Epidemiological Report

DETECTION OF CARRIERS OF TYPHOID BACILLI BY SEWERAGE-TRACING SURVEILLANCE IN MATSUYAMA CITY

NOBUYUKI SHINOHARA, HIROSHI TANAKA, TSUYOSHI SAITO, JUNKO DEGUCHI, REIKO KONDO, KENJI SODA, and MASARU SUZUKI

Department of Microbiology, Ehime Prefectural Institute of Public Health, and *Matsuyama Health Center, Sanban-cho, Matsuyama, Ehime 790

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SUMMARY: Since periodical survey of the sewage entering the sewage-farm in Matsuyama City revealed a high incidence of Salmonella typhi of different phage types, attempts were made to trace the upstream reservoir. It was found that S. typhi was drained into a particular manhole at a distance of about 5 km from the sewage-farm. Two members of two families were found to be carriers. Further investigation detected other 25 carriers. The 27 carriers were all pupils of the same primary school. Ten of them showed mild symptoms such as fever, abdominal pain and diarrhea; the remaining 17 were asymptomatic. The phage type of 24 isolates was of Vi degraded approaching phage type A [degraded Vi(A)] and that of the other three was of type 53. The results coincided with those of the isolates from sewage.

The incidence of typhoid fever in Japan has greatly decreased after World War II. Since 1967, the annual number of patients has been 300 to 500 (Health and Welfare Statistics Association, 1980).

In Ehime Prefecture with a population of about 1,500,000, the cases and deaths of typhoid fever during 1946–1950 numbered 972 and 126, respectively. Cases numbered only six during 1964–1968. Since then, however, small outbreaks have occasionally been detected, implying the presence of asymptomatic carriers. We have continued surveillance for Salmonella typhi since 1974, by setting several sampling spots in the rivers and sewerage in Matsuyama, whose population was around 392,000 in 1976.

This communication describes an outbreak of typhoid infection among pupils found through the surveillance.
Survey of Sewage for S. typhi

Periodical examinations for S. typhi were performed from April to June, 1978, of sewage flowing into the sewage-farm (point P in Fig. 1) located at a distance of 1 km from the city center. The sewage comes from the central area of 958 ha inhabited with a population of 105,700. Having detected S. typhi frequently at point P, we proceeded surveillance upstream through points MS, CRA and R to the manhole at point F, 5 km distant from point P (Fig. 1). Examinations of 154 branching points of the sewerage were performed within two months. The main points are designated in acronyms and the minor points in numbers in Table I and Figs. 1 and 2. Sampling by the tampon method of Moore (1948) was made at 1-week intervals at 10–20 points at a time. Cotton tampons (40×40 mm) tied on thick thread were placed in sewage for 2 to 5 days. The sewage sample squeezed from the tampons (about 60 ml) was cultured in 400 ml of mannitol-selenite broth at 37 C. S. typhi was isolated on five plates each of Salmonella-Shigella and bismuth-sulfite agar. The isolates were examined on Triple-Suger-Iron, Sulfide-Indol-Motility, Voges-Proskauer semisolid agar, Simmons' citrate and lysin decarboxylase media. Serological identification was made with commercial monospecific antisera (Toshiba Kagaku Co., Tokyo). Vi-phage typing was carried out by the National Center for Enteric Phage Typing at National Institute of Health, Tokyo.
Fig. 2. Diagram of the drainage system of the 3 families in relation to the sewer manhole at point F in Fig. 1

62(F)–71(G): Points tested for S. typhi
M, N, K: Three families suspected for the source of contamination
← : Direction of sewer run.

TABLE I
Detection of Salmonella typhi from sewage taken from various points near the F manhole

<table>
<thead>
<tr>
<th>Point No.</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>62 (F)</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>66</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>67</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>68</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>69</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>70</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>71 (G)</td>
<td>.</td>
<td>.</td>
</tr>
</tbody>
</table>

+ positive; – negative; • not done; (F) F manhole.

