Epidemiol. Infect. (1992), **108**, 221–229
Printed in Great Britain

Epidemiology and control of an outbreak of typhoid in a psychiatric institution

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(*Accepted 14 November 1991*)

SUMMARY

An outbreak of typhoid caused by *Salmonella typhi* of the same Vi-phage type (D1) and of the same antibiogram was reported in a large psychiatric institution in Singapore. A total of 95 (4·8%) of the 1965 inmates were infected, 47 with symptoms and 48 asymptomatic. Transmission was through close person-to-person contact and not through contaminated food or water. The source of infection could not be established. The outbreak was brought under control by maintaining a high standard of environmental sanitation, active search for fever and diarrhoeal cases, identification of asymptomatic cases by rectal swabbing, and isolation of those found to be infected. Mass immunization with two doses of heat-phenol inactivated typhoid vaccine was also carried out concurrently. The vaccine was found to have an efficacy of 65·8% in preventing clinical illness.

INTRODUCTION

Typhoid is endemic in Singapore, but it has been brought under control primarily as the result of vast improvements in environmental sanitation and standards of personal hygiene [1]. The incidence rate of indigenous typhoid fever dropped fivefold from 5·9 per 100000 in 1980 to 1·2 per 100000 in 1989, while the percentage of imported cases rose from 32% in 1980 to 72% in 1989. The epidemiology of typhoid is similar to that of the industrialized countries in that the majority of the cases were imported [2, 3]. In 1990, an outbreak occurred in a psychiatric hospital. We describe our experience in the prevention and control of this outbreak.

The hospital

This is a large psychiatric institution with a population of 1120 male and 845 female patients and a staff of 936. It provided treatment and rehabilitative facilities for long-stay, short-stay, chronic sick and child psychiatric patients. There were 20 male wards, 20 female wards, 1 ward for the chronic sick and 2 wards for child psychiatric patients (Fig. 1). The premises were well maintained and provided with modern sanitary facilities. Meals were prepared daily in the

