Cholera in the Kedah River area

by Paul C.Y. Chen
MBBS, MPH (Harvard), SM in Hyg.
Department of Social and Preventive Medicine,
Faculty of Medicine,
University of Malaya,
Kuala Lumpur.

INTRODUCTION

DURING the months of December 1963 to April 1964, an outbreak of El Tor cholera occurred in the state of Kedah, West Malaysia. During this period, a total of 83 cases, including 11 deaths and 60 carriers, were reported. Seventy-five of these cases, including the 11 deaths and 56 of the carriers, were reported from the Kedah River area, this being defined as the area within two miles of the Kedah River, its tributaries and irrigation canals with connection to these waters. It is the purpose of this paper to consider some of the epidemiological and ecological observations made in relation to the outbreak in the Kedah River area.

THE KEDAH RIVER AREA

The Kedah River flows through the low-lying Kedah plain and has two main tributaries, the Sungei Besar in the north and the Sungei Tajar in the south. For the purpose of this report, the area served by any of the canals or tributaries with connection to the western bank of the Sungei Besar will be designated as area "A". The eastern bank and eastern tributaries of the Sungei Besar will be designated as area "B", while the area drained by the Sungei Tajar and its tributaries will be designated as area "C", as depicted in Maps 1 and 2.

On the basis of such a division, area "B" would contain Alor Star town in the south and Kepala Batas airport in the north. It is a relatively densely-populated area with good roads, piped water, electricity and telephones. Economically, it is the most developed of the three areas under consideration. The majority of houses have private connections to the water mains. In addition to this, a total of 57 standpipes were available at the outset of the outbreak.

Area "C", on the other hand, is the least developed of all the three areas. It consists of villages arranged in a linear fashion on both banks of rivers and canals. Beyond these villages stretch the padi-fields. These rivers and canals serve as waterways, for fishing, for washing and bathing, as a source of drinking water, especially when the dry season arrives and the wells dry up, and also as a means of excreta disposal. No water main exists in this area and the main sources of drinking water are wells and the river especially when the drought affects well water supplies. Figure 1 depicts a cross-section through a small river showing the arrangement of padi-fields, houses and surrounding fruit trees, waterways and overhung latrines.

Area "A" is intermediate between the last two areas in that although it resembles area "C" in most

aspects, it has a water main from which 26 standpipes supplied some of the more fortunate villagers at the outset of the outbreak. In the north of area "A" stretches a network of irrigation canals. At some points, these canals have connections to the Kedah River, but throughout the duration of the cholera outbreak these connections were kept closed.

Fig. 1: A diagrammatic representation of a cross-section of a small river showing padi-fields, houses surrounded by fruit trees, and overhung latrines.

EPIDEMIOLOGICAL OBSERVATIONS

1. The occurrence of cholera cases and carriers

(a) The initial phase of the outbreak

The first case that occurred in the Kedah River area, occurred in Kampong Elir, on the upper reaches of the Gunong tributary of the Kedah River. This was a 26-year-old Malay labourer employed at a granite quarry at Gunong. He was stricken with cholera and died at home on December 7, 1963. Diagnosis was based on a positive culture obtained by post-mortem rectal swabbing. At the time of his death, a new coastal road linking Perlis to Alor Star that ran past Gunong was under construction, and was opened only to Public Works Department lorries. The first case of cholera in Perlis occurred along this road on November 26, 1963. Investigations revealed that the dead man had disappeared for about two days some two weeks before his death, and that two days before his death, another labourer from the same area had been admitted into hospital with diarrhoea and vomiting but had been discharged the following day after improving. No rectal swab had been obtained and it is not known whether he was suffering from cholera. The possibility that the case was linked to the outbreak in Perlis will be discussed later.

The second case occurred 18 days later on December 25, 1963, and involved a 59-year-old Malay man who died some 8½ hours after admission into hospital. Prior to his death, he had been visited by one of his daughters accompanied by her three children, all of whom lived in the same village as the granite quarry labourer. Further, this woman had attended the funeral of that labourer.

This was followed by a lull of one month when on January 26, 1964, a 31-year-old Malay woman, who lived a little downstream of the granite quarry labourer, developed cholera. She had a habit of bathing in the river and of drinking from it. A member of her household contacts was found to be a carrier. Thus, during the period December and January, three cases (of which two were deaths), and one carrier were reported in the Kedah River area, all occurring in the northern part of area "A". The location of the three cases are marked as black triangles in Map 1.