The sewage at point F coming from about 100 houses through a narrow duct (30 cm in diameter) gave positive results for S. typhi. Further upstream at point G gave negative results. Examinations of the individual ducts draining
TABLE II
Bacteriological examinations of 11 members of the three families suspected as the possible contamination sources

<table>
<thead>
<tr>
<th>Member</th>
<th>Family</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>N</td>
<td>K</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Husband</td>
<td>Wife</td>
<td>1st Daughter</td>
<td>Husband</td>
<td>Wife</td>
<td>1st Daughter</td>
<td>Husband</td>
<td>Wife</td>
</tr>
<tr>
<td>Age (years)</td>
<td>51</td>
<td>51</td>
<td>16</td>
<td>39</td>
<td>39</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Remarks</td>
<td></td>
<td></td>
<td>moved in from Kobe City in September, 1975</td>
<td></td>
<td>moved in from Osaka City in April, 1971</td>
<td>moved in from Takamatsu City in October, 1978</td>
<td></td>
</tr>
</tbody>
</table>

* phage type 53; ** phage type degraded Vi (A).

from 10 houses located between points F and G allowed focusing the reservoir on three families, M, N, and K (Fig. 2, Table I).

Conn et al. (1972) reported a sporadic outbreak of typhoid fever in Edinburgh, in which the source of infection was found by upstream survey of the suspected sewerage and the river. In Japan, such outbreaks occurred in Hiroshima (Nakamori, Miyazaki and Nishio, 1976) and Kanagawa Prefectures (Nakatsuka et al., 1978).

During six years from July, 1974, the average positive rate of S. typhi in sewage in Matsuyama was as high as 24.3%. Upstream survey was attempted several times without detecting the source of infection and sporadic outbreaks of typhoid fever occurred during this period. Since 1978, we have noticed a change in the phage type of isolates from patients and sewage; degraded Vi(A) type appeared in place of the hitherto predominant type E1. Our attention to this change resulted in detection of the present outbreak.

Survey of Carriers and Contacts

All suspects, 11 members of the three families, who were draining their sewage into the manhole were interviewed and their fecal specimens examined. Two to 3 g of a fresh fecal specimen was cultured in 30 ml of mannitol-selenite broth. Isolation and identification of S. typhi were made as described before. Fecal examinations revealed two carriers in two families, N and K (Table II). The two families were each consisted of the parents and their two children, and had lived at the present places for 6 years and for 8 months. The two carriers, Y. N. and A. K. often met each other, however the isolates from Y. N. and A. K. were identified as phage type 53 and degraded Vi(A), respectively.
TABLE III

Fecal examination of school-children in D school for Salmonella typhi

<table>
<thead>
<tr>
<th>Date</th>
<th>Grade-Class*</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-5 4-5 5-2 5-3 5-4 5-5</td>
<td></td>
</tr>
<tr>
<td>June 28, 1978</td>
<td>1 0 1 6 9 5</td>
<td>1** Initial cases by the family study</td>
</tr>
<tr>
<td>July 3</td>
<td>0 0 8 3 1 0</td>
<td>3(2**) The fifth grade only was examined</td>
</tr>
<tr>
<td>7</td>
<td>0 1 6 1 2 0</td>
<td>All children, teachers and other employees were tested</td>
</tr>
<tr>
<td>11</td>
<td>0 1 6 1 2 0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1 1 6 9 5 5</td>
<td></td>
</tr>
</tbody>
</table>

Figures represent the number of persons giving positive results.
Symbols: • not done; * each grade consists of 5 classes. The average number of pupils in each class is 40. ** phage type 53.

This denied the possibility of contact infection between them. All isolates at point F were of Vi(A), indicating that was the main excreter.

The two carriers both belonged to D Primary School, one in class 5 of the fifth grade and the other in class 5 of the first grade. Then, 1,310 people belonging to D School (1,261 pupils in 30 different classes, 43 staffs, and 6 meal servers) and those who had contact with the carriers found later were examined. The total number of persons examined was 1,922.

A total of 27 carriers including the above two were found among 1,261 pupils (2.14%); one in the first grade, another in the fourth grade, and the other 25 in the fifth grade (including ) (Table III). Most carriers were in the fifth grade, comprising 188 pupils. They were distributed in four classes, 2 through 5. The only carrier in the first grade had an elder brother in the fifth grade. Although his feces gave a negative bacteriological results, his serum gave a Vi titer higher than 1:160, suggesting contact infection from him to his younger sister. The positive Widal reaction should carefully be evaluated from his clinical course and history of vaccination (Nakamizo, Wada and Shimojo, 1958; Suzuki, 1973). He never had received typhoid vaccine; the high anti-Vi titer suggested actual infection. Because the carrier, in the fourth grade and one in the fifth grade had engaged in the same extracurricular activity, the former may have been infected by contact with the latter. No carrier was found among pupils in the second, third or sixth grade. None of the teachers or meal servers gave positive isolates. The isolates from 24 carriers belonged to phage type degraded Vi(A) and those from the other three to phage type 53. This type disappeared suddenly at point CRA and its origin is unknown.

