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Observations on the Spread of Cholera in Hong Kong, 1961-63*

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Cholera, which had been spreading throughout the south-west Pacific in 1961, broke out in Hong Kong in August of that year. The outbreak lasted about six weeks, and recurred in 1962 and 1963; but whereas the 1961 outbreak resembled classical cholera, in the succeeding years the pattern changed. The disease, though still severe, was sporadic and this made it possible to study the epidemiology of the outbreak in some detail. Transmission bore little relation to water or food. A technique of nightsoil sampling was devised, and the results obtained in 1963 indicated the presence of a large number of symptomless excretors of cholera vibrios among the population. The authors suggest that this would make the hypothesis of person-to-person spread a more reasonable proposition than transmission simply from case to case.

Cholera was reported in Hong Kong on 15 August 1961, for the first time since 1946.[3] Rumours that the disease existed in the adjoining territories of Kwong Tung and Macao had been current for the previous two weeks. The outbreak was sudden and short-lived, but the disease recurred in 1962 and 1963. The number of cases and deaths each year, the annual incidence and mortality are shown in Table 1, together with the 1961 census population and estimated projections for each mid-year. The 1961 outbreak was fully described by Mackenzie (1961), while Yeoh & Teoh (1963) have described the clinical features.

At no time has the disease assumed the widespread or explosive proportions once typical of this disease, the greatest number of cases confirmed in one day being eight (on 16 August 1961 and again on 9 October 1963); there were 18 cases in the four days from 8 to 11 October 1963. In 1961 the disease bore a closer resemblance to classical cholera than in succeeding years. Cases followed in more rapid succession, 74 out of 77 being recorded in 28 days. In 1962, 10 out of 11 cases were spread over 28 days, and in 1963 there were 115 in 178 days. The mortality has shown a steady decline from approximately 20% in 1961 to 10% in 1962 and 5% in 1963. The severity of non-fatal cases has also declined. The over-all incidence of cholera among the population was 1 in 25 000 in 1961, 1 in 300 000 in 1962, and 1 in 30 000 in 1963—even in the worst areas not more than 1 in 10 000 persons was affected. This, together with the small and compact area of the Colony of Hong Kong, has made it possible to study certain aspects of the disease in greater detail than might have been possible during a more explosive outbreak. This paper presents information regarding the spread of infection within the urban community which was obtained principally by a new technique of nightsoil sampling devised by one of us (G.I.F.).

GEOGRAPHY AND ENVIRONMENTAL CONDITIONS

The Colony of Hong Kong consists of the Island of Hong Kong—area 29 square miles (75 km²)—and the peninsula of Kowloon—12¾ square miles (33 km²)—which together comprise the administrative urban area, and the New Territories—356½ square miles (923.3 km²). Most of the population is concentrated on the north of Hong Kong Island and on Kowloon peninsula (Fig. 1).

Since 1945, expansion of the population and redevelopment of old property have been taking place rapidly all over the urban area, but the largest

* This report is based on work carried out by the authors and other members of the Hong Kong Government Medical and Health Department in the course of cholera control measures undertaken during the years 1961-63.

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[3] Six cases were recorded in 1947, but all were imported, and the disease was never introduced into the Colony.

TABLE 1
CHOLERA CASES, INCIDENCE AND MORTALITY IN HONG KONG, 1961-63

	Year			Total 1961-63	Census population 7 March 1961
	1961	1962	1963		
Hong Kong	14	4	48	66	1 004 875
Kowloon	28	5	56	89	1 578 026
Harbour	12	1	5	18	90 343
New Territories	23 [a]	1	6	30	456 404 [b]
Transients	—	—	—	—	3 483
Total	77	11	115	203	3 133 131
Mid-year population [c]	3 184 300	3 400 300	3 546 900	—	
Annual incidence per 100 000	2.42	0.32	3.24	—	
Deaths	15	1	6	—	
Mortality rate (%)	19.5	9.1	5.2	—	

[a] Including 10 boat dwellers.
[b] This figure includes the New Territories floating population of 46 459.
[c] From Hong Kong Census, 1961, Population Projections, 1961-1971 (Mok, 1963).

resettlement and rehousing projects are in north-east Kowloon. Population figures for public health administrative districts given in Table 3 below are projections from the 1961 census and must be treated with some reserve. The floating population of boat dwellers, numbering around 150 000, is largely engaged in fishing and in sea communication with the China coast, providing ample opportunity for the introduction of infection from outside the Colony.

Density of population

Certain areas of Hong Kong have a population density as high as 1000 persons per acre; [1] but among the smaller census units of about 5 acres (2 hectares) each, there were 7 in Hong Kong—all old tenement areas—and 6 among resettlement housing estates in north Kowloon with a density of between 2000 and 3000 per acre; there was one unit among the old tenement areas of Kowloon (part of VIII (a) in Fig. 1) with a density of 1982. The most densely populated areas are also some of the oldest in the Colony, made up of three- or four-storey tenement buildings with some of the poorest sanitation. Where new, multi-storey development has taken place, the population density has been kept down to a reasonable level by planning restrictions.

