Milk Sanitation, Communicable Disease, And Public Health

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MILK SANITATION began to exert an influence on communicable disease control and public health near the close of the 19th century, some years after the first outbreak of milkborne disease was recorded. With the development of the sciences of epidemiology and bacteriology, some of the early public health observers and investigators had begun to suspect, on the basis of their epidemiological findings, that milk might be a vehicle of infection. The isolation of the microbic causes of tuberculosis, typhoid fever, and Malta fever laid the basis of milk sanitation, which was to develop rapidly thereafter. The finding of the diphtheria, streptococcus, and staphylococcus organisms in milk emphasized the necessity for improving milk sanitation.

In spite of some resistance to the theory of epidemiology, within a few years of the isolation of many of these organisms it was widely accepted that tuberculosis, typhoid fever, diphtheria, and streptococcal diseases, including sore throat and scarlet fever, were often spread by contaminated milk.

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By 1900 the way was clear for the development of a scientific public health program along two major lines, namely, communicable disease control and sanitation. The health menace involved in the use of a milk supply could then be determined by precise bacteriological procedures, and the need for pasteurization could be proved. These bacteriological methods and knowledge could also be applied to other foods and to water, sewage, and the environment. The diagnosis of communicable diseases of man and animals could be confirmed. Sanitation now had a scientific basis for control of diseases which are spread by direct contact between man and man, and between man and animals.

In 1909, the Public Health Service issued Hygienic Laboratory Bulletin 56 (*1*), which listed 500 outbreaks of milkborne diseases in various parts of the world between 1857 and 1907. However, the 500 outbreaks represented only the few that had appeared in the literature. According to this report, the first recorded summary of epidemics of diseases spread by milk was prepared by Ernest Hart of England in 1881. Hart cited 50 epidemics of typhoid fever, 15 epidemics of scarlet fever, and 4 epidemics of diphtheria. The first cases of typhoid fever shown to be due to contaminated milk occurred at Penrith in Great Britain in 1857. A decade later the first published report of scarlet fever traced to an infected milk supply came from this same community. In 1877, diphtheria was added to the list of milkborne diseases when it was described in Surrey, England. Shortly thereafter there were many similar reports from Western Europe and North America.

In 1947, the Public Health Service published a list of epidemics of milkborne diseases which occurred between 1923 and 1945 (*2*). The 955 outbreaks during this period included 40,177 cases of sickness and 804 deaths caused by infected milk. There were 440 outbreaks of typhoid fever (7,449 cases), 27 of paratyphoid (1,063 cases), 202 of scarlet fever (19,190 cases), 18 of diphtheria (324 cases), 20 of dysentery (1,413 cases), 196 of food poisoning and gastroenteritis (9,780 cases), 34 of brucellosis (275 cases), and 18 outbreaks of miscellaneous diseases (683 cases).

The 34 reported brucellosis outbreaks were only a small fraction of the total that occurred during that period (*2*). It is conservatively estimated that one-third of the brucellosis cases were due to the ingestion of infectious milk or milk products and that the remainder were due to occupational exposure.

Even though the number of cases of bovine-type tuberculosis in man was never more than a small percentage of the total cases of tuberculosis, its elimination and control was one of the first major advances in the reduction of tuberculosis in man. Less than 30 years ago extrapulmonary tuberculosis of bovine origin was common in any American community. Today it is an unknown disease among children in the United States.

During the last decade of the period 1923–45, the case rate for many of the milkborne diseases dropped rapidly. Dauer (*3*) states that in 1952 comparatively few of the disease outbreaks reported were traced to milk or milk products.

Tuberculosis

From a world viewpoint, of the diseases of the cow which are transmissible to man, the most important economically and from the public health standpoint is tuberculosis. For many years most public health workers believed that bovine tuberculosis in man was a disease only of ingestion which produced an extrapulmonary form of disease. Sigurdsson (*4*), with the publication of a study made in rural Denmark, further supported the concept previously developed by Griffith (*5*) and Lange (*6*) that bovine-type tuberculosis was not only a disease of ingestion of infectious milk, but that it was spread by contact with infected animals which caused pulmonary disease in man. In his study, Sigurdsson typed the organism recovered from 566 cases of pulmonary tuberculosis in human beings, 165 of them from rural areas. Of the rural patients, 67 (40.6 percent) were infected with *Mycobacterium tuberculosis* bovine type, whereas only 15 (3.6 percent) of the urban patients had this type of infection.