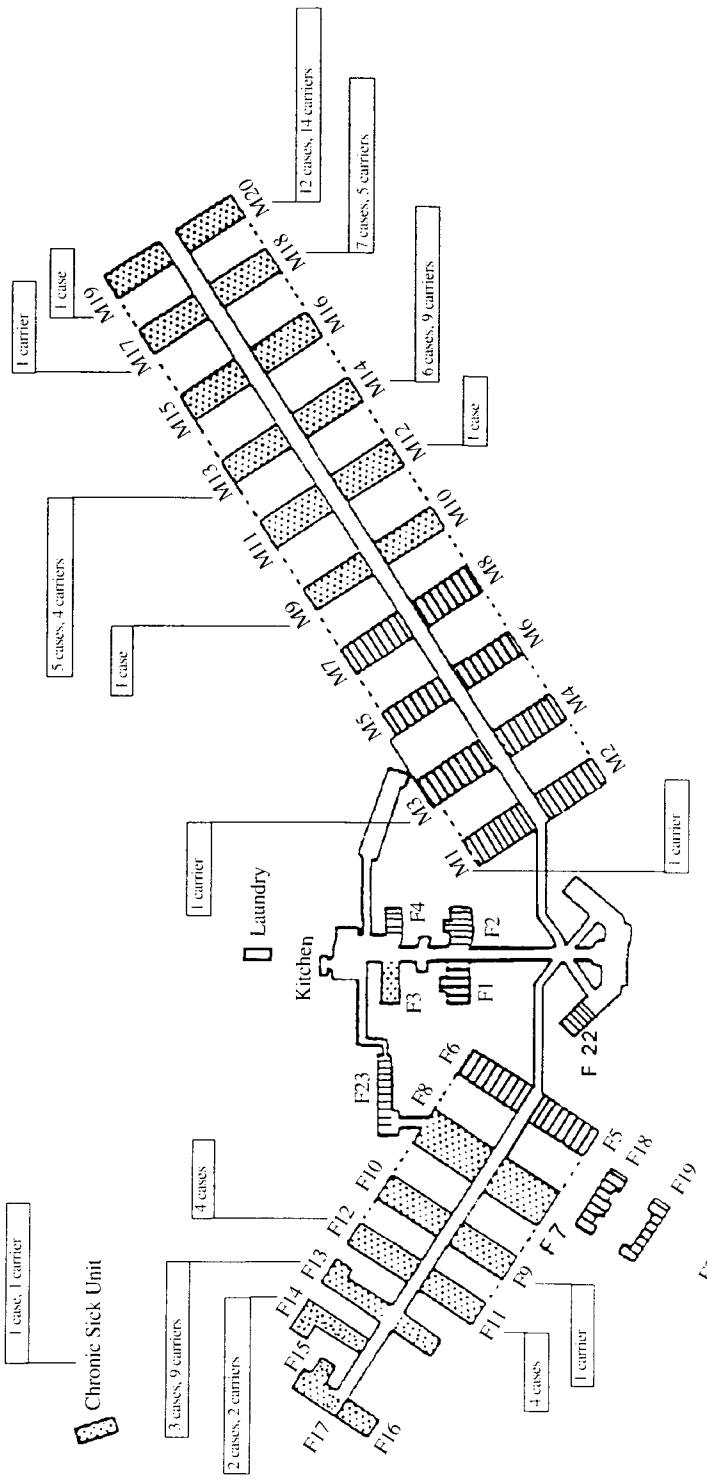

Fig. 1. Distribution of 47 culture-positive cases and of 48 carriers of typhoid fever in a psychiatric institution, April–September 1990. ▨, Long-staying ward; ▥, short-staying ward; M, male ward; F, female ward; - - -, chain-link fence.

https://doi.org/10.1017/S0950268800049700 Published online by Cambridge University Press

hospital kitchen under the supervision of a dietitian. The patients intermingled freely with each other within the ward and with those in the adjacent wards. The personal hygiene of a small number of long-stay patients was poor, some of them needing to be bathed by the staff. Seventy-two well-behaved male and female long-stay patients ('worker patient') from five male and three female wards were deployed to assist in the laundry and in other miscellaneous jobs such as general cleaning of the wards and washing of toilets, but they were prohibited from entry into the kitchen.

The outbreak

On 20 April 1990, a 45-year-old male long-stay pateint from ward M18 developed high fever and diarrhoea and was transferred to Tan Tock Seng Hospital (TTSH) for further investigations. Five days later, another long-stay patient, a 28-year-old male from an adjacent ward (M20), also became ill with fever and diarrhoea. *Salmonella typhi* was subsequently isolated from their blood and stool cultures.

As soon as typhoid was confirmed, epidemiological investigations to determine the source of infection and the mode of transmission were immediately carried out. Preventive and control measures were implemented concurrently.

MATERIALS AND METHODS

The medical and nursing staff were alerted to look out for other mild and unreported cases with fever and diarrhoea. Daily temperature readings were taken and any patient with fever (> 37 °C) with or without diarrhoea was considered as a typhoid suspect and immediately isolated at the Communicable Disease Centre (CDC), TTSH.

All the cooks and their assistants in the hospital kitchen and food handlers from two public food establishments outside the hospital premises were screened for typhoid carrier state by stool and urine cultures for 3 consecutive days. 'Worker patients' were also examined. Water and food samples from various wards and the kitchen were collected for bacteriological analyses and Moore's swabs [4] placed in several points along the hospital's sewers for detection of *S. typhi*.