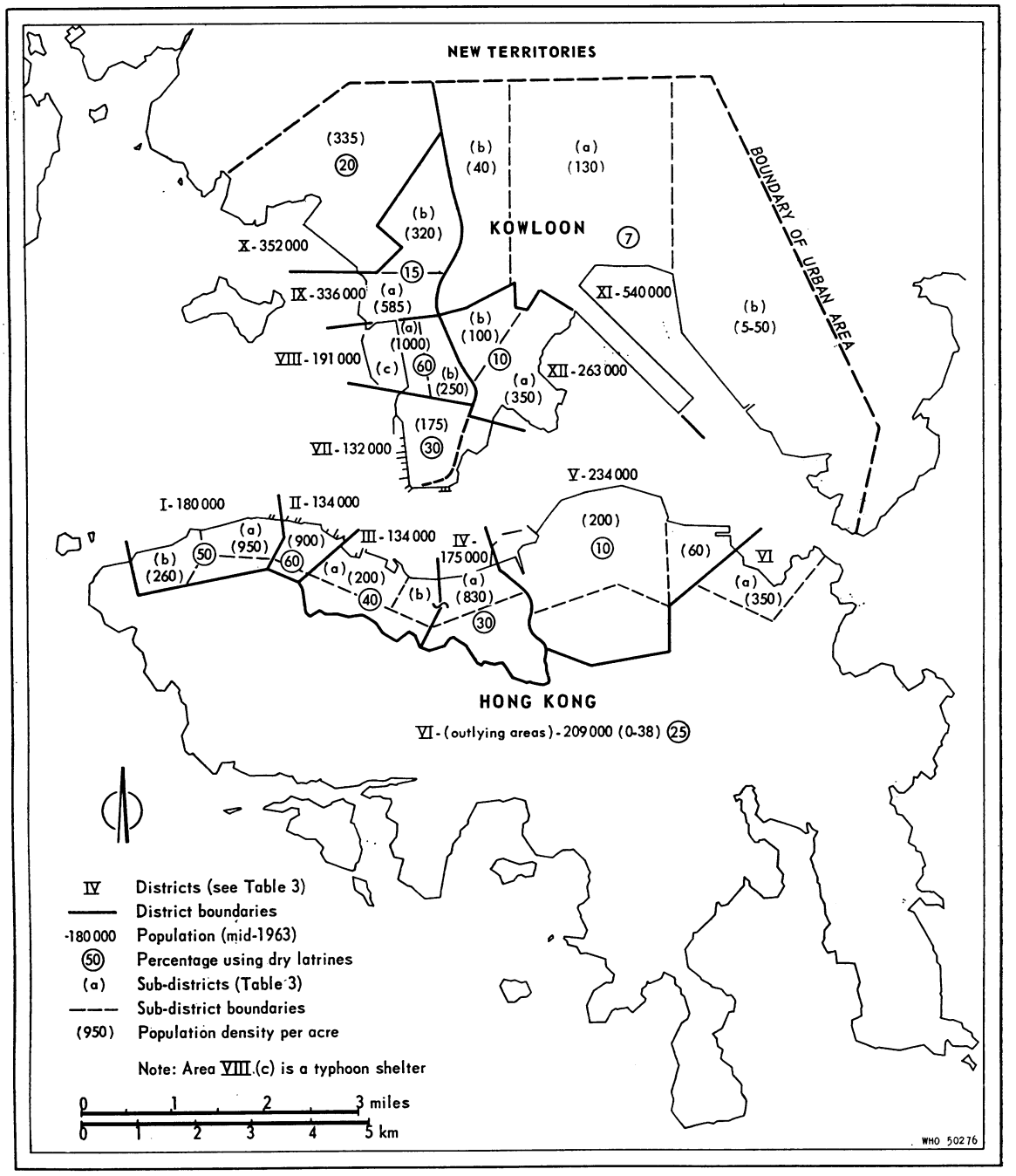
[1] 1000 persons per acre = 2470 persons per hectare.

Water supplies and the effect of the drought

The majority of the urban areas are supplied with mains water of a high standard of purity. Many rural areas are also supplied with piped water, but the purity of this is less carefully controlled. In squatter areas on the outskirts of the urban area some water is obtained from streams and from shallow wells which are chlorinated daily. In addition, a very large number of wells are used to provide water for flushing purposes and are not treated in any way.

In October 1962, the Colony entered a period of exceptional drought: the year 1963 was the driest in the history of Hong Kong, and drastic measures had to be taken to conserve water. From May 1963, mains water has been supplied to domestic users for only four hours on every fourth day, and this has continued up to the time of writing. Many wells and streams in squatter areas dried up, and emergency hydrant supplies of mains water were provided. The population of these areas thus received a purer supply than usual. On some hilly areas of Hong Kong Island natural seepages are used for washing, and the possibility of contamination of food and drink is present. Many trade premises, including restaurants, brought water by lorry from wells in the New Territories which were chlorinated daily, or from streams. Stored water in food premises was

FIG. 1
POPULATION DENSITY AND CONSERVANCY IN DISTRICTS OF HONG KONG, 1961-63



treated by the proprietors under the instructions of health inspectors. Many wells and streams used for flushing purposes dried up and, though much ingenuity was practised in the use of waste water, some latrines remained unflushed for long periods.

CONSERVANCY

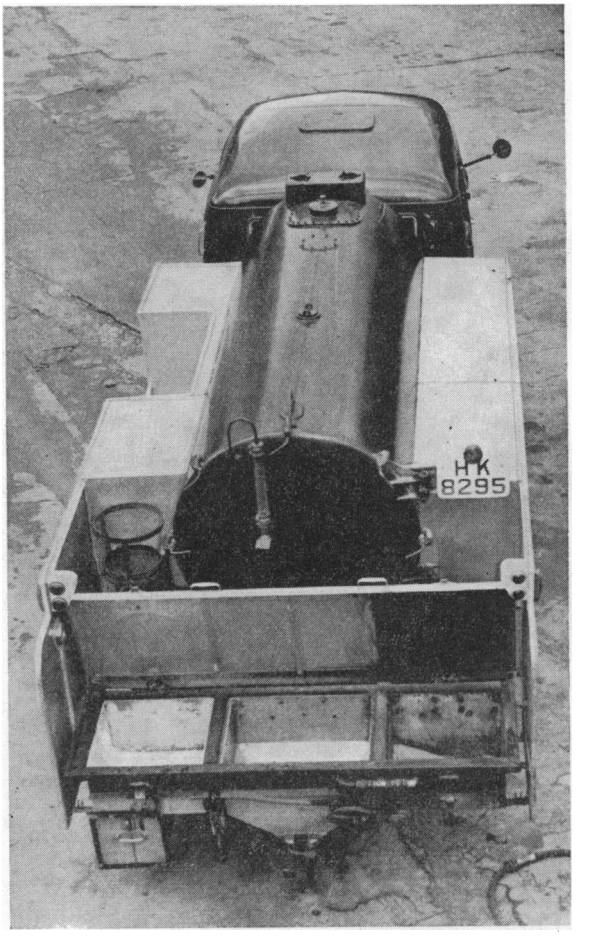
While new buildings in the urban area are provided with flush latrines, many old buildings have only dry latrines; these may be properly built structures in the yard, with concrete squatting slabs and metal pans, or wooden commodes in the kitchen. Some old buildings are being converted from dry to flush latrines, but shortage of flushing water and absence of main drainage have delayed progress. Until recently, no flush latrines were permitted in a large area of Kowloon in order to reduce fouling of the typhoon shelter (area VIII (c) in Fig. 1) into which drains from the area discharged.

Nightsoil collection

Nightsoil is collected from dry latrines between midnight and 6 a.m. daily by female coolies of the Urban Services Department, who empty the pails into collecting vehicles stopping at fixed points along a number of set routes. At the end of each route the nightsoil is discharged into barges which either take it to storage tanks from which, after " maturation ", it is sold to farmers, or dump what is not required at sea. The vehicles used since August 1960 (Fig. 2) are called Sherriff-Baker tankers, after a former Superintendent of the Urban Services Department and the Senior Mechanical Engineer of the Public Works Department who designed them. Basically, each consists of a 750-gallon (ca 3400-litre) tank divided into two compartments, one of 550 UK gallons (2500 litres) for nightsoil and one of 200 UK gallons (ca 900 litres) for water. At the back of the vehicle are three hoppers of 20-gallon (90-litre) capacity each: the first is for the reception of nightsoil, which is pumped into the larger tank; the second contains water, and the third 2% white disinfecting fluid. The pails of nightsoil are emptied into the first, rinsed in the second and then disinfected in the third hopper.

