscopic tube method, using serum dilutions 1:20 through 1:5120. Five-tenths milliliter of antigen suspension supplied by the Bureau of Animal Industry, United States Department of Agriculture, was added to 0.5 milliliter of serum dilution and incubated at 37° C. for 16 to 18 hours followed by 1 hour at approximately 4° C.

The results of the agglutination tests are shown in figure 4. In the great majority, blood samples for culture and agglutinin determination were submitted at the same time or within a few days. In 10 cases, the interval was over 30 days. A single patient failed to show serum agglutinins at the time his blood culture was found to be positive. This patient was a 37-year-old veterinarian in whom two previous agglutinin determinations, 4 months and 7 months before, had revealed incomplete agglutination at a dilution of 1:160. Unfortunately further determinations were not obtained. Seven patients had atypical or incomplete agglutination in dilutions of 1:80 to 1:320.

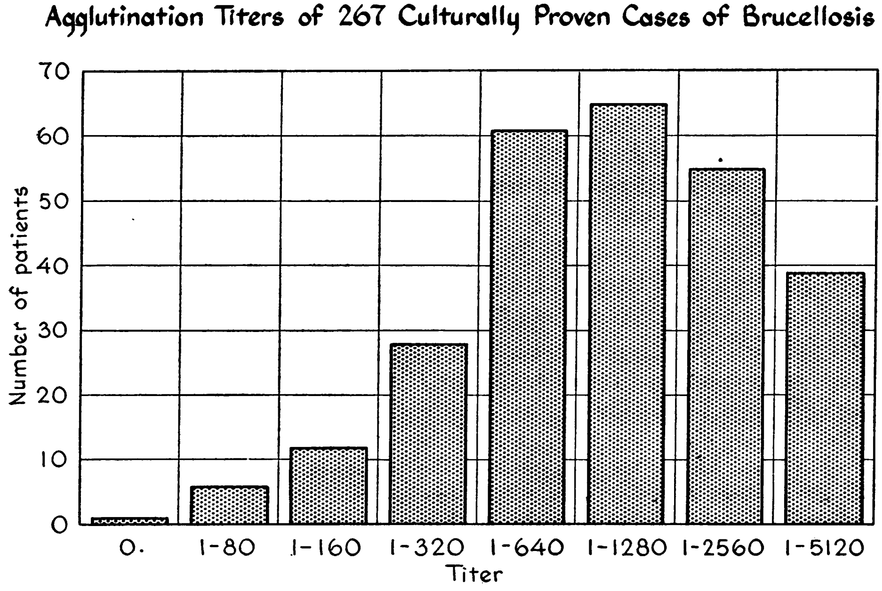

Figure 4.

The remaining 258 cases had complete agglutination in a titer of 1:80 or above. Over 90 percent had titers of 1:320 or above. It is of interest that 3 patients with partial agglutination and 3 with a titer of 1:80 developed complete agglutination at titers of 1:160 or above on subsequent tests carried out within 30 days. It appears probable that agglutinins would have been found in the case of the veterinarian cited above had subsequent studies been made.

The absence of agglutinins in the serum of only one patient in this series of 268 cases having positive cultures is not in agreement with the results of some workers who state that a significant number of patients having positive blood cultures have no demonstrable agglutinins. There may be several reasons for the discrepancy between the data presented here and the findings of others. Important considerations are the method used for carrying out the agglutination test and the type of *Brucella* antigens employed. In these laboratories, the macroscopic tube agglutination technique has proved to be more reliable than the rapid-slide method. Considerable variation in results has been obtained with different *Brucella* antigens. In an occasional patient, there is apparently a fluctuation in the titer of agglutinins, and repeated tests should be performed at appropriate intervals before stating that agglutinins are persistently absent. Less commonly, "blocking" antibodies in some sera may inhibit the clumping of antigen when the usual methods of performing the agglutination test are used (*73*). Occasionally, sera show the presence of a prozone phenomenon in which agglutination does not occur in the lower dilutions of sera.

The agglutination of organisms of the *Pasteurella* group by serum from patients with brucellosis has been reported by several workers (*74*, *75*), but the presence of a true common antigen shared by these organisms remains in doubt. Wilson (*76*) and others were unable to detect any antigenic relationship between them. In the present study, the agglutination test for *P. tularense* was carried out concurrently with the test for *Brucella* in 55 cases. Agglutinins for tularemia were positive in a titer of 1:40 or above in eight, or 14.5 percent, of the cases tested. In none of these eight cases was the agglutinin titer for *Brucella* under 1:640, and 5 had titers of 1:5120. Of these 5 patients, one had a titer of 1:320 for *P. tularense;* 3 had titers of 1:160; and one a titer of 1:80.

Summary and Conclusions

Available evidence reveals a sharp increase in both human and bovine brucellosis in Minnesota since the period before World War II. An analysis of the data on 268 human cases demonstrates that *Br. abortus* is the causative organism in about 85 percent of the cases. The remaining infections, divided almost equally between *Br. suis* and *Br. melitensis*, occur chiefly in meat-packing plant employees handling infected swine, though a few cases have occurred in farmers. Several cases of *Br. suis* infection transmitted through cattle are also cited.

Approximately half of all cases occur in individuals whose occupation involves contact with livestock or slaughtered animals, and nearly three-fourths have some contact with farm animals. Adult males between the ages of 20 and 55 comprise the bulk of this group. Raw milk provides the sole source of infection in about one-fourth of all cases. These cases are equally divided between males and females and are distributed more equally through all ages than are the cases with animal contact. These observations suggest that infection occurs more readily through the skin from handling infectious materials than by invasion through the gastro-intestinal tract following ingestion of contaminated milk.