The national chronic typhoid carrier registry [5] and records of past typhoid cases reported in the hospital were checked to find out whether any of them was among the list of patients. To determine the extent of infection, rectal swabs were collected in batches on 3 consecutive days from each asymptomatic contact in the wards where confirmed or suspected cases had been detected. This was subsequently extended to those in the adjacent wards until all the patients in the hospital had been screened. In wards where suspected cases continued to be reported after rectal swabbing had been completed, asymptomatic contacts were re-screened. In the initial phase of the outbreak, up to 100 swabs were collected each day, but the rate of swabbing subsequently increased to 200 per day when laboratory facilities had been expanded to cope with the increasing demand. Patients found to be infected were immediately isolated and treated at CDC, TTSH.

Blood, stool and urine specimens from symptomatic patients, stool and urine samples from food handlers and rectal swabs from asymptomatic inmates were

sent to the Enteric Bacteriology Laboratory of the Department of Pathology, Singapore General Hospital, for culture for *S. typhi*. Blood cultures in trypticase soy broth with 0·05% sodium polyanethol sulphonate were incubated at 37 °C for a week, during which subcultures were made on blood and eosin methylene blue agar plates. Stool samples were cultured directly on MacConkey and salmonella-shigella agars. Stool, rectal swabs and urine samples were inoculated into enriched selenite F broth which was subcultured after overnight inoculation at 37 °C. *S. typhi* was identified by conventional biochemical reactions and confirmed by slide agglutination with specific antisera (Wellcome Diagnostica, Dartford, England). Antimicrobial susceptibility testing was performed by the method of Bauer and colleagues [6] using BBL Sensi-Disc Antimicrobial Susceptibility Test Discs (Becton Dickinson Microbiology Systems, Cockeysville, MD, USA). Vi-phage typing was carried out according to the technique described by Anderson and Williams [7] and was similar to the one developed by Craigie and Felix [8].

The environmental sanitation of the hospital was stepped up and a high standard of personal and food hygiene was maintained by all categories of medical and paramedical staff. They were instructed to wash and disinfect their hands between handling of patients. Wards in which confirmed or suspected cases and culture-positive asymptomatic cases (carriers) had been reported were thoroughly disinfected and the personal hygiene and movements of the patients within the hospital closely supervised by the nursing staff. Special attention was given to the toilets to ensure that they were properly flushed and disinfected. Soiled linen, bedding and clothing were disinfected at the wards before being transported by trolleys to the laundry. 'Worker patients' were prohibited from assisting in the distribution of food in the ward and food remnants after each meal were properly disposed of under supervision. Patients in the infected wards were quarantined throughout the outbreak period.

Typhoid cases and carriers treated at CDC, TTSH, were permitted to return to the wards only after seven consecutive stool and urine cultures were negative for *S. typhi*. As an additional precautionary measure, typhoid cases were further isolated in two designated wards (one for males and the other for females) for another 3 weeks to monitor for clinical relapses. They were then transferred back to the ward when three consecutive stool and urine samples were found to be negative for *S. typhi*.

To prevent further clinical cases from appearing, a mass typhoid vaccination programme was implemented. Each patient was given two doses of heat-killed phenol-preserved parenteral whole cell inactivated typhoid vaccine at 4–6 week intervals. Symptomatic and asymptomatic patients known to be infected were excluded. Active search for cases with fever and diarrhoea continued for another 6 weeks after the last confirmed case was detected. No patients were allowed to be discharged home unless they had been given two doses of vaccine and rectal swabs were found to be negative for *S. typhi*.

RESULTS

A total of 47 symptomatic patients comprising 34 males and 13 females admitted to CDC, TTSH, during the period 20 April to 18 September 1990 were