It is estimated that about a quarter of the urban population or 700 000 people use this conservancy service. In peripheral squatter settlements some dry latrines are emptied by the conservancy services, but much of the nightsoil is used for agricultural purposes or is discarded into nullahs, pits or open channels. The number of squatters with no service is thought to be of the order of 150 000 persons. Estimates of the proportion of the population using dry latrines are shown by health districts in Fig. 1 and may be compared with the figures of population density.

FIG. 2
SHERRIFF-BAKER NIGHTSOIL COLLECTION VEHICLE



In 1963, 30 vehicles were making 60 trips (two trips each) a night, stopping at about 1000 points and serving 33 000 pails. Thus 60 loads (about 110 tons) of nightsoil were collected every 24 hours, approximately equal quantities from Hong Kong Island and from Kowloon, each tank load representing 12 000 to 15 000 users. This service does not extend to the New Territories, which are excluded

TABLE 2
CONSERVANCY SERVICES IN URBAN AREAS, 1963

Nightsoil collection routes:		
Hong Kong	16	
Kowloon	14	
Total		30
Loads in 24 hours		60
Tons in 24 hours		110
Collecting points		1000
Buckets emptied daily		33 000
Estimated population served (roughly 21 persons per bucket)		700 000
" Wild " squatters with no service (estimated)		150 000
Floating population (assumed discharge into sea)		102 000
Population using flush latrines (by subtraction)		2 072 000
Urban population mid-1963		3 024 000

from the survey described below. These figures are summarized in Table 2.

GEOGRAPHICAL DISTRIBUTION OF CASES

The location of individual cases is shown on the map, Fig. 3, on which three years' cases are shown for comparison. The location of cases may be compared with the population densities and use of dry latrines shown in Fig. 1, the data for both being summarized in Table 3.

Although the number of cases is too small for strict statistical analysis, there have been certain distinct tendencies. In 1961, there was a predominance of cases among the floating population (see Table 4). This was most marked in Hong Kong and in the New Territories (not included on the map) but was not noticeable in 1962 or 1963. There appear to have been more cases in the western than in the eastern areas, while west-central Hong Kong and north-west Kowloon had not only more cases but also a higher incidence per total population.

Relation to overcrowding and use of dry latrines

It has been mentioned that the most overcrowded areas are generally those with the highest percentage of dry latrines, and this is confirmed from Table 4; areas I(a) and II (western Hong Kong), III(b) and IV(a) (east-central Hong Kong) and VIII(a) (Yaumati, Kowloon), with densities of 800 per acre (1976 per hectare) or more, all have between one-third and two-thirds dry latrines. Nevertheless, these are not all areas with the highest incidence: west, west-central and east-central Hong Kong have high incidence but Yaumati, with the highest population density of all, has almost the lowest case incidence, quite the lowest of the fully built-up areas, in fact. On the other hand, north-west Kowloon (areas IV(b) and X), with the heaviest incidence on the mainland, is not overcrowded nor has it a particularly high percentage of dry latrines.

RELATION TO HOUSING AND SANITATION

Table 5 summarizes the case rate among residents in various types of housing according to the use of dry or flush latrines. Totals in each group are small, and the rates must not be taken as exact.

Tenement and multi-storey buildings include all the types of private domestic accommodation found in a crowded city. Where the latrines are dry, other sanitary standards are also generally lower and the higher incidence of cholera in this group, though probably significant, may not be attributable only to the type of latrine used.

Resettlement estates are government multi-storey rehousing projects. The design is basic and the rooms small, but on each floor there are communal washing facilities and flush toilets. Resettlement cottages are single-storey brick or stone dwellings, mostly with communal aqua-privies. Street squatters are the least fortunate members of the community and are taken here to include those living on roof tops and staircases and in huts on pavements. Though this group has far the highest incidence, the number of cases in it was very small. Village squatters are those who have their own huts, mostly on the outskirts of the town.

Cholera and social status

Felsenfeld (1963) pointed out that the 1961-62 epidemic in the west Pacific was restricted to slum and boat dwellers with minimum sanitary facilities, but this was not borne out entirely in Hong Kong in 1963, as may be seen from Table 6. Taken in conjunction with the residential details in Table 5, this shows that a fair proportion of patients were clerks, factory workers and artisans with an average standard of living. There were indeed no cases among the highest income groups, but the disease was not entirely confined to slum dwellers with primitive sanitation.