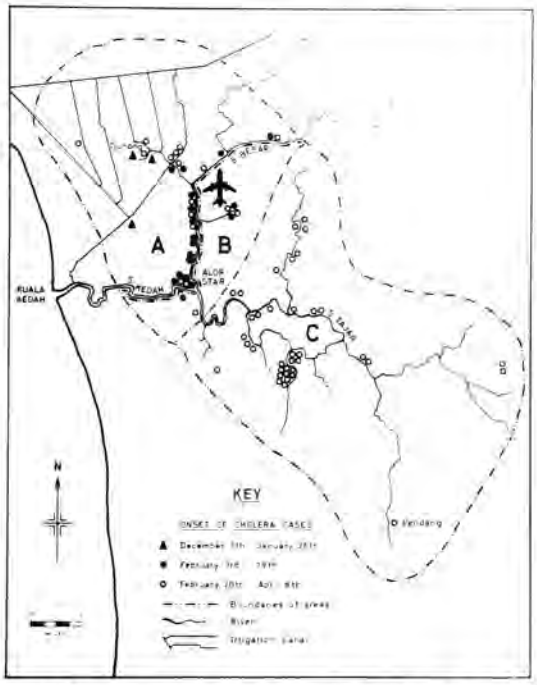
(b) The massive phase of the outbreak

On February 3, 1964, the outbreak moved downstream and the first case occurred in the southern part of area "A" at Seberang Terus, just outside the Alor Star Town Council area. On February 8, a further case occurred and this was followed by a series of cases so that between February 3 and 19, there was a total of 18 cases and 20 carriers. These 18 cases are marked in Map 1 as black spots and are confined to areas "A" and "B" on both banks of the Sungei Besar. Of these 18 cases and 20 carriers, only three cases and two carriers were reported in area "B". This disproportionate distribution of cases and carriers between the two areas will be discussed later. Thus up to February 19, the Sungei Tajar area, area "C", had not been involved.

On February, 20, the first case occurred in area "C". In the meanwhile, the outbreak had begun to decline in areas "A" and "B". On March 6, the last case and carrier occurred in these areas, bringing the total reported cases and carriers in the massive phase for area "A" to 29 cases and 24 carriers, and that for area "B" to six cases and two carriers. Meanwhile, the outbreak continued in area "C" and reached its peak on March 7. Thereafter, the incidence began to drop and by April 8, when the last case occurred, there was a total of 37 cases and 29 carriers in area "C". The geographical distribution of cases is summarised in Map 1, where the initial three cases are marked as black triangles, the 18 cases occurring between February 3 and 19, by black spots, and the remaining 54 cases occurring thereafter by white spots. The daily occurrence of cases and carriers in areas "A" and "B", and in area "C" during the massive phase of the outbreak is summarised in Figure 2.

(c) The origin of the outbreak

The first case of cholera in Perlis occurred on



MAP 1: Map showing the division of the Kedah River area into areas "A", "B" and "C", and the distribution of cholera cases therein.

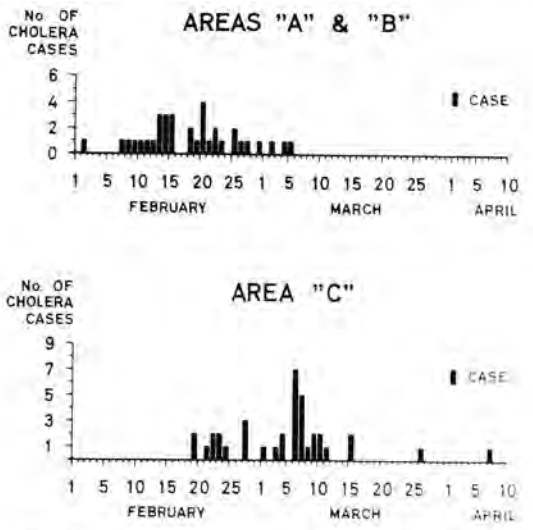


Fig. 2: The daily incidence of cholera cases during the massive phase of the outbreak in the Kedah River area in February, March and April 1964.

November 26, 1963, 11 days prior to the onset of the outbreak in the Kedah River area, and involved a 65-year-old Malay woman. She lived next door to her daughter who was the second wife of a Thai Malay. This man possessed a border pass and constantly shuttled between southern Thailand and Perlis. His last visit to Thailand had been to Songkhla between November 3 and 10, 1963. Since July 24, 1963, the province of Songkhla in southern Thailand bordering on Perlis and Kedah, had been from time to time reporting the occurrence of cholera cases. In the week November 3 to 9, no cases were reported from Songkhla, but in the following week, November 10 and 16, 22 cases and six deaths were reported. In all probability, the Thai Malay was at that time a healthy carrier and might have been the source of infection of his mother-in-law, who lived 5½ miles from Kangar along the new coastal road linking Kangar to Alor Star via Gunong. As has been pointed out, the first case in the Kedah River area lived along this same road at the Gunong end. Although no direct link between these two cases was established, the possibility that the outbreak in the Kedah River area might have been linked to the one in Perlis cannot be discounted.