Laboratory data on 267 cases indicates that the agglutinin test is a highly reliable diagnostic aid in active brucellosis. A negative agglutination test in the presence of a positive blood culture was found in a single case.

Prevention of the human disease is dependent upon eradication of the disease in animals. Pasteurization of all milk would prevent infection in many cases, but there appear to be few practical ways of protecting farmers, packing plant workers, veterinarians and others who work with infectious animals. Control measures for bovine brucellosis have proved effective, especially when conducted over a large area, but shortages of personnel have limited the extension of effective area control into the areas having the greatest number of cattle and highest rates of infection. The ultimate control of brucellosis and removal of the menace it holds for the health and economic welfare of large numbers of the population of agricultural States is an important public health problem.

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Relation of Human and Bovine Brucellosis in Minnesota

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Human cases of brucellosis have been reported in Minnesota since 1927, with an especially marked increase in the last decade (table 1). Bovine brucellosis has long been recognized in Minnesota and causes serious economic losses to livestock owners. Costs to the State for organized Bang's disease control measures from 1934 until August 1947 were $1,403,588.47, covering indemnity and operating expenses (*1*). Concurrent Federal expenditures for this same purpose were approximately the same.

Table 1. *Undulant fever, Minnesota, 1927–48*

Year	Cases	Deaths	Year	Cases	Deaths
1927	6	----------	1938	85	----------
1928	12	----------	1939	92	3
1929	42	----------	1940	137	3
1930	62	----------	1941	177	1
1931	72	2	1942	260	1
1932	62	3	1943	326	1
1933	72	----------	1944	395	----------
1934	102	1	1945	352	1
1935	114	3	1946	403	1
1936	77	2	1947	378	----------
1937	89	5	1948	303	----------

The Minnesota program for the control of bovine brucellosis has recognized that no one method has been effective under all conditions, but has emphasized the test and slaughter principle of removing sources of infection. Since 1934, the area plan and the certified herd plan of control have been based on this fundamental and, with proper sanitation, have been the main programs in Minnesota aimed at controlling bovine brucellosis.

This report analyzes the relation of human brucellosis to the area plan of controlling bovine brucellosis. The area plan is based upon counties, and requires 67 percent of the cattle owners in the county to sign a petition requesting the program before it is put into effect. Once adopted, the plan requires the blood-testing of all cattle in the county at State and Federal expense. Reactors disclosed must be sold for slaughter within 15 days (indemnity paid), or isolated from all other cattle until sold for slaughter (no indemnity if held over 15 days), or the entire herd, including infected animals, must be maintained in quarantine, with calf vaccination required (no indemnity).

*Chief, Section of Preventable Diseases, Minnesota Department of Health, Minneapolis; and Professor of Veterinary Medicine, University of Minnesota, University Farm, St. Paul, respectively.

Importations are restricted to cattle originating in a modified accredited Bang's disease free area, or in certified Bang's disease free herds, or to cattle which have been tested and found free of Bang's disease within 30 days prior to importation, and are quarantined for retest 30 to 60 days following importation. All herds with reactors are quarantined until retested and found negative. All infected herds are retested at intervals until they have passed three consecutive negative tests. Vaccination of calves and adults may be employed in various ways.

The first tests in Minnesota under the area plan were made in November 1939. By August 1, 1947, 21 counties in Minnesota were certified on the basis of the area control plan as modified accredited Bang's disease free. By definition, this means 5 percent or less of herds infected, and 1 percent or less of cattle infected. On May 1,

Figure 1. Minnesota counties in area plan of control, August 1947.

1949, seven additional counties were in the process of accreditation, and three counties were awaiting the initial tests (fig. 1). This represents a total of 31 of the 87 counties in the State supervised under the area plan and comprises slightly more than half of the area of the State, approximately one-third of the herds, and one-fourth of the cattle in the State. Of the 21 accredited counties, six were officially accredited in 1940, seven in 1941, five in 1942, two in 1943, and one in 1944.

This study compares the incidence of human brucellosis during the years 1937–47 in the group of 21 counties accredited under the area plan of control with similar figures in a second group of counties bordering the area counties, and a third group of counties in the remainder of the State. The counties comprising each of these three districts are shown in figure 2. Only the 21 accredited counties are included in district 1. The seven counties in process of accreditation