FIG. 3
CHOLERA CASES IN HONG KONG, 1961-63

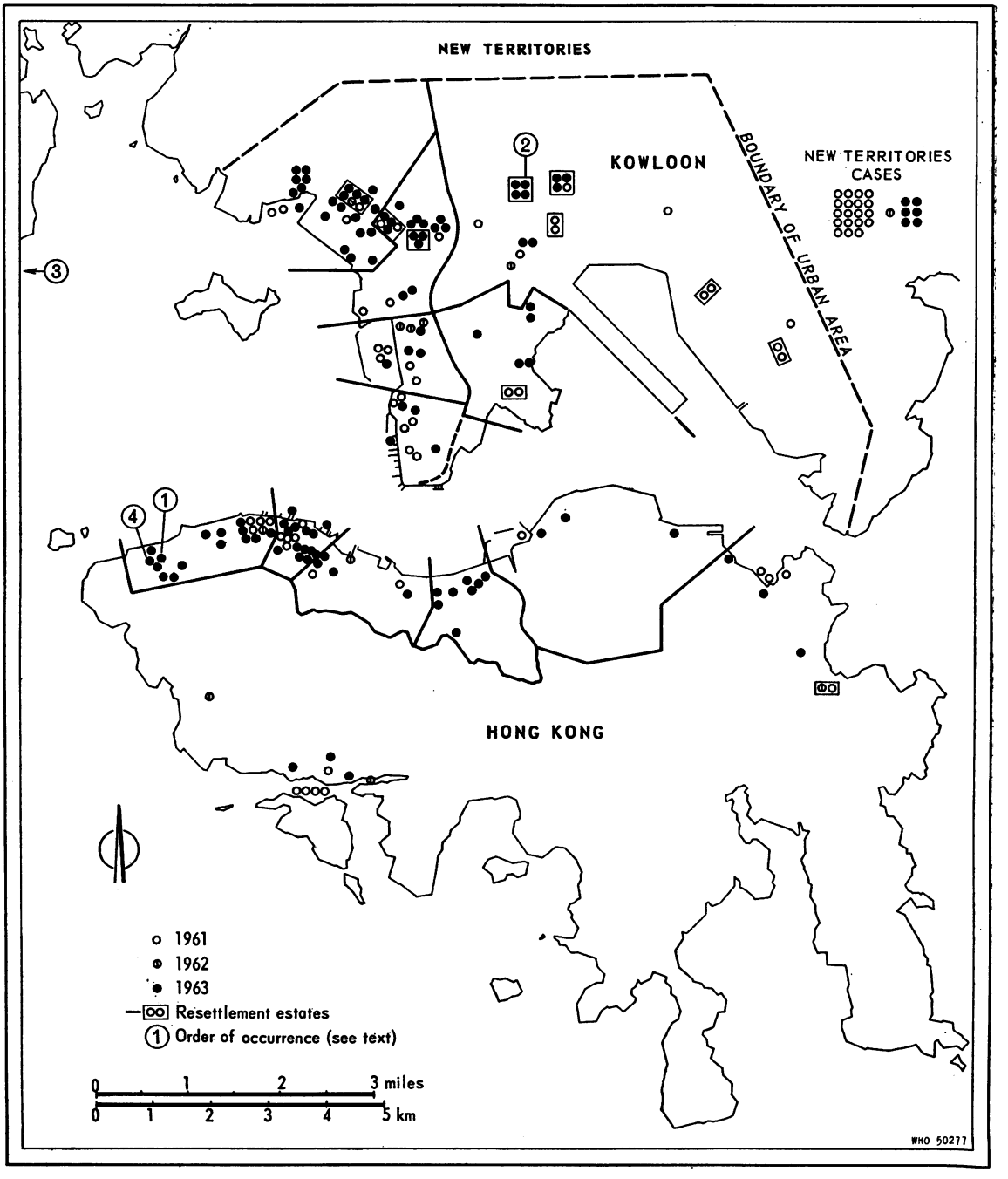


TABLE 3

CHOLERA IN HONG KONG, 1963: INCIDENCE BY DISTRICTS, USE OF DRY LATRINES AND POPULATION DENSITY

District [a]	Population 1963 (thousands)	Cases 1963	Rate per 100 000	Percentage using dry latrines	Sub-districts [a]	Population 1963 (thousands)	Cases 1963	Rate per 100 000	Density per acre [b]
Hong Kong									
I Western	180	15	8.3	50	I (*a*)	102	8	7.8	950
					I (*b*)	62	7	11.3	260
II Western-central	134	12	9.0	60		134	12	9.0	900
III Central	134	4	3.0	40	III (*a*)	46	3	6.52	200
					III (*b*)	193	9	4.7	830
IV Eastern-central	175	8	4.6	30	IV (*a*)				
V Eastern	234	3	1.3	10		234	3	1.3	200
VI Outlying areas	209	6	2.9	25		92	2	2.2	350
Hong Kong Total	1 066	48	4.50	33					
Kowloon									
VII Tsim Sha Tsui	132	3	2.3	30	VII (*a*)	90	2	2.2	175
VIII Yau Ma Tei	191	3	1.6	60	VIII (*a*)	170	2	1.2	1 000
					VIII (*b*)	57	2	3.5	250
IX Mong Kok	336	15	4.5	15	IX (*a*)	159	3	1.9	585
					IX (*b*)	165	13	7.9	320
X Sham Shui Po	352	21	6.0	20		352	21	6.0	335
XI Kowloon City	540	9	1.7	7	XI (*a*)	324	9	2.8	130
XII Hung Hom	263	5	1.9	10	XII (*a*)	208	4	1.9	350
					XII (*b*)	46	1	2.2	100
Kowloon Total	1 814	56	3.1	19					
Harbour	102	5	4.90	—					
Urban Total	3 024	109	3.60	23					
New Territories	523	6	1.15	—					
Total	3 547	115	3.24	—					

[a] Numbers of districts and sub-districts are those shown in Fig. 1.
[b] 1 000 persons per acre = 2 470 persons per hectare.

NIGHTSOIL SAMPLING

In January 1962 the sampling of nightsoil from collecting vehicles was added to the pathological investigations being carried out. When the scheme was introduced, three or four random samples were taken each week from nightsoil vehicles in Kowloon while they were discharging into the barges. Samples were taken with glass rods or sticks dipped into the nightsoil and stirred into tubes of Monsur medium.

Follow-up sampling

After the first positive sample was reported from a nightsoil vehicle on 11 September 1962, the investigation of all vehicles was started with the object of tracing the infection back to its source, whether case or carrier, two samples being taken from each load

TABLE 4
CHOLERA CASES, 1961: INCIDENCE AMONG BOAT DWELLERS

Area	Cases			Boat dwellers as percentage of population
	Boat dwellers	Total	Percentage among boat dwellers	
Hong Kong	7	21	33	3.5
Kowloon	5	33	15	
New Territories	10	23	43	10
Total	22	77	29	—

of nightsoil every night. When a vehicle was found to be infected, the result was telephoned to the District Health Officer, who arranged for sampling of each hopper load on the infected route. The vehicle results were not available until the day after samples were taken, so sampling of hoppers took place on the third night. When a sample from a hopper was reported positive, each pail making up the hopper load was sampled on the fifth night. If a pail was reported positive, the Health Officer took rectal swabs from all the residents in the house or flat in which the latrine was situated, at the same time taking other samples from the premises. This could be done on the evening of the sixth day and the result usually obtained during the seventh day. Thus in six days an infection in a vehicle could be traced back to

TABLE 5
CHOLERA CASES, 1963: RELATION TO TYPE OF HOUSING AND CONSERVANCY

	Number of cases among users of:			Total cases	Population (thousands)	Rate per 100 000
	Flush latrines	Dry latrines	Not known			
Type of housing:						
Tenement and multi-storey building	24	38		62	1 141 570 1 711	2.1 6.7 3.6
Resettlement estate	17			17	516	3.3
Resettlement cottage		3		3	90	3.3
Squatter (street)	3	4	1	8	85	9.4
Squatter (village)		14		14	520	2.7
				22	605	3.6
Type of latrine:						
All flush	44				2 072	2.12
All dry		59			850	6.94
Unknown			1			
Total urban area (land)				104	2 922	3.56
Boat (urban area)				5	102	4.9
New Territories				6	516	1.16
All cases				115	3 548	3.24

TABLE 6
OCCUPATION OF CHOLERA PATIENTS

Occupation or category of patients	Number	Percentage
Factory worker	15	13.04
Artisan	14	12.17
Coolie labourer	23	20.00
Hawker	10	8.70
Clerk/shop assistant	6	5.22
Student	10	8.70
Housewife	12	10.43
Refugee (White Russian)	1	0.87
Fishing	2	1.74
No occupation	22	19.13
Total	115	100

its individual source. The taking of 120 samples from nightsoil vehicles every night was carried out by foremen, but the sampling of hoppers and buckets had to be done by health inspectors. When several routes were infected simultaneously, this placed a considerable burden on the staff.