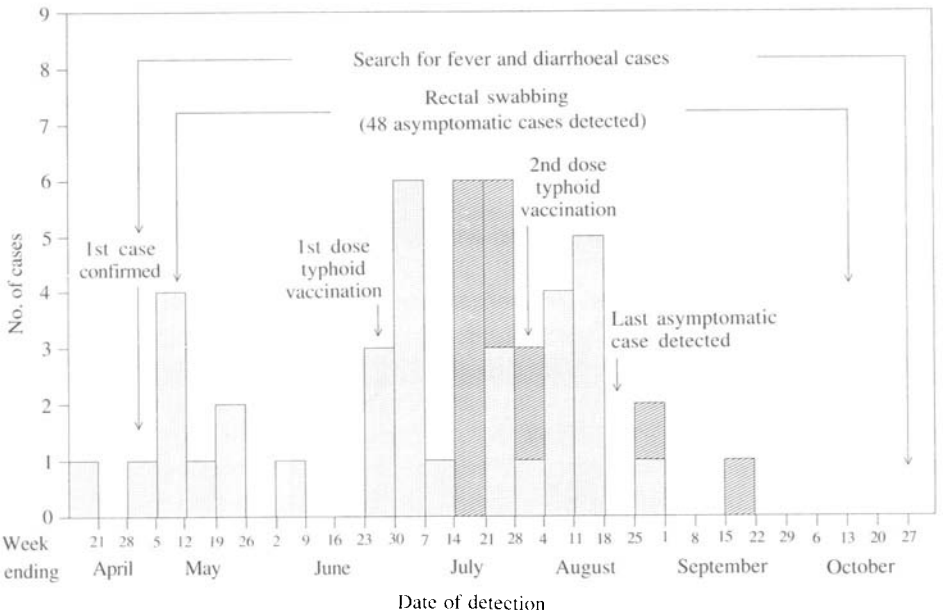

Fig. 2. Distribution of 47 culture-positive cases of typhoid fever in a psychiatric institution. April–September 1990. ▨, Male; ▩, female.

confirmed to have typhoid (Fig. 2). *S. typhi* was isolated from both the blood and stool cultures in 24 (51·1%), from the blood only in 13 (27·7%), and from the stools only in 10 (21·3%). All the urine cultures were negative. *S. typhi* was cultured from 78 (0·6%) of 7888 rectal swabs collected from 48 asymptomatic patients (37 males and 11 females), including three 'worker patients' from wards F11, M18 and M20. All the water and food samples, Moore's swabs (including those placed near the laundry and toilets) and stool and urine cultures obtained from the 55 cooks and their assistants in the hospital kitchen as well as from 15 food handlers in the public food establishments outside the hospital premises were negative. No illness was reported among the staff.

The *S. typhi* isolated from both the symptomatic and asymptomatic cases was of the same Vi–phage type D1 and sensitive to the antibiotics tested. No chloramphenicol-resistant strain was detected.

The overall infection rate (symptomatic and asymptomatic cases) was 4·8%, with the highest rate in the 25–34-year age-group. The infection rate of males (6·1%) was twice that of females (3·2%). Among the three major ethnic groups, Chinese had the highest infection rate (5·2%) followed by Malays (3·5%) and Indians (2·5%), but the difference was not significant.

Infection was confined to long-stay wards, with the exception of two asymptomatic cases in two adjacent male short-stay wards (M1 and M3) (Fig. 1). The infection rate of the 16 affected wards ranged from 1·5 to 36·6%, with the highest rate in ward M20 where one of the first two cases was detected. No association between infection rate and floor space per patient in the affected wards was observed.

From the initial focus at Wd M18/M20, the infection spread to other patients

within the wards and to other contacts in eight adjacent male wards. On 15 July 1990, a female patient from Wd F11 developed a high fever. *S. typhi* was subsequently isolated from her blood culture. Within the 2-week period, three other cases in the ward were confirmed. Infection then spread to four other female wards. Transmission did not cease until 5 months later with the last asymptomatic case detected on 20 August 1990 and the last symptomatic case confirmed on 18 September 1990.