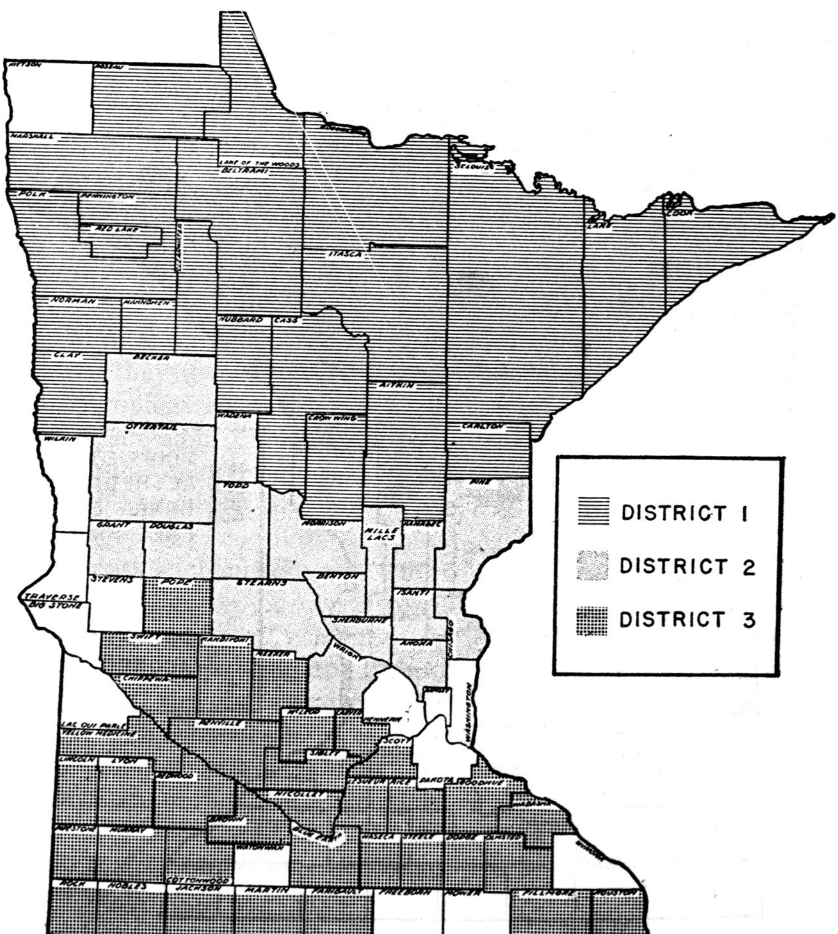

Figure 2. Minnesota counties comprising districts 1, 2, and 3.

are not included in any of the districts. The counties of district 2 were selected for their similarity to district 1 in all farm practices except that of area brucellosis control. District 3 includes the remainder of the State, with important exceptions. Hennepin and Ramsey Counties are not included because of the excessive influence on rates of human infection of the populations of these two counties, which include the two largest cities in the State, Minneapolis and St. Paul, with a combined population of 780,106 (1940 census). In addition, many packing plant cases live in these cities. Washington, Dakota, Winona, Mower, and Freeborn Counties are not included in district 3 because the meat packing plants located in each of these counties contribute a relatively large number of human cases which again would have an excessive influence on rates of infection related to the bovine control program.

Table 2. *Undulant fever in Minnesota, 1937–47, by districts*

District	Population (1940)	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947
1	553,762	10	11	11	8	5	12	14	16	15	17	16
2	394,150	10	9	7	25	17	35	62	81	65	100	75
3	713,404	35	30	42	64	75	96	126	164	134	156	141
		Rate per 100,000 population										
1		1.8	1.9	1.9	1.4	0.9	2.1	2.5	2.8	2.7	3.0	2.8
2		2.5	2.2	1.7	6.3	4.3	8.8	15.7	20.5	16.4	25.3	19.0
3		4.9	4.2	5.8	8.9	10.5	13.4	17.6	23.0	18.7	21.8	19.7

Table 2 indicates for each district the population (1940 census), the number of human cases of brucellosis reported to the State Health Department during 1937–1947, and the rate of cases per 100,000 population annually (*2*). These rates, charted in figure 3, show that no appreciable increase in human brucellosis occurred in district 1 in the period 1937–1947, but that rates of human infection in the other districts increased four- to ten-fold in the same period. The increase in human infection rate is almost identical in the counties of district 2, immediately adjoining district 1, and in the counties of the southern portion of the State. These increases appear to have begun in 1938 to 1939. Apparently, the factors responsible for the increase in human disease operated to the same relative degree in those counties bordering the area controlled counties and in the southern counties. This is important because it has previously been claimed that the northern counties differed to such an extent from the southern, in terms of concentration of cattle and emphasis on livestock farming, that this factor alone accounted for the lower incidence of human brucellosis in the north. It is true that the total number of cattle is far greater in the south district, but dairying with its attendant close

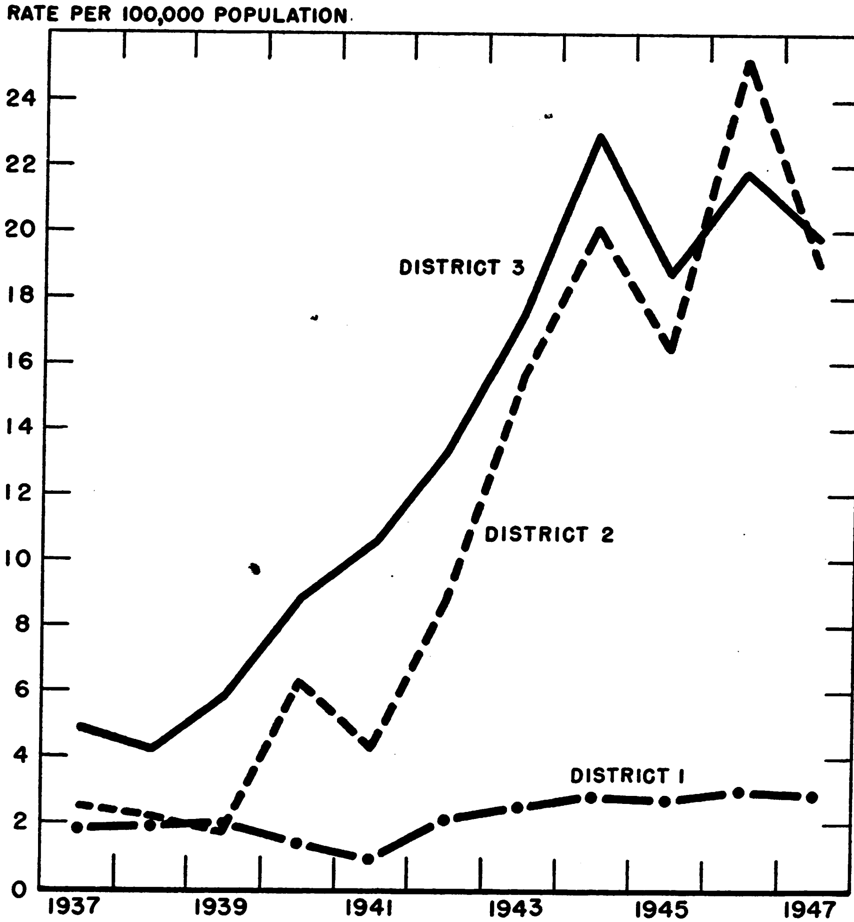

Figure 3. Undulant fever in Minnesota by districts, 1937–47.