The follow-up scheme was continued as long as the 1962 outbreak lasted—little over three weeks. The results during that period were encouraging, and it was decided to continue the sampling of all vehicles through the winter; it was hoped that by this means advance warning might be obtained of a future outbreak. As it turned out, this hope was not fulfilled, but when the first positive result from a vehicle was obtained in July 1963 the follow-up system was introduced again and was continued until the beginning of October. It was anticipated that the outbreak would subside with the onset of colder, drier weather, but it did not do so. In fact a sudden upsurge of infection placed so great a burden on the staff that the follow-up sampling by health inspectors had to be abandoned after 3 October 1963. The sampling of nightsoil vehicles was continued as before.

Interpretation of nightsoil sampling results

While the follow-up scheme was in operation (September-October 1962; July-October 1963), it frequently happened that the discovery of infection in a vehicle was followed by the reporting of more than one positive sample from a hopper or pail. In order to estimate the number of individual sources of infection involved, certain protocols have been laid down. A positive report is counted as a separate source only at the last stage to which the infection could be traced. If a positive report on a route was followed by a positive hopper sample, both were assumed to have originated from the same source: if the positive route sample was followed by two positive hopper samples, each of these would represent a separate group of users, and so two sources would be recorded. If one of the positive hopper samples was followed by a positive pail sample, both of these would be counted as only one source.

If a nightsoil collection route was infected intermittently, the infection was assumed to be due to a fresh source if there was an interval of five clear days without a positive report. Positive reports on up to six consecutive days were regarded as originating from a single source, and in counting the number of infections each week, when infection of a route was continued from one week to the next, this was regarded as being due to a fresh source if the infection had lasted for at least six days.

Symptomless carriers are included in the total number of sources recorded in this way, but confirmed cases are not included in this total.

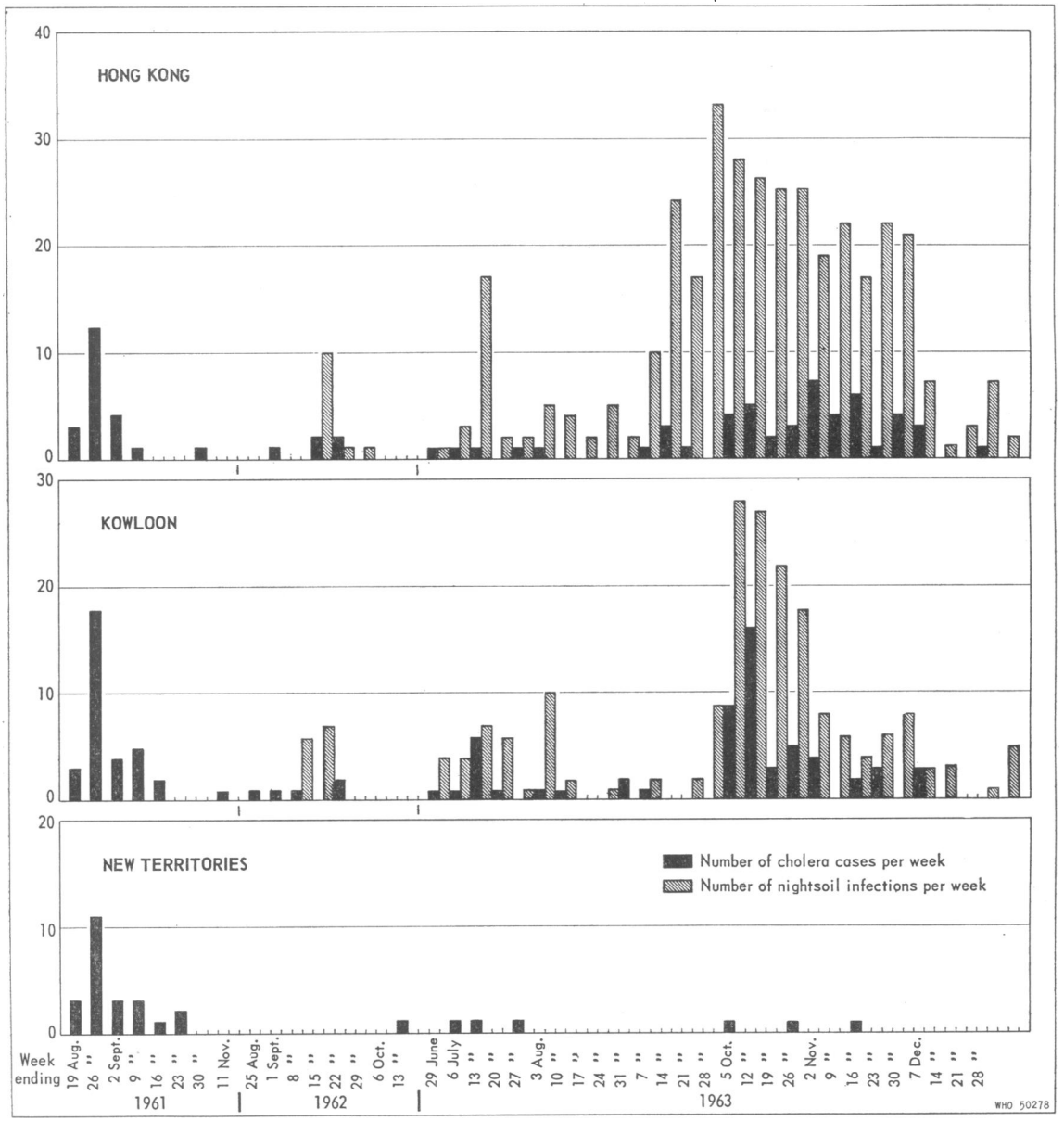
INTENSITY OF INFECTIONS AND CASES OVER THREE YEARS

Fig. 4 shows the weekly incidence of cases and, since 11 September 1962, of nightsoil infections. From this it appears that the outbreaks can be divided into four distinct phases.

Phase 1—1961

This outbreak was short and sharp, though the total number of cases (Table 1) was less than in 1963: 52 cases occurred in the first 12 days, 19 in the next 12 days and 5 in the next 13 days, while one further isolated case was reported in November. A maximum of 8 cases occurred on 16 August, the second day of the outbreak. There is no information as to the occurrence of nightsoil infections during this period. The outbreak subsided completely, and though nightsoil sampling was started again in January 1962 and continued through the spring no positive results were obtained. Although the chances of obtaining a positive result must have been small, the fact that one was obtained 21 days after the first case in 1962, when the infection rate must still have been low, suggests that the infection

FIG. 4
CHOLERA CASES AND NIGHTSOIL INFECTIONS BY WEEKS, 1961-63



had died out or else that the vibrio had become dormant.

Phase 2—1962

The 1962 outbreak was sporadic and atypical in several ways. The first case occurred on 22 August and there were four further cases spread over the next three weeks.

