THE EPIDEMIOLOGY OF SALMONELLA INFECTIONS IN THE CITY OF NEW YORK*

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TYPHOID and paratyphoid fevers have long been reportable diseases, but illnesses caused by other salmonella were not subject to mandatory notification in the city of New York until the new Health Code was adopted in October 1959. The subsequent collection of cases affords the opportunity of reviewing the occurrence and distribution of salmonellosis during the three-year period, 1960 to 1962. In addition, representative outbreaks, especially in childhood populations, are described in further illustration of the natural history of the disease.

The disease agent is a member of the family Enterobacteriaceae which comprises the common enteric pathogens.[1] The genus *Salmonella* now includes over 800 species (often called serotypes) differentiated by their antigenic structure.[2] Of principal importance are the O (or somatic) and the H (or flagellar) antigens as determined by agglutination with specific antisera. The presence of Vi antigen is also an important attribute of some serotypes, including *S. typhi.*

Within some species, differentiation of isolated salmonella strains may be accomplished by means of typing with bacteriophages. This is of particular importance in epidemiological investigations in the field and its traditional usefulness has been in typhoid fever.[3] The following small outbreak is a recent example.

OUTBREAK NO. 1

Three boys residing in separate apartments in a housing project came down with typhoid fever within a few days of one another, thus suggesting a common source of infection. Other members of the three

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families gave no history or evidence of typhoid or the carrier state. The boys had no foods in common that were not consumed by the project's population of 4,500 persons. Health Department records showed that two adult female carriers lived in the project. Careful and repeated questioning of the carriers on the one hand, and of the patients and their families on the other, revealed no contact or exchange of food. Also on record was the finding that one of the carriers harbored organisms of phage type E_1, while the other was a carrier of type A. After typing of cultures from the patients showed that they too were type E_1, further investigation was in order. Inspection of water supply and plumbing had shown them to be in good condition. However, it was elicited that the three boys frequently played together on a grass strip adjoining the building in which the suspect carrier lived. On several occasions prior to the onset of their illness, the grass had been soaked by pumping sewage water onto it from the building basement, the latter having become flooded because of overflow through floor drains from the building's sanitary sewer. Thus the pathway of transmission from the carrier's water closet became clear.

Recently phage typing of *S. typhimurium*, the species most frequently encountered by far, has also been found useful.[4] Because of the ubiquitousness of this serotype, the procedure aids in distinguishing the strain responsible for a given chain of infection from adventitious strains present in the same population or the same environment.

Sources of Infection for Man

As far as is known all species are pathogenic for man, at least to the extent that those isolated from man have been associated with human disease.

Salmonella are widely distributed in nature, their natural habitat being the intestinal tract of vertebrates, especially mammals and birds. In warm-blooded animals they may also be found in other body tissues which, in the form of foodstuffs, may serve as vehicles of human infection. Meat, milk, and eggs, when ingested without adequate heating, may be infectious. That heat treatment must be sufficiently intense and prolonged was shown by Abramson *et al.*[5] They described cases due to *S. montevideo* which remained viable in dried-egg-yolk powder for infants despite the fact that flash heating was sufficient to desiccate and flocculate the liquid yolks. More frequent in our experience is the

contamination of perishable foodstuffs during preparation by an infected foodhandler or housewife. This usually implies the substrate of a comestible that is a suitable culture medium and, subsequently, refrigeration or cooking inadequate in degree or duration. This, of course, is the classical origin of the carrier-induced, common source outbreak of typhoid fever. Less often, meat or poultry may become contaminated by contact with infectious animal viscera during preparation. Also known is an unusual outbreak in which fish for smoking was washed in water contaminated with *S. typhimurium*.[6] As might be anticipated, the smoking process did not attain the thermal death point of the organism.