2. Age and Sex Distribution

Of the 75 cases reported, there were 38 males and 37 females, including six deaths among the males and five deaths among the females. Among the 56 carriers detected, there were 27 males and 29 females, there being statistically no significant difference in the distribution between the sexes.

The mean age of the cases and of the carriers for both sexes, as computed from the original data available from investigation sheets, is summarised in Table I. For comparison, the mean age for both sexes for the general population of Kedah, from the census of 1957, is included. The age distribution by five-year age intervals for the two sexes for both cholera cases and carriers, is shown in Figures 3 and 4.

The standard error of the difference for the data in Table I is 4.5 years, the difference between the mean ages of the cholera carriers and of the general population, Kedah, for both sexes being statistically not significant. However, the difference between the mean ages of the cholera cases and of the general population for both sexes is statistically highly significant, $p = 0.00003$.

Thus, it would appear that cholera cases were relatively more commonly reported in the older groups than the age distribution of the general population would suggest. On the other hand, the

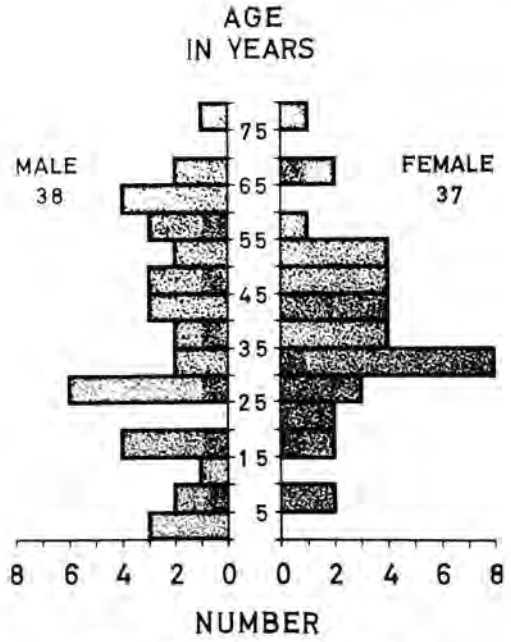


Fig. 3 Age distribution of cholera cases by five-year age intervals.

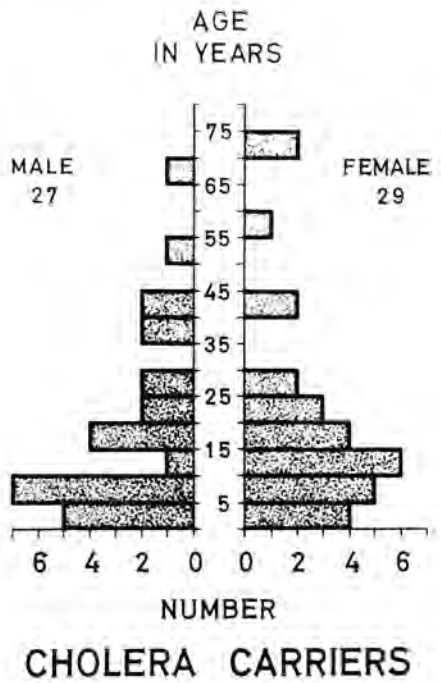


Fig. 4: Age distribution of cholera carriers by five-year age intervals.

distribution of carriers followed that of the general population. This is similar to the findings in Taiwan (Yen, 1964). Dizon **et al.** (1965), studying an outbreak in the Philippines, noted that "the attack rate among those of 20 years of age and older was more than twice that of the population under 20 years of age. The noted higher attack rates is similar to past El Tor outbreaks in Sulawesi and is also characteristic of Asian cholera." Tamayo **et al.** (1965) suggested that there were factors, more common in adults, that predisposed to the manifestation or recognition of the disease. Further investigation is certainly indicated in this field.

TABLE I

Mean age in years of cholera cases, carriers, and the general population of Kedah by sex.

