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Epidemiology of Salmonellosis[1]

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Abstract

Salmonellosis affects more people and more animals than any other single disease. It is one of the most important public health and animal health problems. Salmonellosis may vary in severity from inapparent infections to acute disease which may be fatal to the very young, the old, or the debilitated individual. It is estimated that there are 2 million persons infected each year in the United States. During the past quarter of a century, except for typhoid fever, reported salmonella infections in man in the United States have increased from 504 in 1942 to 20,867 bacteriologically proven infections in 1965. It is impossible to determine how much of the marked increase in reported human salmonellosis is due to actual increase in incidence of infections and how much is due to improved reporting. Methodology has improved during this period, but it is believed that wider application of known methods and more thorough epidemiological investigation of outbreaks have contributed most information about the occurrence and distribution of salmonellae.

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Salmonellosis is a disease with many epidemiologic patterns affecting millions of people and animals. In 1966, 20,040 isolations of salmonella from man were reported. The number of unconfirmed cases is unknown, but some authorities estimate that the 20,040 cases represent only 1% to 2% of the true incidence of 1 to 2 million cases (USA 1968 estimated population, 200,000,000). The National Health Survey estimated in 1964 that 6 to 8 million persons suffer from diarrheal diseases annually, hence the estimate is not unrealistic. Another indication of the under-reporting is the Riverside, California waterborne salmonellosis epidemic in which only 200 cases were known to the health department. A door-to-door and telephone survey revealed that there were more than 16,000 cases in the community, or that only slightly more than 1% (1.25) had been reported. There has been a steady increase in the reported annual incidence since salmonellosis became a reportable disease in 1942. The disease has likewise increased in the animal population, however, there are now twice as many domestic animals and five times as much poultry as 25 years ago. The estimated animal population of the United States today is shown in Table I.

There are no good data for feral animals and birds, but millions of animals and billions of birds are susceptible to salmonellosis and can spread the disease. If the same estimated infection rate of 1% to 2% is applied to animals and birds, which would be low, the number of diseased animals and birds are many millions.

Any animal or bird, as well as man, may be a source of salmonella. How salmonellae are carried to man is not always clear, but there are many known paths and patterns of transmission of the disease. The attack rate in man is highest in children under 1 year of age, and in animals under 6 months of age. Fatalities are likewise high in the very young, although an exception is observed in elderly persons, who account for 70% of the deaths compared with less than 30% in the infant group. The case fatality rate for man is one per thousand.

The distribution of salmonella isolations from man is unusual inasmuch as 50% come from sporadic cases, 20% from family clusters, 15% from general outbreaks, and the remaining 10% from hospital or nursing-home associated cases. The above distribution would no doubt be altered by further investigation of sporadic cases, which could lead to family clusters and general out-breaks. This has been borne out by such simple questions as, "Who else is sick in the household, the building, or the neighborhood?" Inquiry should also be made as to the health of farm animals or pets, especially in rural areas. Reporting to the health department is essential if there is to be any follow-up by the public health specialists and staff. The *Salmonella typhimurium* epidemic of April 1967 in the northeastern states is an example of the importance of reporting. Only a few sporadic cases were reported to the New York City Health Department but they were sufficient to arouse the epidemiologists to request an investigation. The investigation revealed that there were possibly 10–12,000 human infections caused by a kosher egg-yolk dessert, in which the egg yolks were proven to be contaminated. The reporting of disease in man or animals is the first step in any investigation.

Man is an important source of salmonellae when he is suffering from an acute infection in a primitive environment where there are no means of disposing of contaminated feces, or in underdeveloped areas that are overburdened with seasonal population increases. There are a certain number of persons who recover from acute disease, as well as individuals with mild illness, who may excrete non-host adapted salmonellae for months or even years. Only a very small number become permanent carriers, as with typhoid fever. This may occur in children as well as adults. Domestic food animals, pets, feral animals, birds, reptiles and turtles may carry salmonellae for long periods and can be permanent carriers.

Although salmonellae may inhabit most species of warm-blooded and many cold-blooded animals, the major sources of human salmonellosis are livestock and poultry. The latter is most important when the numbers involved are considered as almost 3 billion individual birds and approximately 64 billion eggs marketed annually in the United States. The finding of salmonella in meat animals is not uncommon. A breakdown of 16,250 salmonella isolations from animals reveals that 6,775 (41%) were from turkeys, 5,806 (36%) from chickens, 1,841 (11%) from cattle, and 1,828 (11%) from swine. However, from these reports it is impossible to determine actual rates of infection in these animals, except to say that this high percentage of isolation from poultry can be attributed to the fact that there are more of them and they are examined bacteriologically for salmonella more often than any other species.

TABLE I

Farm animals	
Swine	110 million
Cattle	110 million
(Including 15 million milk cows)	
Sheep	30 million
Total	250 million
Poultry	
Broilers (meat)	2.5 billion
Hens (eggs)	267 million
Turkeys	116 million
Ducks & Geese	52 million
Total	2.935 billion
Recreational and pet animals	
Dogs	25 million
Cats	25 million
Horses	5 million
Birds	15 million
Total	70 million
Total animals	3.255 billion

During the past decade there have been many epidemics attributed to poultry and eggs. One of the largest was an outbreak of diarrhea caused by chicken salad contaminated with *Salmonella blockley.* Another was a Thanksgiving dinner in an institution in which diseased or contaminated turkeys were the vehicle. This past summer a local outbreak was traced to under-cooked turkey rolls served at a picnic. The epidemics traced to eggs, usually frozen or dried egg products, are many. Most egg products of this type are made from ungraded eggs, or the products are mishandled. Raw eggnogs can be dangerous when they are prepared from ungraded shell eggs or canned egg meats. Duck eggs are very often contaminated and should not be used for human food unless cooked at temperatures which kill salmonellae, i.e., 145 F for at least 5 min.