Water-borne infection is a traditional environmental mechanism in the genesis of typhoid fever. While other salmonella usually require the opportunity to multiply in nutrient material, *S. typhi* can elicit a clinical response with the fewer organisms that may be carried for relatively long distances in a water supply. It is evident that this route of infection is more common in rural than in urban areas. What is usually termed direct-contact transmission is rare under normal living conditions. Salmonellosis, unlike shigellosis, seems to spread from person to person only under circumstances of extremely poor sanitation and overcrowding. A conspicuous exception is the nursery for the newborn. In this hazardous environment, infection spreads quite readily from infant to infant, as shown by the following.

Outbreak No. 2

Five cases of diarrheal disease due to *S. newport* occurred in a nursery population of 25 infants. The ages at onset ranged from 2 to 13 days, three infants having become ill after discharge. The first infant became ill at two days of age, became progressively worse, and died at the age of four days. None of the nursery personnel manifested previous gastrointestinal disease and none yielded *S. newport* on stool examination, even though one carried *S. newington* and two were carriers of *S. taksony*. The preparation and bacteriologic examination of formulas and water were unexceptionable. Further investigation disclosed that the mother of the first case entered the hospital in labor and with frank diarrhea. She made no mention of the latter and, in the stress of delivery, it was overlooked. Hence fecal cultures were not taken in the hospital. When she was finally reexamined at home a week later, her

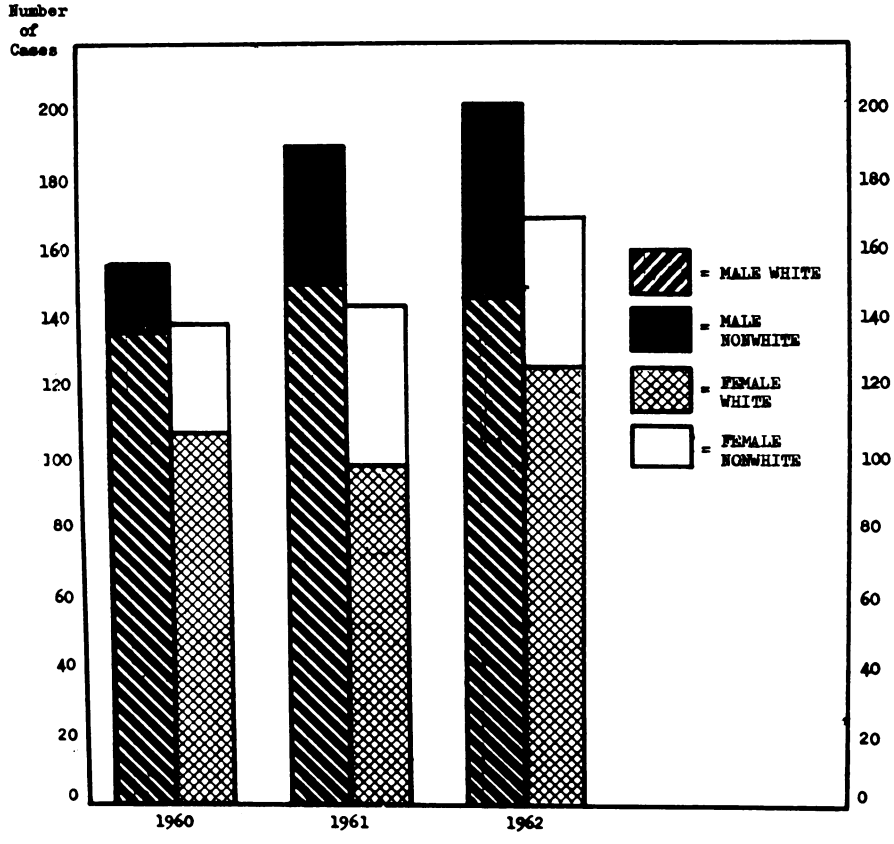

Fig. 1. Number of cases of salmonellosis reported annually in New York City—1960, 1961, 1962—by sex, white, and nonwhite.

symptoms having cleared, several stool cultures showed no pathogens. She was nevertheless considered as the source, since maternal infection seems to be the most common origin for nursery outbreaks. On occasion infected personnel have played a similar role.