All the symptomatic cases presented with fever (37·8–40·5 °C) and nine (19·1%) also had diarrhoea. One of them developed gastrointestinal bleeding and required blood transfusion. There was no mortality. Cases were treated with chloramphenicol (50 mg per kg body weight per day in three to four divided doses for 14 days), except for three who were given ceftriaxone (50 mg per kg body weight per day for 5–7 days) [9]. Asymptomatic cases were treated with ampicillin (75–100 mg per kg body weight per day in four divided doses for 14 days). Four (8·5%) of the clinical cases relapsed within 1 month after treatment and 10 (21·2%) continued to excrete *S. typhi* during convalescence. One of the convalescent carriers and two asymptomatic cases were found to have cholelithiasis by ultrasonography of the hepatobiliary system. Cholecystectomy was performed on two of them while a frail 79-year-old female patient was put on long-term ampicillin therapy (750 mg four times a day).

Opportunity was taken to determine the efficacy of typhoid vaccine in preventing clinical illness. Only four wards (M18, M20, M9, M14) where cases were reported prior to vaccination were considered. Of 264 unvaccinated patients at risk, 10 were confirmed to have typhoid, giving an attack rate of 3·8%. The attack rate was 4·0% (10/251) after the first dose of vaccine and 1·3% (3/236) after the second dose. No protection was conferred after one dose, but the efficacy after two doses was 65·8%.

$$\text{Vaccine efficacy} = \frac{\text{Attack rate of the unvaccinated} - \text{attack rate of the vaccinated}}{\text{attack rate of the unvaccinated}} \times 100$$

DISCUSSION

The confirmation of a case of typhoid in a psychiatric institution should be considered as a public health emergency, because of the rapidity with which the disease could spread, as demonstrated in this outbreak. In spite of the extensive control measures taken, infection spread from the male to female wards and transmission was only interrupted 5 months after the first case was detected. However, infection was localized to the institution and did not spread to the general population.

Typhoid is primarily a food- or water-borne disease [1, 10]. Person-to-person transmission is uncommon as the infective dose is high. In healthy human volunteers, ID_{25} is about 10^4 organisms and ID_{50} $10^{6\cdot7}$ organisms [11]. The outbreak originated from a common source as the Vi-phage type and antibiogram of *S. typhi* isolated from 47 symptomatic and 48 asymptomatic cases were the

same. Contaminated food or water was ruled out as the vehicle of transmission. The source of infection could not be established. Infection could not have been introduced from outside the hospital as sporadic cases of typhoid reported in the community before and during the outbreak period were due to *S. typhi* strains belonging to 17 other different Vi–phage types. Of the three carriers with cholelithiasis, one was from Wd M20 where one of the first two clinical cases was detected. However, he developed fever in the midst of the outbreak (27 July 1990) and was unlikely to be the source of infection. The other two carriers from Wd F13 were detected on 3 August 1990 and 15 August 1990, respectively, when the outbreak was tailing off. From a review of past typhoid cases and carriers in the hospital, a 37-year-old long-stay asymptomatic male patient in Ward M14, who had frequent contacts with other patients in wards M18 and M20, was found to be infected with *S. typhi* of the same Vi-phage type in an outbreak in 1977 (43 cases and 6 carriers). His stool culture was positive for *S. typhi* on 20 August, but subsequently became negative after a 2-week course of ampicillin and no cholelithiasis was demonstrated. In this outbreak, asymptomatic cases and carriers probably resulted from the infection rather than their being the source of infection.

Once the organism was excreted into the environment, the stage was set for the spread of infection by direct contact from person to person because of the close living conditions and poor personal habits of a small number of long-stay patients. Infection was virtually limited to long-stay patients, some of whom were known to pick and eat scraps from the ground or defaecate and urinate indiscriminately when left unattended. Infected patients could excrete 45×10^6–$100\,000 \times 10^6$ organisms per g of stool and *S. typhi* can persist on hands and nails [12]. As it is virtually impossible to maintain a rigid standard of personal hygiene such as thorough washing of hands after toilets and before meals among the patients, cross-infection occurred following exposure to heavy contamination in toilets and the environment and contact with soiled bedding, linen and other fomites. The infection was probably introduced into the female wards by an infected 'worker patient' who was involved in the handling of soiled linen in the laundry. Two other infected male 'worker patients' who had contact with soiled linen could have spread the infection to other male wards situated away from the initial focus of transmission. Other factors could also have contributed to the introduction and persistence of infection: e.g. a case in Wd M14 was transferred from Wd M20 before the outbreak was recognized. One of the cases who was isolated and treated at CDC, TTSH, from 21 May to 20 June had a clinical relapse on 12 July in the ward and probably gave rise to another crop of cases before he was detected and isolated. There was no correlation between infection rate and floor space per patient in the affected wards and so crowding was unlikely to be a contributory factor in the transmission of infection.