exposure is very generally practiced in the north. It would seem that, as concerns the factors influencing human brucellosis at least, the northern counties, as typified by district 2, differ hardly at all from the southern counties. The marked difference in human infection rates in district 1 as compared to district 2 is therefore of greater interest. Farming practices and general conditions are fairly similar in the two districts except that bovine brucellosis has been controlled under the area plan in district 1 throughout this period of years, and not in district 2.

Another frequently mentioned explanation for the observed increase in human brucellosis in recent years has been the great increase in numbers of cattle and dairy products produced during the war years together with attendant difficulty in maintaining usual control measures. These factors have been felt to be of relatively greater importance in the southern counties of Minnesota than in the north. To

Table 3. *Cows and heifers, 2 years old and older, kept for milk in districts 1, 2 and 3, 1937–47*

District	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947
1	266, 500	271, 500	265, 500	270, 500	272, 500	280, 500	291, 500	309, 000	292, 500	264, 000	246, 700
2	411, 300	431, 500	440, 500	442, 500	453, 700	478, 500	488, 500	506, 500	503, 000	489, 560	482, 700
3	746, 500	761, 000	755, 500	765, 000	778, 500	793, 500	804, 500	817, 000	780, 000	751, 500	748, 900

Ratio between minimum and maximum year's cattle population:
District 1—1:1.25 (1947 and 1944).
District 2—1:1.23 (1937 and 1944).
District 3—1:1.09 (1937 and 1944).

examine this aspect, studies were made of the numbers of cows and heifers 2 years old and older kept for milk in each of districts 1, 2, and 3, for the years 1937–47. These figures are available as yearly estimates in the bulletins of the Minnesota State Department of Agriculture, Dairy and Food (*3*). The figures appear in table 3 and figure 4. In the graph the curves are superimposed by using different values on the vertical scale in order to illustrate the com-

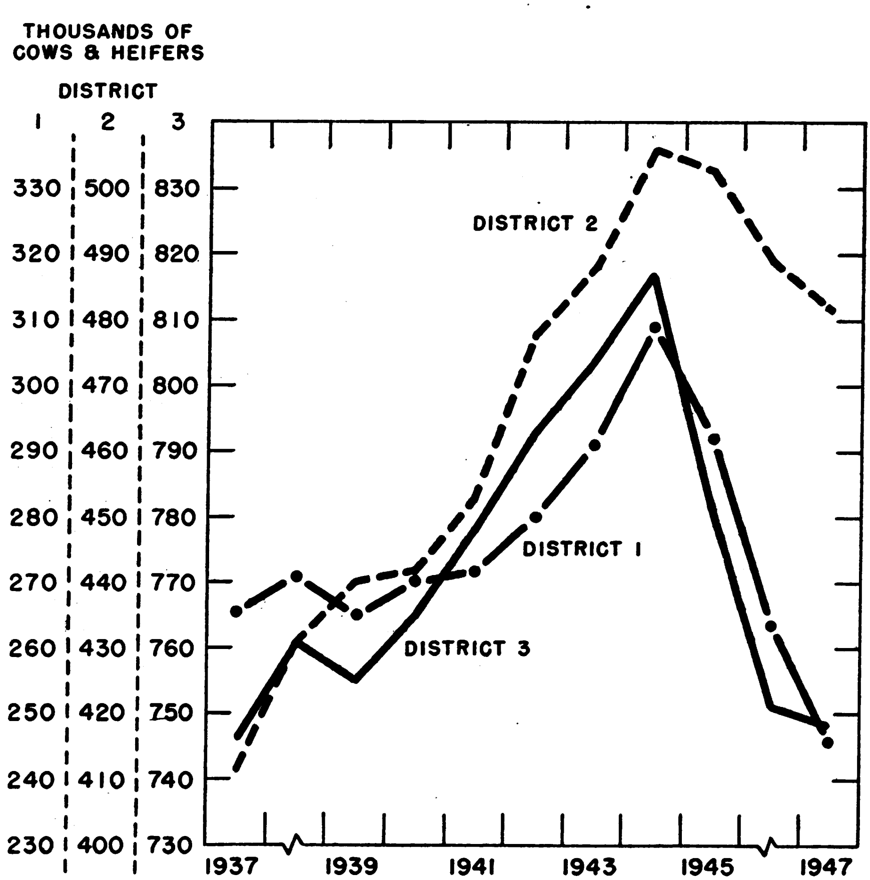

Figure 4. Number of cows and heifers 2 years old and older kept for milk in districts 1, 2, and 3, 1937–47.

parative trends. It is apparent that the same relative increase in livestock during the war years occurred in all districts; districts 1 and 3 are especially alike. This same trend is illustrated by comparing the ratio of the minimum annual cattle population with the maximum for each district during this period. Thus, in district 1 there is a ratio of 1 to 1.26 between the minimum of 1947 and the year of greatest cattle population, 1944. In district 2 this ratio is 1 to 1.23, and in district 3, the ratio is 1 to 1.09. We see that the relative increase in cattle concentration during the war period was greatest in the northern counties. If this was truly a factor in the increase in human brucellosis, it should have had the least effect in district 3, the southern counties. As the annual human infection rates for each district show, however, the opposite occurred.