Occurrence and Distribution of Salmonellosis in the City of New York

One thousand and three cases of salmonellosis in the City of New York were reported and subjected to epidemiologic investigation from 1960 to 1962 (Figure 1). The average annual morbidity rate during these three years was 4.3 per 100,000 population. Fifty-five per cent of the patients were male and 45 per cent female; 76 per cent were white and 24 per cent nonwhite, the latter frequency being consider-

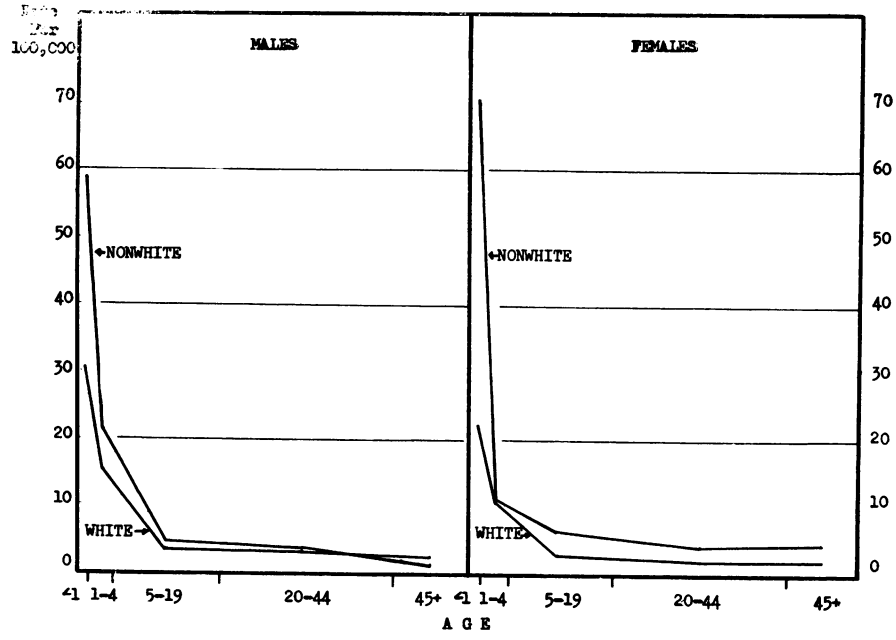

Fig. 2. Reported cases of salmonellosis, by sex, white, and nonwhite—average age-specific rates. New York City, 1960-1962.

ably greater than the proportion of nonwhites in the population.

Average annual age-specific morbidity rates for the categories mentioned (Figure 2) show that salmonellosis is predominantly a disease of infants: the attack rates decline sharply after the first year of life. It is during the first year that the increased vulnerability of the nonwhite is most apparent. The morbidity rate for nonwhite females under one year of age is 70.7 per 100,000, for nonwhite males 58.5. The corresponding rates for white infants are 22.2 and 30.1 respectively.

The geographic distribution of cases in the city of New York according to its 30 health districts is not uniform. The highest rate, 12.7 per 100,000, was in the Kips Bay-Yorkville health district, and this may be due in part to a concentration in this area of hospitals where cultures were taken more consistently. The next highest rates were in the East Harlem and Riverside districts, 8.2 and 8.1 respectively. In general the less heavily populated districts show low rates, with the lowest, 1.5 per 100,000, in Jamaica East. The borough of Richmond, despite its low population density, had an intermediate rate of 3.5 per 100,000. The seasonal distribution of cases (Figure 3) showed a rather