Following up the source of infection of the rural cases, Sigurdsson found that 94 percent of those with bovine-type tuberculosis had been in contact with infected cattle within the past 2 years. Living *Myco. tuberculosis* organisms were found in the dust and dirt of the stables. The importance of the shedding of these organisms in bovine feces had been recognized for 50 years but only in connection with external contamination of milk and not as a source of pathogens for airborne infections. Sigurdsson's study is significant in that it demonstrated the danger to man from contact with infected animals, quite apart from the well-known and long-appreciated danger arising from the ingestion of infected milk. Meyer (*7*) has repeatedly pointed out that *Myco. tuberculosis* bovine type is just as virulent for man as the human type—perhaps even more so.

The importance of bovine tuberculosis as a disease of ingestion is illustrated by the following episodes. In 1948, Ohio Department of Agriculture veterinarians found tuberculosis reactors in a large herd of milking cows when they tested the herd by interdermal inoculation of tuberculin. The infected animals were sent to an abattoir where they were slaughtered and post-mortem examination was carried out. Most of the reactors showed gross lesions of tuberculosis. Investigation by the health authorities revealed that raw milk from this herd had been used in the community, including the local elementary school. A survey was made of the children in this school. The majority reacted positively to the Mantoux skin test, although many of them had been examined only 2 years before and most were negative at that time. A number of children, including one child on the farm where the infected cows were located, developed enlarged cervical lymph nodes.

Since the report of this episode, only 5 cases of bovine-type tuberculosis have been found in man in the United States. Three of the patients were elderly persons hospitalized for other reasons; the fourth was a young housewife who had spent her entire life in the city; and the fifth was a war bride who had been in the United States less than a year when the infection was discovered. She had the pulmonary type of the disease.

The influence of pasteurization on the prevalence of bovine-type tuberculosis in children was dramatically illustrated by Price (*8*) in Toronto, where pasteurization is compulsory. He demonstrated that no bovine tuberculosis was seen among persons in the city, whereas 15 percent of the tuberculosis in children living in the surrounding rural areas was of the bovine type. Blacklock (*9*) relates a similar experience in Glasgow, where the milk is also pasteurized. He states that the mortality from tuberculous meningitis of the bovine type is less than one-quarter of the rate in rural areas of the western counties from which Glasgow draws its milk supplies, and that the morbidity rate in "surgical tuberculosis" due to bovine infection is one-fifth of the rate in rural areas. Reilly (*10*) states that the decrease in tuberculosis of the bovine type in Northern Ireland must be due to the increased use of pasteurization. In 1939 only 7 percent of the milk was pasteurized. At the end of 1949, the amount of heat-treated and grade A milk had increased to 90 percent.

Human-Type Tuberculosis in Cattle

It is important to emphasize in public health practice that the control of bovine tuberculosis is also dependent on the prevention of contact between noninfected animals and persons with open infections. In the late 1920's, veterinarians in Finland called attention to the fact that persons with open lesions of pulmonary tuberculosis may spread their infection to cattle. In cattle, a high incidence of positive tuberculin reactors with few or no anatomical lesions occurs as a result of such exposure. Although the human type of tuberculosis does not become clinical in cattle, it introduces a factor of uncertainty into the interpretation of tuberculin tests.

During the past two decades, there have been reports of human-type tuberculosis infection of cattle in various parts of the world, usually among animals on farms where tuberculous employees were in contact with them. Human-type tuberculosis causes cattle to react to the tuberculin test but does not produce generalized disease. Unfortunately, man can be a carrier of bovine-type tubercle bacilli which can cause serious generalized tuberculosis outbreaks among cattle. Such carriers may account for some of the unexplained sporadic outbreaks of tuberculosis in cattle in disease-free herds. The control of tuberculosis in man is important to good animal health, and the elimination of the bovine type of tuberculosis infection in man is dependent upon eradication of the disease in animals.