Another experience confirming the value of the area control program is the comparison of rates of human infection for Watonwan County with the four bordering counties. Watonwan County in the southern part of the State has been in process of accreditation for nearly 8 years. Until recently it has not been possible by a regular program of testing to reduce bovine infection below the limits set by law for accreditation. This has been due in large measure to reinfection from surrounding counties, retention of infected animals in appreciable numbers of herds, and a high rate of change of tenants on farms. For the 5-year period 1943–47, inclusive, the average number of undulant fever cases reported per year per 100,000 population in Watonwan County was 4.3. The rates for the same period in the four bordering counties were: Cottonwood County, 14.9; Brown County, 11.7; Blue Earth County, 7.7; and Martin County, 24.3. Average for the four border counties was 13.8.

The practical difficulties of conducting an area control program, especially the procurement of sufficient trained personnel to blood-test large numbers of livestock, have limited its extension to the remainder of the State. However, new techniques for screening infected herds, based on herd milk or cream ring tests, may soon make area control work considerably easier. The present difficulties should not be advanced as valid reasons for discontinuing area control work and should not obscure the very real benefits to public health procured by the virtual elimination of bovine brucellosis in the controlled area.

Summary

1. During the period 1937–47, the reported rate of human brucellosis has increased 4 to 10 times in districts of Minnesota not under the area plan of bovine brucellosis control. No appreciable increase occurred in a district of 21 counties under the area plan.

2. During the same period, fluctuations in the cattle population occurred in similar proportions in all these districts.

3. The area plan of bovine brucellosis control in Minnesota appears to produce considerable benefit to the public's health.

REFERENCES

(1) Bang's Disease Control Program in Minnesota. Publication No. 2. November 1947, Minnesota Legislative Research Committee.
(2) Records of Minnesota Department of Health.
(3) Minnesota Agricultural Statistics, 1937–47. Minnesota Department of Agriculture, Dairy and Food.

Symposium on Brucellosis

A symposium on brucellosis will be held September 22 and 23, 1949, at the National Institutes of Health, Bethesda, Md. All sessions will meet in Wilson Hall, Administration Building. The veterinary, public health, clinical, bacteriological, and control aspects of the disease will be discussed. The Symposium is being sponsored by the Bureau of Animal Industry, the National Research Council, and the National Institutes of Health. Inquiries should be addressed to Dr. James T. Culbertson, Executive Secretary, Microbiology and Immunology Study Section, National Institutes of Health, Bethesda, Md.

List of Subjects and Speakers

1. The History of Brucellosis—Dr. Alice C. Evans, Chevy Chase, Md.
2. Brucellosis in Cattle—Dr. Chester Manthei, Animal Disease Station, Bureau of Animal Industry.
3. Brucellosis in Swine—Dr. L. M. Hutchings, Department of Veterinary Medicine, Purdue University.
4. Brucellosis in Animals and other than Cattle or Swine—Dr. W. L. Boyd, School of Veterinary Medicine, University of Minnesota.
5. The Control of Brucellosis in Animals Employing Test and Slaughter Methods—Dr. H. L. Gilman, Professor of Veterinary Research, Veterinary College, Cornell University.
6. The Control of Brucellosis in Animals by the Use of Vaccine—Dr. Jacob Traun, Department of Veterinary Science, University of California.
7. Federal Aspects of Control of Brucellosis in Domestic Animals—Dr. B. T. Simms, Chief, Bureau of Animal Industry, United States Department of Agriculture.
8. The Chemistry of Brucella Organisms—Dr. Robert Pennell, Research Division, Sharpe & Dohme, Inc.
9. Variation in the Genus Brucella—Dr. Werner Braun, Camp Detrick, Frederick, Md.
10. The Physiology of Brucella Organisms—Dr. B. H. Hoyer, Laboratory of Infectious Diseases, National Institutes of Health.

11. Immunology of Brucellosis—Dr. Sanford Elberg, Department of Bacteriology, University of California.
*12. Clinical Aspects of Brucellosis in Man—Dr. W. W. Spink, Department of Medicine, University of Minnesota.
*13. Therapy of Brucellosis in Man—Dr. Wesley Eisele, Department of Medicine, University of Chicago.
14. Bactericidal Tests in Brucellosis—Dr. M. R. Irwin, Department of Bacteriology, University of Wisconsin.
15. The Pathology and Pathogenesis of Brucellosis—Dr. A. I. Braudie, Department of Medicine, University of Minnesota.
16. The Epidemiology of Human Brucellosis—Dr. Carl Jordan, Director, Tarrant County, Health Department, Fort Worth, Tex.
17. Brucellosis in Canada—Representative, Animal Disease Research Institution, Department of Agriculture, Hull, Quebec, Canada.
18. Brucellosis in Puerto Rico—Dr. Pablo Morales-Otero, Santurce, P. R.
19. The Epidemiology of Brucellosis in Indiana—Dr. Raymond Fagan, School of Public Health, Harvard Medical School.
20. Brucellosis as Viewed by a Rural Practitioner—Dr. M. Anderson, Federalsburg, Md.
21. Brucellosis as an Industrial Problem—Dr. R. Newton, Director of Research, Swift & Co.
22. The Laboratory Diagnosis of Brucellosis—Dr. Norman McCullough, Surgeon, Public Health Service, Department of Medicine, University of Chicago.
23. Chemotherapy of Brucellosis in Experimental Animals—Dr. B. N. Carle, Laboratory of Infectious Diseases, National Institutes of Health.
24. A Summary of the Present Knowledge of Brucellosis—Dr. K. F. Meyer, Hooper Foundation, University of California.