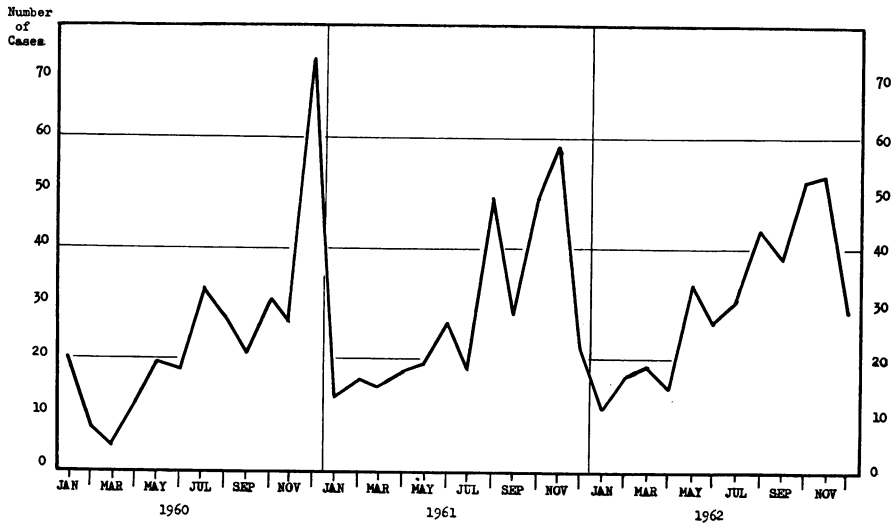

Fig. 3. Number of cases of salmonellosis by month of report—New York City, January 1960 to December 1962.

TABLE I—SALMONELLOSIS IN NEW YORK CITY, 1960-1962
Fatality per 100 Cases by Age

	Typhoid		*Other salmonelloses**	
Age (years)	*No.*	*%*	*No.*	*%*
Under 1	—	—	4	2.3
1-4	1	20.0	2	0.9
5-19	0	0.0	1	0.7
20-44	0	0.0	1	0.5
45 and over	3	15.8	9	5.0
Total	4	5.2	17	1.9

* Exclusive of paratyphoid A and B.

irregular fluctuation tending toward peak incidence in the late autumn or early winter with the low point in the spring.

Deaths from salmonellosis are shown in Table I. Four deaths occurred among 77 cases of typhoid fever, a case fatality ratio of 5.2 per cent. In 908 cases of other salmonelloses (18 of paratyphoid not included), there were 17 deaths, or 1.9 per cent. In the latter group a significantly higher mortality occurred among the 182 patients 45 years of age and over.

TABLE II—SALMONELLOSIS BY SEROTYPE IN NEW YORK CITY, 1960-1962

	No.		No.
S. typhimurium	404	*S. montevideo*	23
S. typhi	77	*S. oranienburg*	22
S. heidelberg	71	*S. derby*	17
S. saintpaul	48	*S. paratyphi B*	15
S. enteritidis	43	*S. muenchen*	13
S. newport	42	Other serotypes (31)	133
S. infantis	36	Undetermined types	31
S. blockley	28	Total cases	1003

TABLE III—SALMONELLA TYPHIMURIUM. AGE-SPECIFIC SECONDARY ATTACK RATES IN 45 HOUSEHOLDS

Age	*Population At Risk*	*No. of Cases*	*Secondary Attack Rate %*
Under 1	6	1	16.7
1-4	23	0	0.0
5-19	42	3	7.2
20-44	69	1	1.4
45 and over	14	4	28.6
Total	154	9	5.9

Forty-four salmonella serotypes were recovered from human sources (Table II). By far the most common was *S. typhimurium*, which comprised 40.3 per cent of all cases. *S. typhi* ranked second with 7.7 per cent. In addition to those shown in the table, other common types were *S. choleraesuis*, *S. panama*, *S. senftenberg*, *S. tennessee*, *S. thompson*, and *S. sandiego*, each isolated on 10 or 11 occasions. Fifteen serotypes were found only once or twice.

Secondary attack rates were computed for 45 households in which a primary case of *S. typhimurium* infection took place in 1960 (Table III). The data were obtained by epidemiologic follow-up of the affected households, including attempts to obtain at least three fecal cultures from each family member at risk. Sometimes the analysis was based upon only one or two cultures in addition to the investigation concerning illness. Among 154 persons at risk, there were nine with

TABLE IV—TYPHOID FEVER AT DAY CAMP—NEW YORK CITY RESIDENTS ONLY

	Number of Persons	*Number Ill**	*Per Cent Ill*
Campers	331	42	12.7
Staff	84**	9	10.7
Total	415	51	12.3

* Does not include 4 temporary carriers.
** Excluding hitherto unknown chronic carrier.

clinically demonstrable *S. typhimurium* infection, a secondary attack rate of 5.8 per cent. In addition, one person had an asymptomatic infection as shown by positive stool culture.