First Organized Public Health Function

Recognition that human tuberculosis of the bovine type could be controlled by animal testing and milk pasteurization was the basis of many of the early milk sanitation programs, and these procedures were the first efforts by many communities to control tuberculosis in man. Shortly after the turn of the century, when raw milk was widely used, cities began promulgating milk ordinances that required the testing of all cows for tuberculosis. This led to the development of milk sanitation and inspection activities which were based on the certified milk program practices. In many instances the milk sanitation program was the first organized public health function. Shortly thereafter, some cities began organizing full-time health departments to control communicable disease and improve sanitation.

The first certified milk program in the United States was organized in 1893 in Essex County, N. J. This program was under the direction of the local medical society, which set certain standards as to the fat content and bacterial count of milk, the tuberculin testing of cows, and dairy sanitation. The actual amount of certified milk sold was small, but the certified dairies set an example and furnished a model for the dairy industry.

It was evident from the early experience of the certified milk commissions that clean milk could be obtained but that maintaining the safety and wholesomeness of the milk presented a different problem. Experience of the past 50 years has shown that the complete exclusion of diseased animals from dairy herds is an ideal seldom achieved. There are always some cows with mastitis or other infections of public health significance. The danger of milk contamination by human beings is always present. The organisms causing tuberculosis, septic sore throat, typhoid fever, diphtheria, scarlet fever, and other human disease can readily contaminate any milk supply. When this was realized, it became evident that the only safe milk is milk which is kept physically clean and then made safe by pasteurization.

With the rapid development of pasteurization, tuberculin testing of cows lagged in some areas of the United States, but during the decade 1920–30 many cities adopted tuberculosis testing even for milk that was to be pasteurized. The demand by the large cities that milk be from tuberculosis-free cows was one of the major reasons for the success of the national bovine tuberculosis eradication program in the United States.

Brucellosis

Brucellosis was first described on the island of Malta in 1861 and was called "Mediterranean fever" or "recurrent gastric fever." Its etiological agent was discovered by Bruce in 1887, but it was not until 1905 that it was reported as a milkborne disease, contracted by the ingestion of raw milk from goats infected with brucellosis. *Brucella abortus* was first described by Bang in 1898. In 1911, Schroeder and Cotton (*11*) suggested the possibility that *B. abortus* was pathogenic for man and urged the pasteurization of milk to prevent brucellosis. In 1918, Alice Evans reported that *Bacterium melitense* was difficult to distinguish from *Bacterium abortus* and that these two organisms might be related (*12*). Shortly thereafter, Meyer and Shaw proposed the generic term *Brucella* for *Micrococcus melitensis*, *Bacillus abortus*, and *Bacillus suis*. *Brucella suis* was not isolated from cows' milk until about 1929, and the first sizable epidemic occurred in Iowa soon after that date. In the 1930's, Taylor and his associates (*13*) reported outbreaks of brucellosis in southern France attributed to *Brucella melitensis* from cows' milk.

Brucellosis cases reported in the United States, 1927–52

Year	Number of cases	Year	Number of cases
1927	112	1940	3, 310
1928	669	1941	3, 484
1929	975	1942	3, 228
1930	1, 435	1943	3, 734
1931	1, 578	1944	4, 386
1932	1, 502	1945	4, 959
1933	1, 788	1946	5, 887
1934	2, 017	1947	6, 147
1935	2, 008	1948	4, 991
1936	2, 095	1949	4, 235
1937	2, 675	1950	3, 510
1938	4, 379	1951	3, 139
1939	3, 501	1952	3, 116

Beginning in 1927, when brucellosis was made a reportable disease in the United States, and continuing through 1947, there was a constant increase in reported cases, but after 1947 a precipitous decrease occurred (see table). From a study of brucellosis incidence in the United States in 1949, Steele and Emik (*14*) concluded that there were 10,709 estimated cases that year as compared to 4,235 cases officially reported. It is believed that the reporting of the disease is no more complete today than it was in 1949.