On 11 September a positive report was obtained from a nightsoil collection vehicle in Kowloon. It was then decided to start full sampling of all Kowloon nightsoil routes, and this was first done on the

night of 13 September. From the results of that night and the next, six routes were found to be infected in Kowloon. On 17 September full sampling was also started in Hong Kong. During the week ending 22 September ten routes were found positive in Hong Kong and seven more in Kowloon, making a total of 23 routes infected out of 34.[1]

During the period 13-18 September six cases occurred, but the infection then subsided rapidly. Four more nightsoil routes were reported infected during the next two weeks, but no further cases occurred except an isolated one in the New Territories on 13 October. Neither cases nor infections were reported from that date until 27 June 1963.

Phase 3—28 June to 28 September 1963

The outbreak in 1963 was prolonged, and marked by local outbreaks followed by quiescent periods. Nightsoil was infected intermittently from 2 July 1963 to 12 January 1964. The first case was reported on 28 June and four days later two nightsoil routes [1] remote from it were reported positive. Cases and infections gradually increased for about three weeks, then continued sporadically until 9 September. On that day two adjoining nightsoil routes in the western-central district of Hong Kong became infected, and on 12 September one case occurred there. There followed three weeks of intensive infection in the district, mainly centred in an area about half-a-mile (one kilometre) across, during which 51 separate sources and 12 carriers were traced. In spite of this high infection rate, only four cases occurred in Hong Kong during the month of September, and only three were reported from the western-central district during the three months from August to October. Throughout this period Kowloon remained entirely free of cases, and for 13 days (10-22 September) no nightsoil infections were reported.

Phase 4—29 September to 28 December 1963

On 29 September, a sudden recrudescence in North Kowloon gave rise to 25 cases in 14 days; this is described more fully below.

Widespread nightsoil infection occurred simultaneously in Kowloon and in Hong Kong, and by 12 October it involved virtually every route in the urban areas. This infection persisted until the end of October, when it declined in Kowloon, although Hong Kong remained widely infected until 7 December. By the beginning of October the number of infections was so great that it was necessary to end the detailed follow-up scheme, which placed a heavy burden on the health inspectorate. During this period, cases occurred at the rate of one or two a day, totalling 52 between 13 October and 6 December. Nightsoil infections decreased until 20 December, after which no infections were reported for a week. The last case occurred, after a gap of 16 days, on 22 December, and scattered nightsoil infections were reported from 27 December 1963 to 12 January 1964.

A single case occurred on 19 February 1964 in Kowloon, and eight nightsoil routes were reported infected on 25 and 26 February, but at the time of writing (April 1964) no further cases or infections had been reported.

SPREAD BY WATER AND FOOD

Water

Cholera has been known for many years as a water-borne disease, and outbreaks spread in this way are still reported. The epidemics in Thailand (Felsenfeld et al., 1961) and in the Philippines (Viterbo et al., 1962) both appeared to have been largely water-borne. The great majority of cases in Hong Kong in 1962 and 1963 were supplied with at least enough mains water of uniform purity and adequate chlorine content for drinking and cooking. No case was traced to contamination of public water supplies, though in one incident the use of impure surface water may have contributed to the spread of infection. At the beginning of September the infection rate in nightsoil from western-central Hong Kong rose sharply. In the search for possible sources of infection, attention was directed to the seepages from hillsides and retaining walls; this water was scooped up and used ostensibly for bathing. One of us noticed that a certain " spring " had a faint but typical odour and a yellowish tinge. Investigation showed that the sewer from a public latrine higher up the hill was leaking, and repair of the sewer stopped the seepage.

Food

In spite of careful investigation of each case in 1961 and 1962, no connexion was found between the spread of the disease and contaminated food or

[1] For 1962 a " route " includes two loads, but in 1963 each load was sampled separately and a " route " therefore includes only one load.

infected food-handlers. Such a connexion was demonstrated twice in the 1963 outbreak.

Kowloon was free of cases between 4 and 28 September 1963. In the following 14 days 25 cases were notified, 17 of which were considered to have a direct or indirect association with a restaurant in north Kowloon. Five cases occurred between 29 September and 2 October, all of them among persons who had taken meals at the restaurant. From 5 to 12 October, a further eight cases were notified in persons who were domestic contacts of people who had eaten at the restaurant. Between 9 and 11 October, four more cases occurred among persons who had bought food at the restaurant for consumption off the premises, or had taken meals at food stalls the owners of which ate at the restaurant.

Investigation of the restaurant was started after the first notified case, and 34 of the 108 employees were found, on rectal swabbing, to be carriers of *V. cholerae*. Twelve carriers were discovered from the first rectal swab, 9 from the second, 7 from the third, 3 from the fourth, 2 from the fifth, and 1 from the seventh.

The spread of infection at the restaurant was considered to be by direct contact with an employee who was a carrier, or by a carrier handling food that was consumed by the patient.

Two further cases were associated with a restaurant in south Kowloon in which one of the cooks was found to be a carrier.

RELATION OF CASES TO NIGHTSOIL INFECTION

During the first 14 weeks of the 1963 outbreak (up to 4 October), when infection was sporadic, 41 cases were notified, of which 20 occurred in users of dry latrines served by nightsoil collection routes; in the same period 173 nightsoil infections were reported. Each case was located according to the route used, and the time between notification of the case and the nearest infection of the nightsoil route was noted.

Of the 173 nightsoil infections, four were followed within six days by a cholera case, while three cases occurred six days or less before the route used became infected. The other 13 cases bore no close relationship to infection of the route used. As this would give only a 1-in-43 chance of forecasting the location of cases, it became clear that it was not a practical application of the sampling scheme.

FIG. 5

NUMBER OF CHOLERA CASES AND INFECTIONS ON NIGHTSOIL ROUTES, 1963

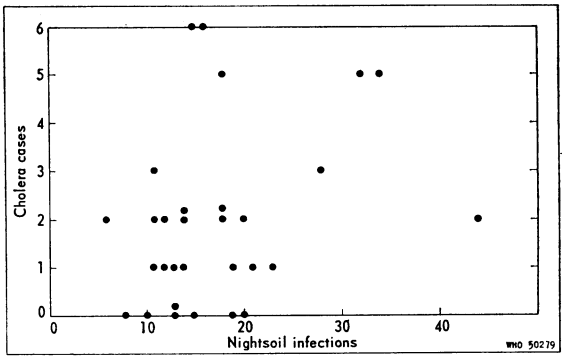


Fig. 4 also shows the absence of a direct time relationship between cases and infections. Weeks with a large number of cases do not coincide immediately with a rise in infections which, in fact, showed a tendency to occur approximately a week later and to continue rather longer than a rise in the number of cases.

At the end of the year, the number of infections of each nightsoil route was estimated together with the number of cases (omitting those known to have used flush latrines). The number of infections on a single route varied from 6 to 44 and the number of cases from 0 to 6, but again nothing more than a chance relationship between cases and infections could be detected. This is shown in Fig. 5: the routes with the highest total of infections are not those with the most cases, and *vice versa*.