OUTBREAKS OF SALMONELLOSIS

In the foregoing, some outbreaks have been mentioned or briefly described by way of illustration. The following examples are presented to show other epidemiological aspects.

OUTBREAK NO. 3

An outbreak of typhoid fever in a children's day camp in Queens, a borough of the City of New York, came to our attention with a report from the Nassau County Health Department on August 12, 1952, that two children living in that county, who attended the day camp, had suspicious Widal reactions.[7] It was subsequently learned that *S. typhi* had been isolated from the blood culture of another child on the same date.[8] Preliminary investigation on the day of report disclosed that the number of camp absentees was not considered unusual and that the known diagnoses were of minor illnesses, with perhaps a disturbing number reported as "glandular fever." Fecal specimens were collected from all foodhandlers at that time. At the conclusion of the visit, the parents of known ill children in the city were notified by telephone and their respective physicians were then called. It became apparent that many children were having continued fever, the earliest with onset July 26. In view of the suggestive findings, the camp was ordered closed and full-scale investigation of the camp population and environmental sanitation was begun.

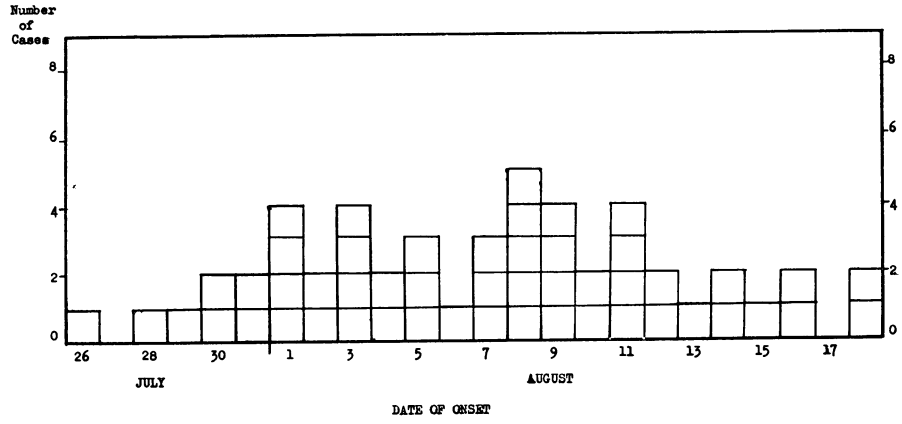

Fig. 4. Fifty-one cases of typhoid fever at day camp, by date of onset.

The total population was 482 persons. Included were 66 children residing in Nassau County among whom there were 21 cases of typhoid fever. The remainder were residents of the city of New York: 331 campers from 3 to 14 years of age and 85 employees. Forty-two cases occurred among campers and 9 in employees. The over-all attack rate for the city residents was 12.3 per cent (Table IV). The onset of the first of these cases was on July 26; the last two cases began on August 18 (Figure 4). One or more confirmatory laboratory data were eventually obtained in all 51 cases. The blood culture yielded *S. typhi* in 4; the stool culture in 42; and a typhoid O agglutination titer of 1:160 or higher was found in 41 cases.

Investigation of environmental factors, such as water supply, food sources, swimming pool, general sanitation, and fly infestation, disclosed no obvious hazard except for inadequacy of the space allocated for preparation and refrigeration of food. Luncheon was the only meal served at camp with the exception of the daily mid-afternoon snack of milk or other beverage in individual containers with crackers. Preparation for the luncheon was customarily begun early in the morning. The main dishes were usually hot foods that were kept at high heat until serving time. The last of the few exceptions was the luncheon of July 21, at which the main item was tuna fish salad. The latter was prepared at 6 A.M. on that date by the cook, who mixed the shredded canned fish, mayonnaise, and other ingredients by hand. The process was completed by 8 A.M., after which the prepared salad remained at room temperature until noon. In the meantime the fecal specimen of

the camp cook was found, two days after submission, to contain *S. typhi.* Her subsequent specimens were consistently positive and she was ultimately declared a chronic typhoid carrier.