Many problems were encountered in bringing the outbreak under control rapidly. The patients could not give a reliable history to enable the chain of transmission to be elicited. Rectal swabs rather than specimens of purged stool were used in the detection of typhoid carriers, and cultures may give false negative results when there are too few organisms excreted. Many close contacts had to be swabbed repeatedly before *S. typhi* was finally isolated. It would not be

practical to resort to duodenal intubation or the duodenal capsule string device [13] for the detection of typhoid carriers in psychiatric patients. No attempt was made to identify urinary carriers as no such carrier has been reported in the national chronic typhoid carrier registry for the past 10 years, and inclusion of a sample of urine for culture would further strain the limited resources. The sensitivity and specificity of highly purified Vi serology in the detection of chronic typhoid carriers [14, 15] have not been established locally. However, it does not detect all the carriers in an outbreak and stool cultures will still be required [16]. All the Moore's swabs were negative, probably because of heavy doses of disinfectant used in the wards, laundry and toilets.

There is no effective single-dose chemoprophylactic drug for typhoid fever. Even if it is available, its use should be discouraged as it may lead to the emergence of antibiotic-resistant strains. Typhoid vaccination was introduced only after careful consideration, as it is known to have a high frequency of unpleasant local and systemic side effects and rare complications have also been documented [17]. It was also realized that it does not limit the spread nor prevent inapparent infection or the carrier state. Its efficacy in preventing clinical illness is moderate if the infective dose is low. Moreover, the already overstrained medical and nursing staff who were involved in surveillance would have to be deployed for the vaccination exercise. It has been stated that mass immunization during an epidemic where the risk of infection is high is not recommended [18]. However, since this was not a food-borne outbreak where the infective dose is high, but transmission was from person to person, the use of typhoid vaccine is justified. Heat-killed phenol-preserved typhoid vaccine was used as acetone-inactivated or purified Vi capsular polysaccharide [19] vaccines which have a greater efficacy were not available locally. Oral typhoid vaccine [20] was not used as it is too expensive and three doses are required.

The vaccine was well tolerated with no severe adverse reactions being reported. The efficacy obtained in this outbreak was comparable to the 54–65% protection reported in field trials involving the general population in the endemic countries [21–23]. However, it should be pointed out that it is the maintenance of a high standard of environmental sanitation, active search of unreported cases and carriers, and isolation of all infected inmates that have contributed to breaking the chain of transmission. Therefore, vaccination against typhoid only has a role in institutional outbreaks if it is accompanied by other public health measure. Typhoid vaccination did not have much impact on the incidence of clinical illness for the first 4 weeks after the second dose was given.

A high degree of vigilance is being maintained at the institution. Environmental monitoring for excretion of *S. typhi* by Moore's swabs is continuing. This is to ensure that asymptomatic cases not prevented by typhoid vaccination are promptly identified. Otherwise, they become a constant danger of further spread of infection.

ACKNOWLEDGEMENTS

We thank the medical, nursing, public health inspectorate and laboratory staff of Woodbridge Hospital, Communicable Disease Centre, Tan Tock Seng Hosptial, Quarantine and Epidemiology Department, Ministry of the Environment, and

Enteric Bacteriology Laboratory, Department of Pathology, Singapore General Hospital, for their assistance and cooperation in the investigation, prevention and control of this outbreak.

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