TRACING OF SOURCES THROUGH NIGHTSOIL SAMPLING

The three main objects of the nightsoil sampling scheme were:

(1) to forecast when and in what area a future outbreak of cholera was likely to occur;

(2) to determine when the outbreak was over and the Colony free from infection; and

(3) to trace infection to its source and to study its spread within the Colony.

When in 1962 the infection of a nightsoil collection route was traced back to an infected pail which had probably been used by a patient, it was hoped that these objects might be attained. The outbreak subsided before the experiment could be carried further, but 1963 provided new opportunities to

TABLE 7
RESULTS OF NIGHTSOIL FOLLOW-UP SCHEME 1963
(28 JUNE TO 4 OCTOBER)

Stage to which infection was traced	No. of occasions on which infection was traced from previous stage	Percentage of previous stage	No. of separate sources traced (total: 97)	Average no. of sources traced from each infection
Vehicle	175	—	—	—
Hopper	30	17	67	2.2
Pail	9	30	16	1.8
Carrier	7	78	14	2.0

test the scheme. In the event, the outbreak started without warning, and the first two cases occurred four days before the first positive nightsoil samples were reported. The infected routes were not those on which cases occurred, and the route that served case 1 (and also case 4) was not infected for over a month.

Thus the first object was unfortunately not achieved; the second was achieved to some extent, but by far the most useful information was obtained in the tracing of sources of infection.

Infections traced during 1963

In 1962, 18 sources of infection were detected in Kowloon by nightsoil sampling; two of these were traced to hoppers only and three to pails. Although no positive rectal swabs were obtained, one infection was probably traced to its source. The scheme was pursued for a longer period in 1963, and the number of infections traced at each stage of the sampling process is shown in Table 7. Out of 175 separate vehicle infections, 30 were traced to hoppers, of which 67 were found to be infected, an average of 2.2 hoppers from each vehicle successfully followed up (the maximum was 13 hoppers from one vehicle); 9 infections in hoppers were traced to pails, and by following up 7 of these 14 carriers were detected.

A positive report on a nightsoil vehicle means that cholera vibrios have been cultured from a few drops of nightsoil from one tank load containing the 24-hours' excreta of 12 000 to 15 000 people. As samples are taken during unloading, thorough mixing should have taken place in the tank, but even so the chances of detecting vibrios must be small. But at each stage of the investigation, the quantity of nightsoil from which the sample is taken becomes smaller. It is therefore not surprising that the percentage of infections traced further increased at each stage.

Estimated number of infections in the community

The number of sources assumed to have been traced further back than a vehicle was 97. But if every infection in a vehicle had been successfully followed up and if the same average number of sources had been detected at each stage, it is evident from the figures given in the last column of Table 7 that the number of sources would have been $2.2 \times 1.8 \times 2.0$, or approximately 8 times as great. Although the follow-up scheme had to be abandoned in October 1963, it was possible to continue the full sampling of vehicles. From the information obtained from over 1000 positive reports on vehicles, it was estimated that 522 separate infections occurred during the year, and on this basis they would have indicated the existence of over 4000 sources.

The figure of 522 vehicle infections is probably less than the true figure. During the first three months of sampling, relatively few routes were infected and the total is probably representative; but for one month in Kowloon and nearly two in Hong Kong virtually every route was continuously infected. A positive report from a vehicle can be recorded as only one infection however heavy the infection may be—present methods cannot detect more than one infection at a time—and there is no reason why a positive sample at the height of the infective period should not have represented more than one infection. If a graph of the weekly infections were drawn on the basis of Fig. 3, it would be seen to have a "flat top" during the periods of maximum infection, and it is likely that this should in fact have been replaced by a considerably higher peak.

In calculating the probable number of infective sources, it will be realized that the 4000 estimated above occurred in only 25% of the population—those using the nightsoil collection service. There is no reason to suppose that infection was confined to users of dry latrines, and the absence of a clear relation between cases and infections (Fig. 4) indicates infection throughout the total population to a varying degree. It cannot be assumed that the infection rate among those who used flush latrines and those who used dry latrines was the same, and it will be seen from the first two lines of Table 5 that in comparable groups of tenement dwellers the case rate among dry latrine users was about three times that among users of flush latrines, who have generally better living conditions. However, allowing for a fairly high infection rate among squatters with no conservancy services, it is probable that there were at least 10 000 separate infections in the Colony during the year.

OTHER EVIDENCE OF INFECTION IN THE COMMUNITY

As soon as any case was notified, all contacts were rounded up and placed in an isolation centre for six days. Rectal swabs were taken daily, and if one was found positive the contact was given a course of streptomycin. In 1963, 70 carriers were discovered in this way among 1781 case contacts; 34 carriers were found among the restaurant workers already mentioned. It was thought that random sampling of the population might therefore reveal at least a small proportion of carriers. It was found possible to sample four groups, and the results are shown in Table 8.

It is particularly significant that in the sample groups only one carrier was found, and that was among the nightsoil coolies, who above all were exposed to the risk of infection (though well protected by inoculation). There is no simple explanation of the failure to detect carriers, though it is not hard to understand that the taking of a single rectal swab might be a less reliable means of detecting vibrios than sampling the complete bowel contents even after passage first into a latrine pail and then into a tanker. Smith et al. (1961) have pointed out that the excretion of vibrios may be limited to a very short period even in cases of frank cholera.

The number of carriers found in the population was 119, made up of 70 case contacts, 34 restaurant workers and one nightsoil coolie, together with 14 found during the follow-up of nightsoil infections.

TABLE 8

DETECTION OF CHOLERA CARRIERS IN SELECTED POPULATION GROUPS

Group investigated	No. sampled	No. pos.
Applicants for identity cards	1 060	0
Illegal immigrants	539	0
Prisoners on remand	807	0
Nightsoil collection coolies	905	1
All groups	3 311	1

DISCUSSION

The outbreaks in 1961 to 1963 posed two questions: firstly, how the disease was introduced into the Colony; and secondly, how it was maintained during the years with such long intervals between cases and with such low over-all incidence. There is little doubt that in 1961 Hong Kong had been free of cholera for 15 years and that the disease was first reintroduced by fishermen and boat dwellers from neighbouring countries where the disease was established. Felsenfeld (1963) has reported that the disease was endemic in the Celebes throughout 1961 and has traced its spread throughout the west Pacific in that year and 1962.

The first case reported in Hong Kong was in a child in a fishing village whose inhabitants had contact with the mainland of China, four miles away; the next two were also boat people, but thereafter infection spread rapidly throughout the Colony. In 1961 the incidence in the floating population was 4.72 per 100 000 compared with 2.42 in the whole Colony; apart from the 22 cases among boat dwellers there was a tendency for cases to appear round the coast generally. In 1962 this association with the sea was lost. The first patient lived in central Kowloon and had no known connexion with places abroad. During the year there was only one case among boat dwellers and one in the New Territories, the other nine being widely spread through the urban area (see Fig. 3).