After the camp was closed, further investigation was made by public health nurses of about 380 camp contacts ostensibly not affected. These contacts were questioned as to the occurrence of illness and, if ill, about the symptoms and the physician in attendance if any. Two stool specimens, one week apart, were obtained from each interviewee. Eleven of the 51 city clinical cases were discovered by these means and, in addition, four with asymptomatic infections ("temporary carriers"). Chloramphenicol was used in all cases, usually after other antibiotics, and quite late in the course of many of the illnesses. One of the cases developed a thrombocytopenia that was attributed to the drug. Many received chloramphenicol prophylactically, contrary to our advice.

Comment

This was the largest outbreak of typhoid fever encountered in the city of New York in recent years and it aroused widespread public interest and apprehensiveness. However, no secondary cases resulted.[9] The epidemic curve shown in Figure 4 illustrates significant aspects of the epidemiologic characteristics of this outbreak. The range of onset dates, within the span of the incubation period of typhoid fever, is indicative of a common source or point epidemic. The approximate date of exposure may be estimated by counting back two weeks from the modal onset date, August 8, i.e., to July 23. This is in reasonably close agreement with the date of the suspected meal, that of July 21. The validity of the latter is attested to by the onset, 5 days later, of the initial case and an interquartile range of onsets from 11 to 20 days from the same meal.

Outbreak No. 4

In a private boarding school, with 40 boys from 10 to 15 years of age, 29 pupils became ill with acute gastroenteritis and fever; among the 12 employees one house master, three kitchen employees and the house mother had similar illnesses. Ten of 12 fecal specimens submitted by patients showed *S. oranienburg.* Two boys who were hospitalized yielded the same organism on blood culture. Thirty-one of the 34 cases began on February 25 and 26. Later questioning of the cook

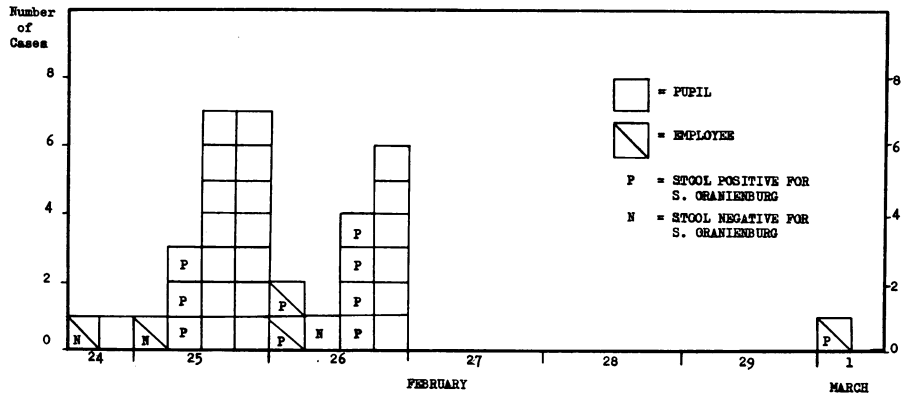

Fig. 5. *S. oranienburg* infection in private boarding school.

revealed in retrospect that she had had diarrhea during the early morning of February 24 (Figure 5). Stool specimens were not obtained from her until several days later and they proved negative. The earliest secondary case began on February 24, about 10 hours after breakfast. The house mother did not become ill until March 1, four days after the onset of the last prior case. She had cooking facilities in her own suite and ate little in the common dining room. However, she was active in caring for the sick boys in the early stages of their illness and it is believed she became ill as a result of exposure during her nursing activities.

