

## Human infection with *Salmonella choleraesuis* in Hong Kong

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(Received 21 November 1966)

### INTRODUCTION

Human infection with *Salmonella choleraesuis* has been reported in China repeatedly. In an investigation of the salmonella serotypes isolated from clinical specimens in Hong Kong, Huang & Chan-Teoh (1964) found that *S. choleraesuis* was second to *S. typhi* in prevalence amongst hospital patients. This prevalence of *S. choleraesuis* infection is most probably the result of similarity in cooking, eating and related customs here and in China. The report of Huang & Chan-Teoh (1964) is extended in the present paper to include another nine strains of *S. choleraesuis* that have been isolated in the same laboratory subsequently. We have re-investigated and compared the cultural characters, drug sensitivities and H<sub>2</sub>S production of a total of 49 strains of *S. choleraesuis* isolated from 47 patients between July 1953 and June 1966 and tabulated the clinical presentation of the cases.

### MATERIALS AND METHODS

#### *Isolation and identification from clinical materials*

The methods used in a previous study (Huang & Chan-Teoh, 1964) were applied also to the new cases reported here. Failure to ferment trehalose and arabinose were the criteria taken to discriminate *S. choleraesuis* from the serologically related serotypes *S. paratyphi C*, *S. decatur* and *S. typhisuis*. Differentiation of *S. choleraesuis* into diphasic, H<sub>2</sub>S-negative American variety and monophasic, H<sub>2</sub>S-positive Kunzendorf variety was carried out by using infusion-agar slants and TSI-agar slants (Edwards & Ewing, 1955) and by slide agglutination with specific (c) and non-specific (1, 5) sera obtained from the Wellcome Research Laboratories, England. To test for H<sub>2</sub>S production, both the butt and the slope of the TSI-agar were inoculated with the culture. A strip of filter-paper soaked in 10% solution of lead-acetate and then dried was held in place in the inner side of the test-tubes containing the media by cotton plugs. The cultures were incubated at 37° C.

#### *Drug sensitivity tests*

The usual disk method was employed. Oxoid S.T. agar and Oxoid multodisks containing respectively streptomycin, tetracycline, chloramphenicol, sulphafurazole, polymyxin B and nitrofurantoin were used. In addition, disks containing kanamycin and neomycin prepared in this laboratory were included. Later, when disks became available, some of the old stock strains and the freshly isolated strains were tested against nalidixic acid, ampicillin, gabbromicina, cephaloridine and

colistin. The concentrations of the drugs and the numbers of strains tested against each drug are given in Table 5. The cultures were incubated at 37° C. and read for inhibitory zones of growth 18 hr. afterwards.

## RESULTS

### *Age incidence and sex ratio*

The age incidence and sex ratio is indicated in Table 1. The youngest patient was a male 7 months old who had an abscess of the right thigh and the organism was isolated from the pus. The oldest patient was a woman of 81 years and the organism was recovered from the pus of a breast abscess. The incidence corresponds with the findings of Saphra & Wassermann (1954).

Table 1. *Age incidence*

Age group	Nos. of patients from whom <i>S. choleraesuis</i> was isolated	
	Male	Female
Under 1	2	2
1-10	14	4
11-20	1	0
21-30	4	1
31-40	6	1
41-50	5	0
51-60	0	1
Over 60	2	4
Total	34	13

### *Frequency of occurrence and the ratio of incidence to other salmonella serotypes*

Table 2 displays the comparative frequency of *S. choleraesuis* in clinical specimens examined in this laboratory in 13 years. Its occurrence fluctuated from year to year in a manner not related to the total numbers of specimens examined. Only 49 strains were isolated from more than 100,000 specimens, so that *S. choleraesuis* was, in general, not encountered commonly. But among salmonella serotypes isolated from hospital patients it ranked second to *S. typhi* in prevalence (Huang & Chan-Teoh, 1964).

### *Correlation of clinical manifestations and types of specimen*

Table 3 correlates the clinical manifestations and the specimens from which *S. choleraesuis* was isolated. The clinical syndromes are arranged according to Saphra & Wassermann (1954). The organism was isolated most frequently from blood cultures and was recovered more often from pus and aspirates than from faeces. Rarely it was isolated from cerebrospinal fluid, urine and sputum. The frequent isolation of the organism from blood cultures reveals the septicaemic tendency of the infection in man. Only five faecal specimens were positive. Apparently transient gastro-enteritis caused by this organism was rare (Saphra &