The greatest increase in brucellosis cases was reported between 1938 and 1947, a period which parallels the increase in domestic animal population and in the prevalence of animal brucellosis. During this same period, there was an expansion of the dairy industry, accompanied by an increased use of pasteurization, and the reported incidence of urban cases declined. Inasmuch as most of the urban cases were usually attributed to the ingestion of contaminated dairy products, it is quite apparent that pasteurization was making itself felt, although it should be remembered that the diagnostic criteria were at the same time becoming much more critical, a factor which would tend to eliminate some cases that previously would have been diagnosed as brucellosis.

After 1948, the use of pasteurized dairy products increased very rapidly in urban, rural, and resort areas. In addition, some areas were beginning to require that all fluid milk, whether to be pasteurized or to be distributed to the consumer in the raw state, be from herds that were free of brucellosis or were under some kind of control plan. In 1950, Illinois adopted requirements that by 1955 all grade A milk, whether pasteurized or not, must be from herds that are free of brucellosis. This action had a very stimulating effect on the neighboring States supplying Illinois with milk, and they immediately took steps to expand their State control programs. Since 1950, a number of other States and large cities have adopted similar requirements. The 1953 recommendations of the Public Health Service Milk Ordinance and Code (*15*) state that "within 3 years at the most after the adoption of this ordinance, all milk and milk products for pasteurization shall be from herds qualified by the State Livestock Sanitary Authority as following plan A or plan B approved by the Bureau of Animal Industry for the eradication of brucellosis." This action is very similar to the adoption of compulsory tuberculosis testing of milk cows 25 or 30 years ago. The effect will be far reaching, and within a decade the prevalance of bovine and human brucellosis will be reduced even further. It may be that in another decade, local milk regulations will require that all types of domestic animals on farms where milk is produced be free of brucellosis.

Q Fever

Q fever was first described in 1937 among abattoir workers in Brisbane, Australia. It was not considered an important disease until 1944, when outbreaks of atypical pneumonia among Allied and Axis troops in Italy and Greece were identified as Q fever. Since then it has been found in many countries of Europe, North Africa, and the Middle East, and in the United States. The principal sources of human infection are now known to be cattle, sheep, and goats. All of these animals, though apparently well, may excrete the organism in the feces, urine, milk, placenta, and fetal membranes. Man is probably infected either by inhaling dust contaminated with these excreta or by drinking contaminated milk. Bell and his associates (*16*) pointed out that the infection rates among persons who used raw milk were 10 times higher than the rates among those who used only pasteurized milk.

The organism of Q fever is remarkably hardy, and the usual temperature used in pasteurization of milk is not adequate for its complete destruction. It also resists many disinfectants and can persist in dust for long periods. In a study of 66 cases in England (*17*), it was found that 26 patients drank unpasteurized milk. A study of the milk supply of 20 of these revealed that *Coxiella burnetii* was present in the milk supplied to 10 patients, and that the milk received by 4 other patients was from herds with serologic evidence of Q fever. The remaining 6 patients received raw milk in which there was no evidence of infection. Many of the 26 persons who drank raw milk also lived on farms, which made it difficult to determine the cause of infection, but in 13 cases there was no obvious source of infection other than the milk supply.

To date, little progress has been made in the control or prevention of Q fever in endemic or enzootic areas. Some promising results on the use of vaccines in cattle are under study in the western part of the United States. Most communities that are concerned with Q fever as a public health problem turn to pasteurization as one means of control. As stated earlier, pasteurization may not always destroy all the organisms present, but it does render the milk less infective and is probably reducing the hazard to man of milk naturally infected with the Q fever organism. So far as can be determined at this time, there is no evidence that pasteurized milk has produced the disease in man. There are no recommended public health practices for dealing with the problem other than pasteurization, but with the continued research in North America and Europe new control techniques should evolve.

Other Animal Disease Problems

Anthrax, salmonellosis, streptococcal and staphylococcal mastitis, torulosis, and foot-and-mouth disease have all been described by various authors as milkborne diseases. In many instances, milk sanitation practices have influenced the course of control of these diseases.