Group	Sex	Mean age in years
Cholera cases	Male	36.6
	Female	36.1
Cholera carriers	Male	18.5
	Female	18.5
Kedah population*	Male	17.7
	Female	17.3

*Census of 1957

3. Ratio of carriers to cases

When the carrier-case ratios are compared for various age groups as summarised in Table II, a very striking feature stands out, namely that although the overall ratio of carriers to cases for all age groups is approximately 0.7:1, the ratio is 3.5:1 for the age group 0-14 years and only 0.2:1 for the age group 45-79 years, indicating a preponderance of carriers over frank cases among subjects below the age of 15 years and a preponderance of frank cases over carriers in the higher age groups. Fairly similar findings were reported by Yen (1964) from Taiwan.

4. Household cases

The 75 cases were studied to determine the frequency of households with multiple recorded cases. Examination revealed that there were six households (9%) out of a total of 67 in which there were multiple cases. In four of these six households, the household cases occurred on the same date as the index case. In the remaining two households (3%), the secondary cases occurred later, namely five and seven days after their respective index cases.

The occurrence of the household cases on the same date as the relevant index case in the four households seems to suggest that household cases,

TABLE II
Cholera carrier-cases ratios by age

Age-group (Years)	No. of carriers	No. of cases	Carrier-case ratio
0 – 14	28	8	3.5 : 1
15 – 24	13	8	1.6 : 1
25 – 44	10	32	0.3 : 1
45 – 79	5	27	0.2 : 1
TOTAL	56	75	0.7 : 1

and the index case for each of the households, showed a common source or a common contact. On the other hand, the remaining two household cases, occurring five and seven days after their respective index cases, would be consistent with a secondary spread from index case to household case. Nevertheless, what is apparent is that the majority of cases (91%) occurred as the only case in the household.

Dizon **et al.** (1965) found that 3.6% of households contained multiple cases. They also noted that this was characteristic of the El Tor outbreaks in Sulawesi and suggested that either the infection, once introduced into a community or household, did not spread easily or that infection caused significant disease on rare occasions only. Van de linde and Forbes (1965) noted that "in Hongkong 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."

5. Inoculation status

The inoculation status of cholera cases and of their household contacts, at the time of the reporting of each individual case, was investigated. The investigations included a rectal swab for culture of **Vibrio cholerae**, investigations into the inoculation status of all contacts, and the collection of other relevant epidemiological information. A total of 320 household contacts were thus investigated in the Kedah River area, of whom 56 were found to be carriers.

Inoculation status has been summarised into two categories, "valid" and "non-valid/nil". A "valid" inoculation, on the same basis as international requirements, is defined as one given six or more days but not longer than six months prior to the onset of symptoms in the cholera case in question or in the index case of that contact in question. A "non-valid/nil" inoculation, on the converse, is defined as one given within six days or longer than six months prior to the onset of symptoms in the cholera case in question or in the index case of that contact in question, and includes the unvaccinated. The inoculation status of the 75 cases, 56 carriers and 264 negative contacts is summarised in Table III.

Comparison of the distribution of "valid" and "non-valid/nil" inoculations among the three groups of individuals by the chi-square test showed that there was no significant difference in the distribution among them (p = greater than 0.1). It would therefore appear that anti-cholera inoculation conferred little if any protection during the outbreak in the Kedah River area. The Philippines Cholera Committee (1968), carrying out a controlled field trial, noted that the cholera El Tor vaccine used conferred more than 50% protection for a period of at least six months against El Tor infection. Mosley **et al.** (1969) noted in their field trial in East Pakistan that "a single injection of cholera vaccine reduced the cholera case rate by 46% while the 2-injection schedule had an effectiveness of 64%". They also noted that "a significant level of protection was maintained for only about three months." In the Kedah River area, many different preparations from various sources were used.

ECOLOGICAL FACTORS

1. Pollution of the Kedah River

In the early stages of the outbreak, the whole of the Kedah River area was dotted with hundreds of overhung latrines. Typically, these consist of a simple makeshift arrangement of a few boards secured together as a squatting platform built upon piles driven into the shallows of the river or canal running past the house, the structure being discreetly located among bushes or surrounded by some cover to provide some degree of privacy. A photograph of an example is shown in Figure 5. Not only did these overhung latrines abound in the remoter areas, but several existed within the Alor Star Town Council area.

A second method of excreta disposal fairly common in the Kedah River area is indiscriminate depositing on to soil around nearby bushes – soil which often drains into adjacent streams, canals or padi-fields. A few pit-latrines existed in the area. Many more were added as a result of the cholera control programme.