Table 2. *Ratio of S. choleraesuis to other salmonella serotypes*

Year	Total no. of specimens examined	No. of strains of salmonella serotypes (including <i>S. typhi</i> )	Percentage of <i>S. choleraesuis</i> to total salmonella serotypes	
			No. of <i>S. choleraesuis</i>	
1953-54	1,008	9	0	—
1954-55	1,522	19	0	—
1955-56	1,585	17	4	23.5
1956-57	2,325	20	4	20.0
1957-58	3,027	34	3	8.8
1958-59	3,091	15	3	20.0
1959-60	6,637	34	2	5.9
1960-61	9,372	51	6	11.8
1961-62	10,807	55	3	5.5
1962-63	13,651	76	13	17.1
1963-64	14,947	51	5	9.8
1964-65	15,373	47	3	6.4
1965-66	21,945	49	3	6.1
Total	105,290	477	49	10.3

Table 3. *Correlation of clinical manifestations and specimens with positive cultures from different sources in 47 patients*

Clinical manifestations	No. of strains of <i>S. choleraesuis</i> isolated						Total
	Blood	Sputum	Urine	Stool	c.s.f.	Pus and aspirates	
1. Gastroenteritis	—	—	—	3	—	—	3
2. Fever, septic type	6	—	—	—	—	—	6
3. Fever, typhoid type	4	—	—	1	—	—	5
4. Bronchopneumonia	4	1	—	—	—	—	5
5. Localized suppurative process							
Peritonitis	1	—	—	—	—	—	1
Lung abscess	1	—	—	—	—	—	1
Liver abscess	2	—	—	—	—	3	5
Perinephric abscess	—	—	—	—	—	1	1
Brain abscess	—	—	—	—	—	1	1
Meningitis	1	—	—	—	2	—	3
Osteomyelitis	1	—	—	—	—	2	3
Cervical abscess	—	—	—	—	—	2	2
Parotid abscess	—	—	—	—	—	1	1
Breast abscess	—	—	—	—	—	1	1
Abscess of lower limbs	—	—	—	—	—	3	3
6. Chronic debilitating diseases							
Carcinoma of liver	—	—	2	1	—	—	3
Monocytic leukaemia	1	—	—	—	—	—	1
Chronic lymphocytic leukaemia	2	—	—	—	—	—	2
Haemolytic anaemia	1	—	—	—	—	—	1
Syphilitic aneurysm	—	1	—	—	—	—	1
Total	24	2	2	5	2	14	49

Wassermann, 1954); or perhaps patients with this kind of infection were rarely admitted to hospital because of the mildness of their symptoms. Table 3 also lists the non-specific clinical syndromes complicated by *S. choleraesuis*. Febrile infections of either typhoid or septicaemic types and localized suppurative infections were common. The organism was isolated many times in chronic debilitating diseases such as carcinoma of the liver, leukaemia, haemolytic anaemia and syphilitic aneurysm. Among all the cases reported here, only one death ascribable to the infection took place in hospital and is known to us. It was a case of hepatosplenomegaly with haemolysis complicated by *S. choleraesuis* infection. The organism was isolated twice from blood cultures before death.

Table 4. *Biochemical reactions of S. choleraesuis isolated*

	No. of strains tested	% of positive strains
Motility	49	100
Glucose	49	100
Lactose	49	0
Mannite	49	100
Sucrose	49	0
Salicin	49	0
Dulcitol	40	50
Xylose	40	100
Rhamnose	40	100
Inositol	40	0
Arabinose	49	0
Trehalose	49	0
D-Tartrate	22	100
H <sub>2</sub> S production		
(a) with lead acetate paper	49	6*
(b) in butt of TSI agar	49	4†
Indole	49	0
M.R.	40	100
V.P.	40	0
Citrate	40	100
Urease	40	0
Nitrate	40	100
Gas production in fermented sugar	49	86

\* Two diphasic strains, one monophasic strain.

† One diphasic and one monophasic strain.

*Biochemical reactions of the strains isolated*

Table 4 presents the biochemical reactions of the strains isolated. These agree with those described by others (Kauffmann, 1954; Edwards & Ewing, 1955; Wilson & Miles, 1964). Half of the strains fermented dulcitol within 24 hr. incubation. Seven anaerogenic strains were encountered; two were reported previously (Huang & Chan-Teoh, 1964) and two were recently isolated. These four were anaerogenic from primary isolation. The other three were aerogenic on first isolation however, and anaerogenic substrains emerged only when stock cultures were re-tested. Gas production from sugar fermentation is thus not a constant character

of *S. choleraesuis*. It varied not only from strain to strain but also in substrains of a gas-producing strain.