(Printed programs will be available in advance of the meeting)

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* Papers for evening session, September 22.

INCIDENCE OF DISEASE

No health department, State or local, can effectively prevent or control disease without knowledge of when, where, and under what conditions cases are occurring

UNITED STATES

REPORTS FROM STATES FOR WEEK ENDED JULY 30, 1949

A total of 1,962 cases of poliomyelitis was reported, as compared with 1,444 last week (an increase of 36 percent), 1,213 for the corresponding week last year (representing an increase of 24 percent) and 740 for the 5-year (1944–48) median. Reports from the Middle Atlantic and North Central areas accounted for 501 of the net increase of 518 cases, as follows (last week's figures in parentheses): Middle Atlantic 244 (143), East North Central 489 (308), West North Central 509 (290). Current figures for 35 States reporting more than 7 cases each (7 of which showed a combined decline of 45 cases) showed a net increase of 547 cases. Figures for 23 States reporting more than 18 cases each are as follows (last week's figures in parentheses): *Increases*—Massachusetts 33 (31), New York 200 (116), New Jersey 27 (21), Ohio 65 (38), Illinois 145 (75), Michigan 149 (82), Wisconsin 47 (29), Minnesota 91 (79), Iowa 83 (45), Missouri 194 (73), South Dakota 32 (6), Kansas 68 (45), West Virginia 24 (21), Kentucky 47 (41), Tennessee 48 (40), Oklahoma 96 (80), Texas 95 (89), Idaho 30 (16), Colorado 21 (16), California 87 (80); *decreases*—Indiana 83 (84), Nebraska 23 (25), Arkansas 73 (91). A total of 7,375 cases has been reported since March 19 (average week of seasonal low incidence), as compared with 5,443 for the same period last year and a 5-year median of 2,797.

Two human cases of plague have been reported in New Mexico—one in Taos County with onset on July 29, and one in Sandoval County, date of onset not given.

Of 40 cases of Rocky Mountain spotted fever reported (last week 32, 5-year median 32), 31 occurred in 12 South Atlantic and South Central States, 3 in Colorado, and 1 each in New Jersey, Pennsylvania, Indiana, Iowa, Wyoming, and California.

Of 291 cases of typhoid and paratyphoid fever, California reported 184, of which 182 were paratyphoid fever.

Deaths recorded during the week in 94 large cities in the United States totaled 8,945, as compared with 8,233 last week, 8,338 and 8,504, respectively, for the corresponding weeks of 1948 and 1947, and a 3-year (1946–48) median of 8,338. The total for the year to date is 281,632, as compared with 283,670 for the corresponding period last year. Infant deaths during the week totaled 687, last week 577, same week last year 694, 3-year median 679. The cumulative figure is 19,429, same period last year 20,212.

Telegraphic case reports from State health officers for week ended July 30, 1949

(Leaders indicate that no cases were reported)

Division and State	Diphtheria	Encephalitis, infectious	Influenza	Measles	Meningitis, meningococcal	Pneumonia	Poliomyelitis	Rocky Mt. spotted fever	Scarlet fever	Smallpox	Tularemia	Typhoid and paratyphoid fever [e]	Whooping cough	Rabies in animals
NEW ENGLAND														
Maine	-----	-----	-----	14	-----	4	15	-----	3	-----	-----	3	8	-----
New Hampshire	-----	-----	-----	1	-----	-----	1	-----	1	-----	-----	-----	-----	-----
Vermont	-----	-----	-----	17	-----	-----	1	-----	-----	-----	-----	-----	1	-----
Massachusetts	8	-----	-----	60	3	-----	33	-----	11	-----	-----	4	92	-----
Rhode Island	-----	-----	-----	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Connecticut	2	-----	-----	70	-----	15	14	-----	2	-----	-----	3	33	-----
MIDDLE ATLANTIC														
New York	4	1	(e)	223	2	104	200	-----	[d] 20	-----	-----	7	185	13
New Jersey	-----	-----	-----	136	-----	43	27	1	7	-----	-----	2	71	(1)
Pennsylvania	2	-----	(e)	177	3	-----	17	1	9	-----	-----	6	111	1
EAST NORTH CENTRAL														
Ohio	1	-----	3	167	3	37	65	-----	21	-----	-----	11	111	7
Indiana	8	-----	-----	19	-----	-----	83	1	6	-----	-----	2	25	16
Illinois	3	3	-----	103	2	45	145	-----	8	-----	-----	4	127	1
Michigan [e]	1	2	-----	109	2	30	149	-----	24	-----	-----	2	105	1
Wisconsin	-----	-----	-----	214	-----	1	47	-----	2	-----	-----	-----	74	1
WEST NORTH CENTRAL														
Minnesota	1	-----	-----	7	-----	3	91	-----	2	-----	-----	-----	1	-----
Iowa	-----	2	-----	12	1	-----	83	1	1	-----	-----	-----	16	7
Missouri	2	-----	-----	6	3	12	194	-----	2	-----	5	4	7	-----
North Dakota	-----	-----	-----	9	-----	-----	18	-----	-----	-----	-----	-----	7	-----
South Dakota	-----	-----	-----	1	-----	1	32	-----	-----	-----	-----	-----	1	-----
Nebraska	-----	1	2	3	-----	-----	23	-----	1	-----	-----	-----	1	-----
Kansas	-----	-----	-----	4	-----	5	68	-----	4	-----	-----	1	8	-----
SOUTH ATLANTIC														
Delaware	-----	-----	-----	2	-----	-----	1	1	-----	-----	-----	-----	4	-----
Maryland [e]	2	-----	1	12	-----	15	7	4	1	-----	1	2	48	-----
District of Columbia	-----	-----	-----	19	-----	18	1	1	-----	-----	-----	1	2	-----
Virginia	2	-----	71	42	-----	16	13	9	9	-----	1	3	30	-----
West Virginia	2	-----	-----	9	2	-----	24	-----	4	-----	-----	2	25	-----
North Carolina	3	-----	-----	22	-----	-----	[1] 15	7	5	-----	-----	1	54	-----
South Carolina	4	-----	41	46	-----	22	8	1	2	-----	1	4	3	4
Georgia	6	-----	4	24	3	5	9	1	2	-----	1	10	4	5
Florida	4	-----	-----	12	1	5	7	-----	3	-----	1	-----	3	-----