During the period March 8 to April 5, 1964, a total of 30 samples of raw river water were obtained and cultured for the cholera vibrio. Twenty-one of these samples were taken from the headworks of the Bukit Pinang Water Works while the remaining nine

TABLE III
Inoculation status of cholera cases, carriers and negative contacts

Group	Inoculation status				
	"valid"		"non-valid/Nil'		Total
	NO.	%	No.	%	
Cases	30	40.0	45	60.0	75
Carriers	21	37.5	35	62.5	56
Negative contacts	131	49.6	133	50.4	264
TOTAL	182	46.1	213	53.9	395

samples were taken from other stretchs of the Kedah River. Only one sample, taken at low tide on March 8 at Limbong in area "C", yielded a positive culture of **Vibrio cholerae** (Ogawa type). The position of this site is shown on Map 2 as a spot within a circle.

The Institute for Medical Research (1915) observed that "cholera vibrios inoculated into water drawn from the river at Alor Star could be recovered from it as long as 80 days thereafter and that . . . similar numbers of cholera vibrios inoculated into similar quantities of Kuala Lumpur tap water were dead in less than 24 hours in nearly every case." It was suggested that this was due to the inorganic salt content rather than to the organic content of the waters.

2. Rainfall

The onset of the cholera outbreak coincided with the beginning of the dry season and was at its height during the driest month of the season, February

Fig. 5: In the foreground is an overhung latrine, while in the background can be seen a house surrounded by fruit trees.

1964. This relationship between the outbreak and rainfall is summarised in Figure 6 where the monthly incidence of cholera cases is plotted along with the monthly rainfall as recorded at the meterological station at Kepala Batas Airport, Alor Star. The dry season of January, February and March 1964 was a particularly dry one. The average monthly rainfall during those three months for that year was much lower than during corresponding months for the previous years of 1961, 1962 and 1963, as shown in Table IV. During this particularly severe season, many wells that usually survived the dry season were affected.

3. Water supplies

The people of the Kedah River area obtain their water supplies from three main sources, namely tap water, well water and river.

(a) Tap Water Supplies

The main source of tap water is from the Bukit Pinang Water Works. The Sungei Besar tributary of the Kedah River is tapped at Bukit Pinang, filtered, chlorinated and stored at two reservoirs from which the supply is distributed mainly to area "B", the town of Kuala Kedah at the mouth of the Kedah River, and along the trunk road south. In area "B", a total of 57 standpipes and a large number of individual house connections existed at the time of the outbreak. A second source of tap water is from the Bukit Wang Water Works. Water is tapped from a catchment area in Kubang Pasu District and the only form of treatment rendered is chlorination. Apart from supplying those living in Kubang Pasu District, a main flows along into area "A", in which a total of 26 standpipes existed at the outset of the outbreak. Few individual house connections existed then.

(b) Well water

A number of unprotected earth wells exist in the area, especially in areas "A" and "C". A few semi-protected wells, constructed under the Rural Development programme, also exist. However, as the dry season in early 1964 was a particularly severe one, most of the wells dried up and were of little use.

(c) River water

Except for area "B" where tap water is readily available to most people, river water formed the main source of water for bathing, cooking, drinking and personal ablution for most of the people, as was indicated by the investigations. Although there was a water main from the Bukit Wang Water Works

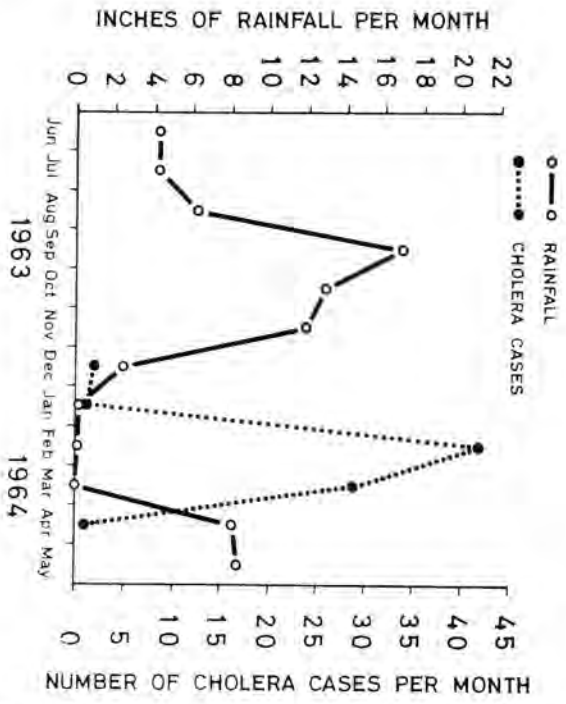


Fig. 6: The incidence of cholera cases in relation to rainfall.