Clinical Observation of Carriers

All excreters of S. typhi were isolated in a detention hospital. During 3 months before admission, four carriers (14.8%) had received some medical
treatment on diarrhea, abdominal pain and fever, other six (22.2%) had received no treatment because their symptoms were mild and the other 17 (63.0%) none either as they were completely symptomless. None of them nor their families had previous history of typhoid fever. There were more severe cases of similar ages in previous outbreaks (Shinohara et al., 1972). The percentages of pupils who visited the medical room of the school during this period were 2.1, 2.6, 4.1, 2.3, 13.3 and 4.4% for the first through the sixth grades, respectively. None of the carrier pupils was absent from school for a long period.

The 27 carriers when detected were apparently healthy. This may have been due to (1) they were in an early stage of infection, (2) attacked by a small dose of the bacilli, or (3) the bacilli were of low virulence. None of them had received typhoid vaccine. The average duration of hospitalization was 19 days. They were discharged when three consecutive bacteriological tests made every other day on their feces after antibiotic therapy gave negative results. After discharge, monthly bacteriological tests were continued for 6 months. None of them gave positive result. Negative results were also obtained with the families of the carriers and 97 contacts.

Paired sera taken from 23 of the 27 carriers at admission and discharge were examined by Widal test for anti-Vi and anti-O titers (Fig. 3). Anti-Vi titers of 1:20 and higher and anti-O titers of 1:160 and higher were regarded as positive. At admission, sera from six pupils (26%) showed positive results in anti-Vi, and none in anti-O. At discharge, the number of positives in anti-Vi was the same. A little rise in anti-Vi titer was seen in other two cases though not regarded as positive. Similarly, anti-O titers rose in 10 cases, and one of them was regarded as positive (Fig. 3). Serum samples taken from 130 of 163 noncarriers in the fifth grade were also assayed. Four samples (3%) were positive in anti-Vi, and none in anti-O.
**Search for the Source and Route of Infection in D Primary School**

Pupils are provided with meals in D Primary School. Therefore, retrospective investigation was made for previous 3 months on menus, the way of serving, sanitation of flatwares, and of the people engaged in meal services. Tap water was also examined by use of LiCl as tracer (Takechi et al., 1981).

Since many carriers were found in the fifth grade, investigation by questionnaire was made among pupils in this grade on their extracurricular activities including eating and drinking. Six weeks before, the pupils of the fifth grade went on a school excursion to Ishite Dam, about 5 km distant from school, where they cooked rice in canteens. Other foodstuffs were brought from their own homes. Four of the 25 carriers were absent from it. Three of the five classes of the fifth grade had another cooking practice 1–3 weeks before, but the other two did not. Occurrence of carriers was not correlated with these cooking practices.

The health status of the meal servers and hygienic conditions of the lunch room, the flatwares, and food storage was all well. Most carriers drank tap water at school. City water is first put into the underground reservoir, pumped up to two towers on top of the school building, and brought by gravity to each tap in drinking and washing places and toilets. The sewage from 11 toilets is drained into the city sewerage through a duct separate from general waste water.

Most carriers used water from only one of the two towers. The water was shown to contain residual chlorine of less than 0.3 ppm; the water from the other tower contained 0.7–1.0 ppm chlorine. Such a low value suggested a possible contamination with organic substance(s). The leakage test turned out to be negative and contamination with sewage was ruled out. The low residual chlorine value may have been caused by spontaneous degradation due to infrequent use of the tower. The pupils of the school live in 16 different areas and those living in the same area go to school together for safety. Careful interview with all carriers, however, failed to correlate them with particular residential areas or any extracurricular activity.

Despite such an early detection of many carriers, the source or route of infection was not determined. In this outbreak, *S. typhi* cultures of two phage types were detected. Type 53 was detected in early stages and disappeared in later stages. This suggests that infection with this type preceded that with the other type and that the former was so mild that no pupil developed clinical symptoms.

The purpose of our periodic examination of the sewerage is to predict outbreaks of typhoid fever and to detect the source of infection as early as possible. In this regard, our efforts may have contributed to confine the present outbreak to school pupils only, otherwise it might have spread in a larger scale. For the following year after this outbreak, *S. typhi* was not detected in sewage samples.
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REFERENCES