With the possible exception of anthrax, most of these problems can be handled by good milk sanitation practices, including pasteurization. Fortunately, nature helps with the problem of anthrax by reducing or cutting off lactation. There are no reports of milkborne or meatborne anthrax in the United States, according to available information (*18*).

Salmonellosis infections in cattle are not rare, but the pasteurization of milk is an effective procedure in preventing transmission of the infection to man.

Streptococcal and staphylococcal mastitis in cows is a common problem throughout most of the world, but except for the strains of the organisms that are toxin producers, they do not threaten human health if milk is properly pasteurized. The toxins formed by some strains of streptococcus and staphylococcus will survive pasteurization. These toxins produce vomiting and prostration of short duration, but the dilution effect of the milk probably prevents most food poisoning of this type in man.

Torulosis, or cryptococcosis, is a rare infection in man and even more rare in cattle. A mycotic infection primarily of man, it involves the central nervous system. It also produces meningitis, skin lesions, and pneumonic symptoms. In cattle, the symptoms are many and varied, but the most important from a public health point of view is mastitis. Inasmuch as the source of the disease in man is unknown, the outbreaks reported in dairy herds have been studied as to their public health hazard. Thus far no human infection has been found associated with infected dairy herds. *Cryptococcus neoformans*, the causal agent, can readily be isolated from the milk of affected cows, and it is readily destroyed by pasteurization (*19*).

Foot-and-mouth disease causes infection in man only under rare circumstances. The early medical and public health literature carried many reports of its spread by milk, but in recent years no conclusive reports have appeared. If the virus should appear in milk, it would be destroyed by pasteurization.

Recent reports of the propagation of duck virus, Newcastle disease virus, and the virus of human influenza A, Puerto Rico 8 (PR8), for 2 weeks in the bovine mammary gland suggest many new potential problems (*20*). The bovine mammary gland, one of the best natural sites for the propagation of microbic agents, should be examined more critically with regard to its potential health importance.

Pasteurization

Pasteurization is one of the most far-reaching sanitary practices that has been introduced into public health. The process was first applied to wine by Pasteur less than 100 years ago to prevent souring and abnormal fermentation. The first practical application of heat treatment of milk was made by Franz von Soxhlet in 1886 when he systematized and popularized the idea of sterilizing the milk for use by infants. Germany and Denmark were the first countries to accept this principle. In America, the heat treatment of milk was described by Abraham Jacobi as early as 1873 and reiterated in 1889 after von Soxhlet published his recommendation. In 1895, a Danish pasteurizing machine was introduced into this country with the assistance of Nathan Straus. During the next decade, Rosenau, Parker, and Theobald Smith advanced the cause of pasteurization (*21*).

The pasteurization time and temperature necessary to insure a safe milk are calculated from the thermal death curve of the tubercle bacillus, *Myco. tuberculosis*. At the time pasteurization was introduced, this organism was considered to be the most resistant pathogen found in milk, and the temperature and time used in pasteurization ranged from 138° F. (59.1° C.) for 20 minutes to 160° F. (70.9° C.) for 20 seconds. Later, in controlled experiments, it was found that the size of the inoculum may cause some variation in the time and temperature necessary to destroy the bacterium. For many years, the recommended pasteurization temperature was 143° F. (61.4° C.) for 30 minutes or 161° F. (71.6° C.) for 15 seconds. In recent years these temperatures have been increased, especially as cream lines became less of a competitive factor and the practice of homogenization came into use. This upward revision has also been influenced by the observation of investigators in England and California that *C. burnetii* was not always destroyed by the above recommended pasteurization temperatures. Enright (*22*) has pointed out that *C. burnetii* will survive 143° F. when 10,000 infectious guinea pig doses are present in 1 cc. of milk. There is no survival when the temperature is raised to 145° F. (62.7° C.) for 30 minutes. If the inoculum is increased above the 10,000 guinea pig doses per 1 cc. of milk, it is possible that some *C. burnetii* organisms may survive 145° F. (62.7° C.). Inasmuch as no naturally infected milk has been found which contained more than 10,000 infectious guinea pig doses, the survival of high population is only of theoretical interest. Investigations are being pursued in regard to the survival time and temperature of other viruses and bacteria in milk.