Only one monophasic, H<sub>2</sub>S-positive Kunzendorf variety was found. This strain blackened not only the lead-acetate filter-paper strips suspended over either infusion- or TSI-agar, but also the butt of the latter medium. According to Edwards & Ewing (1955), TSI-agar is less sensitive for testing H<sub>2</sub>S production than lead-acetate paper strip. Out of 48 diphasic strains, two gave definite blackening of the lead-acetate paper strips and one of these two blackened the butt of the TSI-agar. The blackening of the paper strips placed over the culture in the TSI-agar was more intense than that of the strips over infusion-agar. Slide agglutinations with monophasic specific (c) and non-specific (1, 5) sera were repeatedly positive in both. They were, therefore, H<sub>2</sub>S-positive diphasic strains. Subsequent tests by Craigie tube technique to obtain monophasic substrains were repeatedly H<sub>2</sub>S-positive, trehalose and arabinose negative. When 0.000001 ml. of a 24 hr. broth culture of these substrains was injected subcutaneously into rabbits weighing about 2 kg., the animals died within 10 days. On the other hand, 0.1 ml. of a 24 hr. broth culture of a strain of *S. paratyphi C* injected similarly failed to kill the rabbits injected. The virulence of these monophasic substrains of *S. choleraesuis* for rabbits is accordingly the same as that reported by Tenbroeck, Li & Yü (1931) in Kunzendorf strains.

Table 5. Results of drug sensitivity tests

Drug employed	No. of strains tested	% of sensitive strains
Streptomycin, 10 µg.	30	0
Tetracycline, 10 µg.	30	100
Chloramphenicol, 10 µg.	30	100
Nitrofurantoin, 50 µg.	30	100
Polymyxin B, 100 units	30	100
Sulphafurazole, 100 µg.	30	43
Ampicillin, 25 µg.	30	100
Neomycin, 10 µg.	30	100
Kanamycin, 10 µg.	30	100
Nalidixic acid, 30 µg.	22	100
Gabbromicina, 5 µg.	22	100
(aminosidine sulphate)		
Cephaloridine, 25 µg.	22	100
Colistin, 5 µg.	22	100

#### Drug sensitivities

The results of drug sensitivity tests are presented in Table 5. All strains were insensitive to streptomycin. Oxoid S.T. agar which has a reduced salt concentration (0.3 % NaCl) was used, and the insensitivity to streptomycin is an inherent property of *S. choleraesuis* and is not due, in our study, to the influence of the salt content of the medium indicated by Barber & Garrod (1963). The organism was sensitive to kanamycin and neomycin and so there was no cross-resistance to drugs related to streptomycin. *S. choleraesuis* was sensitive to most of the drugs tested including the more recently introduced ones, such as nalidixic acid, ampicillin, gabbromicina, cephaloridine and colistin.

GEOGRAPHICAL DISTRIBUTION OF *SALMONELLA CHOLERAESUIS*  
IN CHINA AND OTHER EAST ASIAN COUNTRIES*China*

Human infection due to *S. choleraesuis* has been reported in many parts of the world since Salmon & Smith described the organism in 1885 (Wilson & Miles, 1964). That it is endemic in China is revealed in Tables 6–8. Table 6 presents the incidence and distribution of the various salmonellas including *S. choleraesuis* that have been reported by different workers in China. In Table 7 the reports of *S. choleraesuis* in China from 1927 to 1959 are arranged chronologically, and Table 8 is an excerpt of the wartime data presented by Japanese workers. The earliest report of human infection due to this organism was that of Hicks & Robertson (1927) from Shanghai. Following that many reports appeared in the literature (Tables 7 and 8). However, since 1955 most of the reports were published in the Chinese language and are inaccessible to many workers. These reports are, therefore, briefly reviewed in the following paragraphs.

In addition to the report of Lu & Yeh (1955), which was written in English and in which 45 cases of *S. choleraesuis* infection examined in Shengyang, Liaotung during 1951–52 were described, two more reports of *S. choleraesuis* infection appeared in the Chinese literature in the same year. Jen & Pan (1955) described two cases which occurred in Peking, and were successfully treated with chloromycetin. Ku, Li & Chang (1955) observed 2 cases with three deaths in Wuhan, Central China. Over half of their cases were the typhoid-septicaemia type and the organism was isolated from blood, bone-marrow and faeces of all patients and from the peritoneal fluid of one. Seven of the 26 cases were in children under 2 years. In the following year, Liu (1956) described 54 cases in children all with positive blood cultures occurring in the Kweilin area of Kwangsi Province. Eight of the 54 children died. He considered that his cases were associated with an epidemic of hog-cholera then prevailing in the region. He noted that farmers slaughtered the sick animals and sold the meat to the market at a reduced price; three-fifths of the pigs he examined carried *S. choleraesuis* in their blood.