TABLE IV
Average monthly rainfall for the years 1961 – 63 and 1964

Month	Average monthly rainfall in inches)	
	1961 – 63	1964
January	1.37	0.14
February	1.01	0.11
March	3.81	0.03

running into area "A", few houses had connections since the cost of connection was beyond the means of the majority. In area "C", no water main existed. Further, due to the unusually dry period, the majority of wells dried up. Thus, during the initial part of the dry season, the majority of the people in both areas "A" and "C" were using the river as a source of water. One of the control measures, and probably the most important one, was the provision of potable water to the affected areas. The villagers were warned that the rivers and canals were polluted and dangerous. Approximately 90 standpipes were installed along existing water mains during February and March. In addition, a temporary water main was

brought across the Kedah River to Seberang Nonya, where six cholera cases and seven carriers were reported. In early March, water was supplied by lorries and boats to various affected areas. Approximately one million gallons of water each day was supplied in this manner to these areas, during that period.

It should be pointed out that the tides affected the Kedah River and its effects could be felt several miles upstream, particularly since the water level in the river had dropped unusually low as a result of the severe drought. As a result the river water was used mainly when the tide was low and the salinity at its lowest. Nevertheless, the water remained palatable along most tributaries of the Kedah River. However, where salinity remained high, particularly towards the mouth of the river at Kuala Kedah, the water was not used.

4. The distribution of cholera cases and the salinity of the Kedah River

The salinity of the river water was tested at 15 different sites along the Kedah River and its related irrigation canals. A total of 85 samples, taken at these various points between March 2 and 11, were sent to the Department of Chemistry in Penang for analysis. Salinity values were reported in terms of parts of thousand (o/oo) values below 0.1 o/oo being reported as "insignificant." The 15 sites at which the samples were drawn are marked in Map 2. Those with salinity values of 0.1 o/oo or more at any time are marked with black squares, while those where salinity was consistently "insignificant" are marked as white squares. The results of the salinity tests are summarised in Table V and in Map 2.

Read **et al.** (1939) established, in the course of their investigations, that "in the absence of salt, multiplication did not occur in any peptone concentration and in no case did survival reach 24 hours." They also noted that multiplication of **Vibrio cholerae** was observed in the case of 1/500 peptone water at a salt concentration as low as 0.075 o/oo.

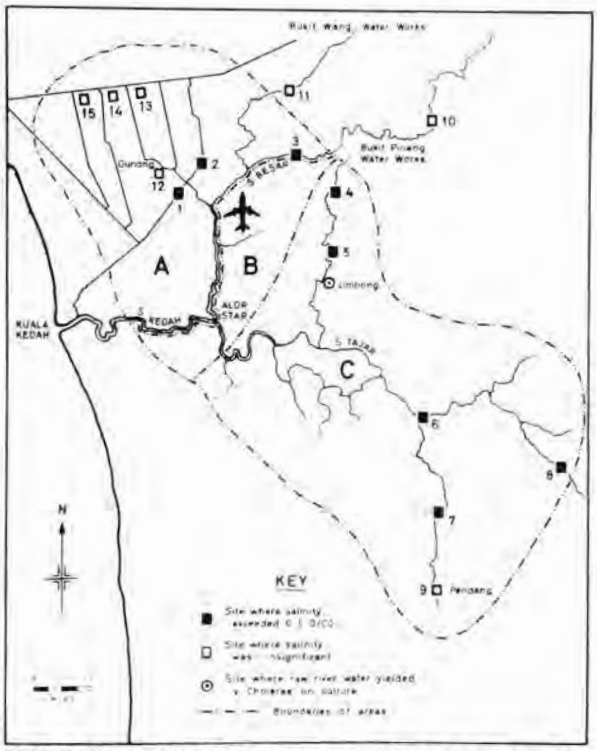
It will be noted that, with the exception of six cases occurring in the Gunong and the related irrigation canal areas and one occurring in the Pendang area, all other cases, totalling 68, occurred in proximity to areas of the Kedah River where salinity exceeded 0.1 o/oo. Further, it should be noted that the Gunong and related irrigation canal areas have a population excess of that for the remaining parts of area "A". Where salinity was sufficiently high to make the river water unpalatable, as at Kuala Kedah, no cholera cases were reported.