Pork has been seldom identified as a cause of salmonellosis, although salmonellae are frequently recovered from normal hogs on the farm, and in stockyards, sales barns and slaughterhouses. In finished products, sausages yield salmonellae much more frequently than carcass meat.

Beef has rarely been the cause of food-borne salmonellosis, but salmonellae infections are a common cause of calf morbidity and mortality and are now recognized as a feedlot problem. Dairy cattle are known to carry infection for as many as 5 months in their alimentary tract. The organisms can be recovered from the rumen, stomach, gall bladder, small and large intestine, and rectum. Milk products have been found infected and may be the cause of human disease outbreaks. Milk when infected is almost always contaminated from an external source, usually feces. Mastitis caused by salmonellae is extremely rare.

Horse meat is frequently contaminated with a wide variety of salmonella serotypes. A worldwide survey a decade ago revealed that most horsemeat was contaminated. Outbreaks of salmonellosis in sentry dogs and kennel animals have been traced to horse-meat pet food. Horses are known to be susceptible to salmonella infections, especially *Salmonella abortus equi,* formerly an important infection among thoroughbreds. In recent years *Salmonella typhimurium* has been a problem in mares and foals. The disease is so common in some areas that all horses are routinely checked at clinics for salmonellae. Fortunately, no human cases or outbreaks have been attributed to horse contact, but there is no doubt they could be the source of human infection.

Salmonella infections in pets have been found in a broad host range, including ponies, dogs, cats, birds and turtles. Different surveys of household dogs have revealed that as many as 15–20% may be infected with salmonellae. The rate in kennel dogs is usually higher. The disease has also been reported in racing animals, hunting dogs and guard dogs. Direct transmission of salmonella from dog to man, and man to dog has been observed. Cats are not as frequently reported to be infected as dogs, but this may be due to the lack of examination or surveys. They are susceptible and may be carriers of salmonellae for weeks and months. Pet chicks and ducklings, such as those given to children at Easter, are often infected and spread disease to their owners. Cage birds may also harbor salmonellae, but rarely have they been associated with human disease.

Snakes have been known to be susceptible to salmonellae for many years, but only in the past few years have turtles become a public health hazard. Since 1963 more than 200 instances have been reported where pet turtles were the source of human infection in households where they were kept. Many of the infections were in children who handled the turtles in the aquariums or played with them. Some cases occurred in infants, where the epidemiological history revealed that the turtle aquarium was washed in the kitchen sink or bathroom washbowl and the infant's formula was made up at the same site. Studies of domestic turtles reveal that they are often infected when hatched, indicating they become infected in the eggs. Likewise, wild turtles, including those imported from abroad, are often diseased.

Rats, mice, guinea pigs and other laboratory animals are all susceptible to infection and can be a source of disease among animal handlers and those who keep them as pets. Laboratory animals are infected usually by contaminated food, but human carriers can be a problem. Wild rodents reflect the environment in which they live—those in the wild have low rates of infection while those living in sewers and slums have a high rate. The infection rate ranges from less than 1% to 13% in rats, and the organism may survive for 148 days. Human infections attributed to rodents are usually traced to food contaminated by rodent feces.

Aside from direct transmission of salmonellae from animals and by food of animal origin, a number of other vehicles have been incriminated as carriers of the bacteria. These include supplemental or enriched foods which contain soya milk, dried yeasts, cereal powder and cottonseed meal. Other products found to be contaminated are coconut meat, chocolate, food coloring and some drugs. One of the most unusual was the discovery of *Salmonella cubana* in carmine dye, a substance used as a food and candy coloring, and as an intestinal marker in hospital patients who are under study. The contamination of the carmine dye, which is made from cochineal insects, is most unusual. Investigation of the sources of the cochineal insects in Peru, where they are collected from cactus plants and dried on the ground or streets, leads one to believe that animal and bird droppings are the source of contamination, but why only *Salmonella cubana,* a relatively rare serotype, should be the principal serotype isolated is an unanswered question. Other serotypes have subsequently been recovered from the dried insects.

The percentage of animal feeds found contaminated is large. Studies by universities and government agencies reveal that the rate of contamination varies between the source and kind of product. The lowest recovery of salmonellae, 1–3%, is in the cereals; it increases, in fishmeal to 4–7%, and then rises sharply to 30–40% in rendered animal products.

Control of salmonella disease in man and animals calls for production of specific pathogen-free feeds along with clean water supplies, proper disposal and treatment of sewage, elimination of ghetto and slum housing, and reduction of feral rodents, cats, dogs and birds. All are a part of this complex disease problem which reflects the human and animal population growth. Neither man nor animal can live in an expanding world that is grossly polluted. The problem of keeping the burgeoning world clean is a responsibility of all people, but leadership must come from the scientific community.

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