In 1963 evidence as to the origin of the outbreak was ambiguous: during June there were strong rumours of cholera occurring in adjoining Chinese territory and, more particularly, in Macao. The first patient was a lorry driver who worked at the

wharves, where produce including shellfish from Macao was off-loaded. It was natural to suspect introduction from abroad, though the evidence was not conclusive.

But the second case, which was reported one day after the first, confused the picture. The patient was a woman living in a multi-storey resettlement estate in north-west Kowloon (almost at the opposite end of the urban area from the first case) and no connexion with places abroad could be established, nor had she consumed food such as shellfish from Macao. The estate is provided with flush latrines and running water, and the woman had not been out of her room since giving birth to a child three weeks before.

The third patient was a New Territories fisherman on a boat which had had very recent contact with infected areas, while the fourth, a woman whose husband was also a lorry driver, lived close to the first. The locations of these four cases are indicated in Fig. 3.

The first cases developed a few days after a Chinese festival at which large crowds gather by the sea to watch boat races—an example of the traditional association of cholera with fairs and festivals. Some had contact with overseas territories from which, as in 1961 and 1962, there were either reports of outbreaks or rumours of cases before the disease appeared in Hong Kong, but other cases developed in widely distributed locations throughout the Colony with no detectable connexion with places abroad.

Though about 30 000 nightsoil samples were taken between 13 October 1962 and 27 June 1963 without positive results, even this cannot be taken as proof of freedom from infection, particularly since the first two cases in 1963 occurred four days before nightsoil infection was detected. The evidence as to whether infection lay dormant between the years 1961, 1962 and 1963, or whether it died out and was reintroduced each year from outside is therefore inconclusive, and the answer will never be known.

With regard to the method of spread, neither water nor food can be said to have played more than a small part in Hong Kong outbreaks. Each was involved in a small group of cases only, and these were the groups where some localization occurred as compared with the otherwise sporadic nature of the outbreak.

The only samples giving consistently positive results for *Vibrio cholerae* were those taken from the immediate environment of patients: latrines, both dry and flush, drain outlets, kitchen utensils, and, in one case, an infected cockroach.

D. J. M. Mackenzie [1] therefore drew attention to the probability of person-to-person spread as a major factor in Hong Kong. Seal et al. (1956) reported that 7% of cases in Calcutta had had contact with other cholera patients. De, Bhattacharya & Mondal (1957) claimed a figure of 34% in the same city but Pollitzer [2] concluded that direct contact was of little importance there. In Hong Kong in three years no direct household contact was established between two cases at any time. In fact, the occurrence of one case seemed like a talisman protecting the remainder of the household from disease. Had there been heavy or localized incidence, direct case-to-case spread would be easy to understand, but the sporadic nature of the outbreaks, and the distances and time intervals between cases, make transmission difficult to explain unless there exists a large reservoir of symptomless carriers among the population.

The results presented here support this hypothesis. In 1963, 109 urban cases occurred in six months. The whole of Kowloon was without cases for 24 days in September, while smaller areas were free for much longer periods. Apart from the two areas in which there was a definite concentration of cases, there was no tendency for any case to appear in the same area as a previous one, but rather for cases to occur sporadically with an almost random distribution throughout the Colony.

The figures for infections are little more than informed guesswork, but if they are accepted they suggest that about 1 in 300 of the population may have been infected at some time, which may be compared with the case-incidence of 1 in 30 000. This level of infection was not reached at one time but spread, like the cases, over six months. As it is probable that a source normally remains infectious for about a week, the level of infection at any time must have been well below this. Nevertheless, these results make the hypothesis much more feasible than simple case-to-case spread. Undoubtedly, many other factors are at work to account for the continued maintenance of an outbreak with the development of so few cases of frank disease.

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[1] In an address to the Hong Kong Branch of the Society of Medical Officers of Health, August 1963.

[2] *Review of the recent literature on cholera*, unpublished working document WHO/Cholera/25.

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RÉSUMÉ

En août 1961, le choléra fit une brusque apparition à Hong Kong. Dans l'espace de six semaines, on dénombra 77 cas et 15 décès, sur une population de près de 3,5 millions d'habitants. Onze cas furent diagnostiqués en 1962, et 115 en 1963, mais l'affection cette fois prit une allure sporadique: les cas décelés en divers points de la ville étaient sans relation apparente, à l'exception de 17 infections cholériques dont l'origine alimentaire commune put être démontrée.

Les auteurs ont tenté, à cette occasion, d'élucider l'épidémiologie de l'affection par le prélèvement d'échantillons de matières fécales dans les véhicules servant à l'évacuation de la gadoue. Mis en œuvre occasionnellement au début de 1962, le procédé fut systématiquement appliqué dès septembre de la même année après la découverte d'un premier échantillon positif.

On put, à plusieurs reprises, remonter à la source de l'infection et démontrer, par l'examen des selles, l'existence d'un nombre considérable de cas sub-cliniques parmi la population. Les auteurs évaluent à plus de 500 le nombre des sources d'infection distinctes, chiffre correspondant à un total de 10 000 personnes infectées, en 1963, pour l'ensemble du territoire.

Ces observations suggèrent que la transmission de l'infection par l'eau et les aliments est exceptionnelle. Il est d'autre part difficile d'expliquer que, en 1963, 115 cas de choléra seulement aient été constatés sur une population de 3,5 millions de personnes, si l'on admet la propagation d'un cas à un autre. L'hypothèse la plus plausible est qu'il existe un nombre très important de porteurs asymptomatiques et que la transmission de l'infection se fait de personne à personne.

REFERENCES

De, S. N., Bhattacharya, K. K. & Mondal, A. (1957) *J. Indian med. Ass.*, **28**, 514

Felsenfeld, O. (1963) *Bull. Wld Hlth Org.*, **28**, 289

Felsenfeld, O., Jatanasen, S., Buspavanich, S., Thavaramara, B., Nanthavanij, S., Morgan, F. M. & Panniom, W. (1961) *J. trop. Med. Hyg.*, **64**, 207

Mackenzie, D. J. M. (1961) *Report on the outbreak of cholera in Hong Kong*, Hong Kong, Government Press

Mok, K. C. (1963) *Population projections 1961-71*, Hong Kong, Government Press

Seal, S. C. et al. (1956) *Indian J. publ. Hlth*, **1**, 9

Smith, H. L., jr, Freter, R. & Sweeney, F. J., jr. (1961) *J. infect. Dis.*, **109**, 31

Viterbo, G. H., Abalo, E., jr, Curry, F. & Munoz, E., jr (1962) *J. Philipp. med. Ass.*, **38**, 306

Yeoh, G. E. & Teoh, T. M. (1961) *Trans. roy. Soc. trop. Med. Hyg.*, **57**, 46