DISCUSSION

It would appear that in the initial phase of the cholera outbreak during the months of December and January in which three cases and one carrier were

TABLE V
Salinity of water samples taken from
15 sites in the Kedah River area
between March 2 and 11, 1964

Site Number	Site of Sampling	Number of samples	Range of salinity in parts per thousand
1	Sg. Baru Bridge	10	1.83 to 24.17
2	Sg. Baru A. Melintang	10	1.83 to 24.13
3	Kepala Batas Bridge	10	0.21 to 5.32
4	Sg. Langgar, Masjid Lama	5	1.41 to 1.63
5	Sg. Langgar Bridge	10	1.41 to 2.10
6	Titi Haji Idris	3	1.82 to 1.97
7	Pekan Tanah Merah	10	0.15 to 1.82
8	Kg. Paya Rawa, Sg. Rambai	5	Insignificant to 0.26
9	Pendang	5	Insignificant
10	Kg. Lubok Batu I	4	Insignificant
11	Sg. Tg. Pauh, Kg. Chegar	5	Insignificant
12	Gunong Keriang	2	Insignificant
13) 14) 15)	Jalan Sanglang, Canals 1, 2 and 3	6	Insignificant
	Total Number of Samples	85	



MAP 2: Comparison of this map with Map 1 shows that the majority of cases occurred in areas of high salinity, from which also was obtained the only sample positive for *Vibrio cholerae*.

reported, the infection was carrier-borne. The three cases were separated in time by 18 and 32 days from one another. They occurred during the early phase of the dry season and in an area with "insignificant" salinity. On the other hand, the subsequent phase was characterised by the massiveness and speed associated with a common source of infection, such as a polluted communal water supply. With the exception of the last two cases, occurring on March 27 and April 8, the interval between cases was very short and in no case longer than five days. The peak of the outbreak in areas "A" and "B" occurred 11 days after the onset of the massive phase of the outbreak, while that in area "C" occurred ten days after the first case occurred in this area.

It appears that it was a combination of many factors that led to the massive phase of the outbreak. They may be classified into two groups – the predisposing factors and the precipitating factors.

(a) Predisposing Factors:

Chief among these was the excremental pollution of the rivers via overhung latrines. The second predisposing factor was the use of river water for drinking, unboiled, by people who were not aware of the danger involved.

(b) Precipitating Factors:

Primarily there was the importation of cholera vibrios from Perlis by a human carrier into the Kedah River area. The second precipitating factor was the pollution of the river water by a carrier and/or frank case during the period of the drought as borne out by the recovery of cholera vibrios therefrom. The presence of the drought itself was the third and final determinant which further aggravated and perpetuated the second in the following manner. Firstly, the drought dried up a great many wells which led to the more frequent use of river water for domestic purposes. Secondly, the drought diminished the volume and flow of the river leading to a greater concentration of vibrios, and to their longer life on account of increased river water salinity. The increase of river water salinity was due to the lowering of the level of outgoing freshwater flow, so that the incoming tidal flow was greater in volume and ascended to higher reaches. Nevertheless, the degree of salinity was not enough to make the water undrinkable in the populated areas above Kuala Kedah

The waterborne aetiology of the massive phase of the outbreak is proved by the following features. Firstly, the geographical distribution of the cases, which were most numerous in the areas where river water was most used. Secondly, the decline of the outbreak as soon as piped water was supplied, either through pipes or by lorries, as for example in area "A" where the outbreak rapidly declined upon the provision of standpipes linked to the existing water mains. Likewise, as soon as potable water was ferried into the affected regions of area "C" via water trucks and water boats, the outbreak in this region declined. Thirdly, the waterborne aetiology is proved by the decline of the outbreak when the drought ended. The occurrence of the outbreak during the dry season in Kedah is in contrast to the findings of Macnamara (1876) that "cholera is at its height . . . every year in March and April and again in September and October, and these are the very months in which we get heavy downpours of rain, washing the surface soil and its contents into wells and tanks from which we procure our drinking water." On the other hand, Pollitzer (1959) noted that "cholera manifestations, if they arise after or during periods of exceptional drought, often become particularly dangerous . . . at such times, the people are forced to make use of the scanty water supplies remaining available, however unsuitable or even repulsive they may be."

Other possible sources of the massive phase of the outbreak could have been the piped water, which would surely have produced many more cases; or one or more polluted wells, when there would have been a higher incidence of cases in families using the wells; or carriers at a focal point such as a restaurant, in which event, the distribution of cases would have been less extensive than it was. It would thus appear that the river was undoubtedly the source of the massive phase of the outbreak. Nevertheless, it could not have been heavily polluted, otherwise there would have been many more cases, and this is borne out by the recovery of vibrios from only one out of the nine samples taken from likely areas of the river.