EAST SOUTH CENTRAL														
Kentucky	4			6	2	24	47	1	5			6	30	14
Tennessee			21	13	2	27	48	3	5			2	38	
Alabama	6			12		10	16	1	2			2	12	5
Mississippi [a]	5			2	1	7	12						2	
WEST SOUTH CENTRAL														
Arkansas	2		13	9	1	12	[1] 73	1	3		10	3	33	4
Louisiana	1			1		14	6		3			6	3	
Oklahoma	1	1	7	5		13	96	1	1		3	3	20	2
Texas	12	1	198	65	11	189	95		8		1	8	110	11
MOUNTAIN														
Montana				43			1						2	
Idaho			3	20		5	30		[d] 3			2	2	
Wyoming	1			2			2	1						
Colorado		1	16	25	2	8	21	3	4			1	6	
New Mexico	2			23		11	5						2	
Arizona	1		16	16		5	8					2	1	1
Utah [a]				10	1	3	5						18	
Nevada							(1)							
PACIFIC														
Washington				40	1		16		7				10	
Oregon				17		15	3						34	
California	6		2	125	1	21	87	1	[d] 23			184	112	4
Total	96	12	398	1,977	47	745	1,962	40	214		24	291	1,592	
Median, 1944–48	164	11	571	2,058	75		740	32	589	4	23	146	2,428	
Year to date 30 weeks	4,048	311	75,867	583,848	2,193	53,240	[1] 8,298	347	57,759	39	727	1,911	33,410	
Median, 1944–48	6,688	275	190,197	543,412	4,274		3,060	292	85,067	259	571	2,076	57,712	
Seasonal low week ends	(27th) July 10		(30th) July 31	(35th) Sept. 4	(37th) Sept. 18		(11th) Mar. 19		(32d) Aug. 14	(35th) Sept. 4		(11th) Mar. 19	(39th) Oct. 2	
Since seasonal low week	280		112,137	636,241	3,037		7,374		80,457	49		1,451	43,443	
Median, 1943–48 [b]	479		334,488	578,358	5,778		2,797		123,638	342		1,601	85,841	

[a] Period ended earlier than Saturday.

[b] The median of the 5 preceding corresponding periods; for diphtheria, poliomyelitis and typhoid fever the corresponding periods are 1944–45 to 1948–49.

[c] New York City and Philadelphia only, respectively.

[d] Including cases reported as streptococcal infection and septic sore throat.

[e] Including paratyphoid fever; currently reported separately, as follows: Maine, 1; New York, 1; Ohio, 4; Illinois, 1; Maryland 1, Georgia, 3; Kentucky, 1; Tennessee, 1; Texas, 2; Colorado, 1; California, 182. Cases reported as Salmonella infection, not included in the table, were as follows: Massachusetts, 1; New York, 2.

Leprosy: California, 1.

[1] Corrections—Cases.—Poliomyelitis: Week ended July 16, Arkansas, 99 (instead of 101), week ended March 26, North Carolina, 1 (instead of 2); Rabies in animals: week ended June 18, New Jersey, 2 (instead of 1).

Alaska: Pneumonia, 1.

Hawaii Territory: Measles, 5.

CASES OF PLAGUE IN TAOS AND SANDOVAL COUNTIES, N. MEX.

Under date of August 3, 1949, a case of plague in a 10-year-old boy was reported in Cerro, Taos County, N. Mex., with onset on July 29. Later, a case was reported in a 37-year-old man, in Sandoval County. These are the first reports of plague in human beings in that State, but the infection was found in fleas from prairie dogs in Taos County in April of this year and in Sandoval County in June of this year and in fleas from grasshopper mice in May of 1943.

PLAGUE INFECTION IN KANSAS AND NEW MEXICO

Under date of July 29, plague infection was reported proved in specimens of fleas collected in Kansas and New Mexico, as follows:

KANSAS

Thomas County: In a pool of 6 fleas from 2 grasshopper mice, *Onychomys* sp. (reported as leucopus), trapped on July 12 from 5 to 7 miles north of Oakley on U. S. Highway 83, and in a pool of 341 fleas recovered July 13 by flagging abandoned burrows of prairie dogs, *Cynomys ludovicianus*, on a ranch 4 miles south thence 3 miles west, of Halford.

This is stated to be the first demonstration of plague infection in Thomas County, Kans.

NEW MEXICO

Rio Arriba County: In a pool of 78 fleas from 68 white-footed mice, *Peromyscus maniculatus*, trapped July 12 at a location 7 miles east of Dulce on State Highway 17.