Comment

This outbreak serves to contrast one caused by a "food poisoning salmonella" with that of typhoid fever above. With the shorter and less variable incubation period, 31 of the 34 cases began within a 2-day interval. Regarding the incubation period as 12 hours, with a usual range from 6 to 72 hours, the putative date of exposure is February 24. The cook who became ill prior to the breakfast of February 24 is regarded as the index case, although proof of her infection is lacking. Contamination of food prepared by her for breakfast or lunch on that date is assumed, although none of the foods was available for bacteriological examination. The house mother who became ill on March 1 was considered a tertiary case.

Outbreak No. 5

Beginning in March 1963, an increase in the number of isolations of *S. derby* was reported by our laboratories and by the Salmonella

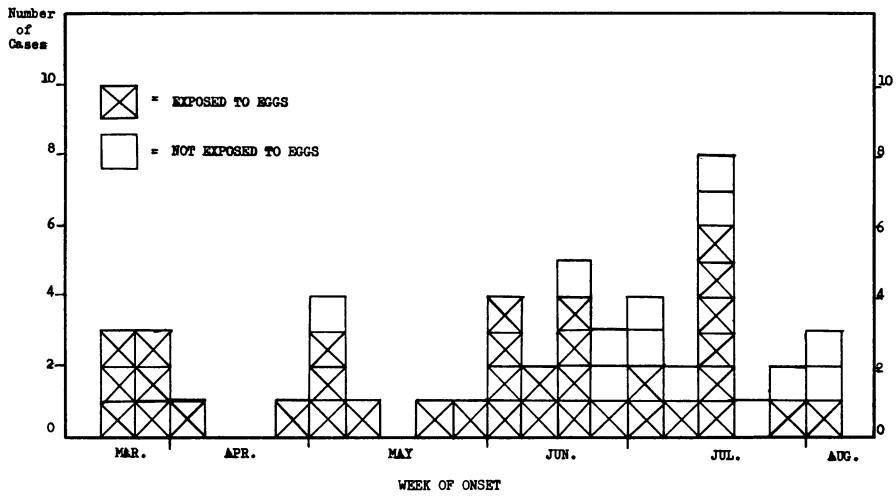

Fig. 6. *S. derby*—hospital-associated cases by week of onset, New York City, 1963.

Center at Beth Israel Hospital, New York, N. Y. At the same time word was received of an even more explosive outbreak in Philadelphia hospitals, and subsequently cases of *S. derby* infection were reported in hospital patients in several northeastern states. Among the earliest cases in New York were five in one hospital, which followed within a few days of gastrointestinal surgery. Operating rooms and personnel were not common to all cases, and attention centered upon articles of special diets; especially liquid, high-calorie foods, and contrast media for gastrointestinal x rays. It gradually became apparent that the use of raw eggs in liquid diets for postoperative patients and for other debilitated patients as well, was the principal factor in almost all early cases. Of 49 cases in several major New York hospitals, 36 were associated with that vehicle (Figure 6). Some later cases are believed to have become infected by other means. In addition, many carriers were found in patients and personnel. According to investigations reported by the United States Public Health Service, eggs from several hospitals in the city of New York and elsewhere were traced in part to two poultry farms where *S. derby* was recovered from an unusually large proportion of samples.[10]

Comment

This outbreak has aroused considerable interest because of its widespread distribution, unusual in hospital-associated salmonella infections.

Naturally infected eggs have frequently been responsible for extensive epidemics but these have usually resulted from the distribution of commercially dried products. Symptomatic cases were found predominantly in those under stress because of prior major surgery or because of debilitating primary disease for which hospitalization was required. Routine stool examination of hospital personnel disclosed asymptomatic infections among them.

Summary

The descriptive epidemiology of salmonellosis in the city of New York has been based upon 1003 cases investigated in the three-year period, 1960-1962. Forty-four serotypes were isolated. *S. typhimurium* was the most common, and *S. typhi* was next in frequency. The occurrence and distribution of the disease with regard to various epidemiologic factors have been presented. Several outbreaks, both within and without the three-year period, have been described as further illustrations of the natural history of salmonellosis in this metropolitan environment.

Acknowledgment

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