SUMMARY

The cholera outbreak in the Kedah River area of West Malaysia between December 1963 and April 1964 involved 75 cases and 56 carriers. It appears that the outbreak had two phases, an initial carrier-borne phase and a later massive waterborne phase. The massive water-borne phase itself may be distinguished into the component affecting areas "A" and "B", and that affecting area "C". The spread was from area "A" downstream to "B", and thence to area "C".

Of the 75 cases and 56 carriers reported, no significant difference was found in the distribution between the two sexes. However, it was noted that the mean age of cases for both sexes (males 36.6 years and females 36.1 years) differed significantly from that of the general population of Kedah (males 17.7 years and females 17.3 years). On the other hand, the mean age of carriers for both sexes (males 18.5 years and females 18.5 years) did not differ significantly from that for the general population of Kedah. The ratio of carriers to cases for the age group 0-14 years is 3.5:1 and that for the age group 45-79 years 0.2:1, indicating a preponderance of carriers over frank cases among subjects below the age of 15 years, and a preponderance of frank cases over carriers in the higher age groups.

Analysis of households for multiple cases showed that only six (9%) out of the total of 67 households had multiple cases. This feature of a preponderance of single cases in households has also been noted in similar outbreaks in the Philippines, Hongkong and Sulawesi.

Comparison of the distribution of "valid" and "non-valid/nil" anti-cholera inoculations among the frank cases, carriers and negative contacts, showed no significant difference and suggests that inoculations conferred little if any protection during the outbreak in the Kedah River area.

The aetiological factors of the massive phase of this outbreak include the predisposing factors, namely, river pollution by human excreta via over-hung latrines and the use of this river water for drinking, unboiled, by people not aware of the danger involved. The precipitating factors include first the importation of cholera vibrios by a carrier from the neighbouring state of Perlis, and second the pollution of river water in the Kedah River area during a drought which diminished the volume of river water, increased the volume of incoming tidal water and thus increased the salinity of the estuaries in the area of the outbreak.

ACKNOWLEDGEMENT

The writer is indebted to the Director-General of Medical Services, Malaysia, for his permission to publish this paper. He also gratefully acknowledges the guidance and help given in the field by the then Cholera Control Officer, Kedah, Dr. Raja Ahmad Noordin.

REFERENCES

1 DIZON, J.J., ALVERO, M.G., JOSEPH, P.R., TAMAYO, J.F., MOSLEY, W.H., and HENDERSON, D.A. (1965) Studies of cholera El Tor in the Philippines 1. *Bull. Wld Hlth* **Org. 33**, 627-636.

2. INSTITUTE FOR MEDICAL RESEARCH. (1915) *Annual Report for 1914*, **14**, 53.
3. MACNAMARA, C (1876) A History of Asiatic Cholera, London.
4. MOSLEY, W.H., MCCORMACK, W.M., FAHIMUDDIN, M., AZIZ, K.M.A., MIZANUR RAHMAN, A.S.M., ALAUDDIN CHOWDHURY, A.K.M., MARTIN, A.R., FEELEY, J.C. and PHILLIPS, R.A. (1969) Report of the 1966-67 cholera vaccine field trial in rural East Pakistan. *Bull. Wld Hlth Org.* **40**, 177-185.
5. PHILLIPPINES CHOLERA COMMITTEE. (1968) A controlled field trial of the effectiveness of various doses of cholera El Tor vaccine in the Philippines. *Bull. Wld Hlth Org.* **38**, 917-923.
6. POLLITZER, R. (1959) Cholera, *Wld Hlth Org.* Geneva.
7. READ, W.D.B. et al. (1939) Growth and survival of **V. cholerae** with special reference to growth and survival in water. *Indian J. med. Res.* **27**, 1.
8. TAMAYO, J.F., MOSLEY, W.H., ALVERO, M.G., JOSEPH, P.R., GOMEZ, C.Z., MONTAGUE, T., DIZON, J.J. and HENDERSON, D.A. (1965) Studies of cholera El Tor in the Philippines 3. *Bull. Wld Hlth Org.* **33**, 645-649.
9. VAN DE LINDE, P.A.M. and FORBES, G.I. (1965). Observations on the spread of cholera in Hongkong, 1961-63. *Bull. Wld Hlth Org.* **32**, 515-530.
10. YEN, C.H. (1964) A recent study of cholera with reference to an outbreak in Taiwan in 1962. *Bull. Wld Hlth Org.* **30**, 811-825.