DEATHS DURING WEEK ENDED JULY 23, 1949

[From the Weekly Mortality Index, issued by the National Office of Vital Statistics]

	Week ended July 23, 1949	Corresponding week, 1948
Data for 94 large cities of the United States:		
Total deaths	8,233	8,034
Median for 3 prior years	8,135	
Total deaths, first 29 weeks of year	272,687	275,332
Deaths under 1 year of age	577	629
Median for 3 prior years	671	
Deaths under 1 year of age, first 29 weeks of year	18,742	19,518
Data from industrial insurance companies:		
Policies in force	70,326,114	71,001,899
Number of death claims	12,217	10,658
Death claims per 1,000 policies in force, annual rate	9.1	7.8
Death claims per 1,000 policies, first 29 weeks of year, annual rate	9.4	9.8

FOREIGN REPORTS

CANADA

Provinces—Notifiable diseases—Week ended July 9, 1949.—During the week ended July 9, 1949, cases of certain notifiable diseases were reported by the Dominion Bureau of Statistics of Canada as follows:

Disease	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario	Manitoba	Saskatchewan	Alberta	British Columbia	Total
Chickenpox		22		59	122	13	65	59	107	447
Diphtheria				87				3		90
Dysentery, bacillary				4		3		1		8
German measles		4		13	10		12	72	2	113
Influenza		5	1			3	1			10
Measles		26	1	169	263	68	263	169	293	1,252
Meningitis, meningococcal		4				3		1		8
Mumps		20		27	100	9	4	5	47	212
Poliomyelitis				13	12		1		7	33
Scarlet fever		4		31	34		1	8	7	85
Tuberculosis (all forms)		4	22	81	12	9	18			146
Typhoid and paratyphoid fever	1			7					1	9
Undulant fever				3	1					4
Venereal diseases:										
Gonorrhea	6	8	8	127	59	36	26	33	45	348
Syphilis	5	6	14	60	41	13	1	5	7	152
Whooping cough		4		75	25	1	2	2	5	114

Newfoundland cases: Week ended July 2, 1949, chickenpox 1; measles 2; scarlet fever 1; whooping cough 2; gonorrhea 6; syphilis 4. Week ended July 9, 1949, scarlet fever 1; whooping cough 1; gonorrhea 5; syphilis 2.

NORWAY

Notifiable diseases—April 1949.—During the month of April 1949, cases of certain notifiable diseases were reported in Norway as follows:

Disease	Cases	Disease	Cases
Cerebrospinal meningitis	9	Measles	3,477
Diphtheria	22	Mumps	720
Dysentery, unspecified	1	Pneumonia (all forms)	2,413
Encephalitis, epidemic	2	Poliomyelitis	4
Erysipelas	321	Rheumatic fever	94
Gastroenteritis	2,262	Scabies	1,733
Gonorrhea	309	Scarlet fever	344
Hepatitis, epidemic	103	Syphilis	90
Impetigo contagiosa	1,968	Tuberculosis (all forms)	363
Influenza	2,970	Weil's disease	3
Laryngitis	10,174	Whooping cough	3,840
Malaria	2		

REPORTS OF CHOLERA, PLAGUE, SMALLPOX, TYPHUS FEVER, AND YELLOW FEVER RECEIVED DURING THE CURRENT WEEK

Note.—The following reports include only items of unusual incidence or of special interest and the occurrence of these diseases, except yellow fever, in localities which had not recently reported cases. All reports of yellow fever are published currently.

A table showing the accumulated figures for these diseases for the year to date is published in the PUBLIC HEALTH REPORTS for the last Friday in each month.

Cholera

Ceylon.—Trincomalee.—The 2 fatal suspected cases of cholera near Trincomalee, Ceylon, reported in PUBLIC HEALTH REPORTS, July 8, 1949, p. 883, were later confirmed. The Government of Ceylon declared Trincomalee free from cholera on June 14, 1949.

China—Amoy.—During the week ended July 9, 1949, 1 fatal suspected case of cholera was reported in Amoy, China.

Plague

Basutoland.—Plague has been reported in Basutoland as follows: Week ended April 16, 1949, 6 cases, 2 deaths, in Masern District; week ended April 23, 1949, 10 cases, 7 deaths, in Mohale's Hoek District; week ended May 14, 1949, 8 cases, 2 deaths, in Mafeting District.

Smallpox

Arabia—Aden.—During the week ended July 2, 1949, 3 cases of smallpox (imported) were reported in Aden, Arabia.

French Equatorial Africa.—During the period June 21–30, 1949, 42 cases of smallpox, with 16 deaths, were reported in French Equatorial Africa.

Netherlands Indies—Java—Cheribon.—For the week ended July 2, 1949, 51 cases were reported in Cheribon.

Typhus Fever

Afghanistan.—During the period April 25–May 24, 1949, 126 cases of typhus fever were reported in Afghanistan.

Yellow Fever

Gold Coast.—According to information dated July 21, 1949, two further suspected cases of yellow fever have been reported in the Gold Coast—one case at Akwatia and one case at Bawdua in Birim District. Of the four suspected cases reported in the Gold Coast in PUBLIC HEALTH REPORTS, August 12, 1949, p. 1020, three cases were stated to have been confirmed, one case shown to be negative, by laboratory examination.

Peru—Cuzco Department.—During the period January 1–31, 1949, one death from yellow fever was reported in Quincemil, Cuzco Department, Peru.

Refresher Courses in Laboratory Diagnosis

The Communicable Disease Center will offer refresher courses in laboratory diagnosis during the period September 12 to December 16, 1949. The following courses are planned:

Laboratory diagnosis of parasitic diseases—September 12 to October 21 (6 weeks).

Laboratory diagnosis of bacterial diseases, part 2, general bacteriology—October 31 to December 2 (5 weeks).

Laboratory diagnosis of rabies—November 14 to November 18 (1 week).

Advanced enteric bacteriology—December 5 to December 16 (2 weeks).

Applications and requests for information should be made to the Chief, Laboratory Division, Communicable Disease Center, 291 Peachtree Street NE., Atlanta, Ga.