As early as 1892, Sedgwick, Batchelder, and Strauss were advocating the adoption of general pasteurization (*21*), but about 50 years of public health education were required to win over its many opponents, including physicians and veterinarians. World War II had a sizable influence on the acceptance of pasteurization in rural communities in the United States. Even during and after the war, however, there were those who argued that pasteurization was inefficient, that it put a premium on carelessness in milk production, and that it would injure the food value of the milk. It is now estimated that more than 85 percent of the market fluid milk consumed in the United States is pasteurized. In many rural areas, the milk hauler who picks up raw milk also delivers bottled pasteurized milk.

The dramatic disappearance of Pott's disease (tuberculosis of the vertebrae), the precipitous drop in human brucellosis in urban populations, and the decline of other milkborne human diseases, including typhoid fever, summer diarrhea, diphtheria, and streptococcal infections, are self-evident. Pasteurization cannot take credit for all of the decline of those diseases among men, but it has been a sizable factor and in some cases the most important single public health practice. What the full extent of pasteurization may be is not readily answered. In an address before the 1953 meeting of the Southern Branch of the American Public Health Association, Dr. Haven Emerson stated:

"Surely the first and most important contribution to the prevention of acute rheumatic fever and the deaths from valvular heart disease was not the wonderful resource of chemical and antibiotic bacteriostats and bacteriacides, but that wide sweeping enforcement of pasteurization of milk which first made a frontal attack on streptococcal throat infections.

"Without claiming credit for what belongs to the alert and intensive practice of preventive pediatrics and to the general reduction in family outbreaks of hemolytic streptococcus, or claiming that the health officer is responsible for the much milder scarlet fever now common north and south, we must note the not accidental coincidence of a falling acute rheumatic fever death rate among persons under 30 years of age with the consistent enforcement of pasteurization of milk in our large urban populations.

"The better we do our basic sanitation and communicable disease control, the less will internists, cardiologists, and chest surgeons have to do with the heart complications of middle age and later."

It is probable that the overall influence of pasteurization will not be felt for years to come, until there is an opportunity to study a population that has used only pasteurized milk.

Sanitation Practices

To be effective, licensure must be followed up with adequate inspection, and inspection of the premises and practices of all licensed milk dealers and producers is the basis of any milk control program. However, the influence of routine inspection over many years is not readily ascertained. Most milk ordinances require that all milk-producing farms be visited by an inspector at least every 6 months, and once every 3 months or more often is recommended if changes and corrections are being made.

Milk plants and dairies should be checked regularly, and inspections should be made of the water supply, toilets, sewage and manure disposal, and cleanliness of barns, cowyard, milkhouse, utensils, animals, and man. Compliance with sanitary requirements for these items has probably been one of the most constructive steps in rural sanitation and has had a profound influence on public health in rural areas. This is attested to by the installation of running water, septic tanks, and water heaters in rural homes on dairy farms where some of these items are required.

Summary

One of the chief problems of milk sanitation is the zoonoses which are transmissible to man by contact with milk cows and through milk and milk products. The methods of prevention are: (*a*) animal disease control, (*b*) pasteurization, and (*c*) sanitation. To provide maximum protection of the public against the hazards of milkborne diseases, all of these must be fundamental requirements of any milk sanitation program.

The control of animal diseases can be described as biological control, whereas pasteurization and sanitation constitute physical control. Prevention of animal diseases has a far-reaching effect in that it also prevents occupational disease on the farm and in animal handling industries, increases milk production, and stabilizes animal industry. Pasteurization prevents the transmission of disease by means of milk, but it should not be the only line of protection. Sanitation, especially milk sanitation, is an essential part of any communicable disease control program. When these public health practices are successfully coordinated, a communicable disease control program which has depth as well as practicability results.

The promotion of milk sanitation and communicable disease control is a responsibility of all public health workers, but the veterinarian has the greatest responsibility because of his knowledge of the interrelation of the diseases of man and animal, and their economic and sociologic effects. The coordination of animal disease control and public health practices will result in a more efficient program that will advance public health and human welfare throughout the world.

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