Several reports of *S. choleraesuis* infection appeared concurrently in the Chinese medical literature in 1957. Liao (1957) briefly listed the incidence of *S. choleraesuis* infection in China and described 113 Kunzendorf strains examined by him in Kweiyang, Kweichow Province; 108 of these strains were isolated from human blood cultures. Another four were isolated from pigs and one from the shell of an egg. Liao stated that for 2 years *S. choleraesuis* headed the list of salmonellas in Kweichow Province accounting for 37.6% as against 33.8% for *S. typhi*. Hsu & Chang (1957) reported that *S. choleraesuis* formed 42.6% of the total number of salmonellas, other than *S. typhi*, occurring in Hunan Province between 1953 and 1956, and that the percentage had increased over this period in which laboratory methods of diagnosis had remained unchanged. They concluded that the disease was assuming considerable epidemiological importance. They presented the clinical symptoms of 23 cases with three deaths. The true incidence might have been found to be higher if the patients were not indiscriminately

Table 6. Incidence of salmonellosis in man in China

Authors ...	Wu & Zia	Pasteur* Institute	Chih & Chien	Lu & Yeh	Ku et al.	Fu et al.	Hsu & Chang	Liao	Fu et al.†
Year published...	1935	1949	1949	1955	1955	1957	1957	1957	1957
Region	Peking	Shanghai	Chungking	Liaotung	Wuhan	Chengtu	Changsha	Kweiyang	Shanghai
<i>S. paratyphi A</i>	65† (9·4)	64 (10·8)	10 (3·2)	3 (2·0)	10 (6·6)	5 (3·0)	11 (6·7)	11 (3·8)	59
<i>S. paratyphi B</i>	22 (3·2)	47 (7·9)	5 (1·6)	9 (5·7)	4 (2·6)	2 (1·2)	15 (9·2)	64 (22·3)	29
<i>S. typhi-murium</i>	—	3 (0·5)	1 (0·3)	—	—	11 (6·6)	—	1 (0·4)	5
<i>S. derby</i>	—	5 (0·9)	—	—	—	7 (4·2)	—	3 (1·1)	3
<i>S. paratyphi C</i>	2 (0·3)	12 (1·9)	—	29 (18·4)	5 (3·3)	—	4 (2·5)	—	13
<i>S. choleraesuis</i>	—	—	—	—	—	—	—	—	—
var. <i>american</i>	—	19 (3·2)	—	41 (26·1)	26 (17·1)	14 (8·3)	23 (14·1)	—	23
var. <i>kunzendorf</i>	21 (3·0)	—	3 (0·9)	4 (2·5)	—	7 (4·2)	—	108 (37·6)	2
<i>S. thompson</i>	—	5 (0·9)	—	—	—	—	—	—	2
<i>S. potsdam</i>	—	1 (0·2)	—	—	—	—	—	—	—
<i>S. newport</i>	—	2 (0·3)	—	—	—	—	—	1 (0·4)	1
<i>S. typhi</i>	581 (84·1)	403 (68·1)	297 (93·7)	69 (44·0)	107 (70·4)	102 (61·1)	109 (66·9)	97 (33·8)	—
<i>S. sendai</i>	—	1 (0·2)	—	—	—	—	—	—	2
<i>S. dublin</i>	—	—	—	—	—	—	—	1 (0·4)	7
<i>S. enteritidis</i>	—	7 (1·1)	1 (0·3)	—	—	—	1 (0·6)	1 (0·4)	—
<i>S. blegdam</i>	—	16 (2·6)	—	—	—	—	—	—	—
<i>S. gallinarum</i>	—	—	—	—	—	—	—	—	—
<i>S. london</i>	—	1 (0·2)	—	—	—	3 (1·8)	—	—	—
<i>S. anatum</i>	—	5 (0·9)	—	—	—	15 (9·0)	—	—	—
<i>S. seftenberg</i>	—	—	—	2 (1·3)	—	—	—	—	—
<i>S. aberdeen</i>	—	1 (0·2)	—	—	—	—	—	—	—
Not defined	—	—	—	—	—	1 (0·6)	—	—	1
Total	691	592	317	157	152	167	163	287	147

\* Quoted from Le Minor (1964).

† *S. typhi* excluded.

‡ Figures indicate numbers of strains.

Figures in parentheses indicate percentage incidence of serotypes in each report.

treated with antibiotics immediately after admission to hospital. Fu, Lin, Chou, Chen, Pan & Ch'iu (1957) reported that 21 out of 65 cases of salmonellosis in Chengtu in West China were due to *S. choleraesuis*. They noted that the incidence of this organism in Chengtu was just as high as it was in other parts of China. Wang, Peng, Hsieh & Tang (1957) described a fatal case of *S. choleraesuis* septic-

Table 7. *Human S. choleraesuis infections reported in China between 1927 and 1959*

Authors	Year published	Region	<i>S. choleraesuis</i>	
			American variety	Kunzendorf variety
Hicks & Robertson	1927	Shanghai	1	—
Tenbroeck <i>et al.</i>	1931	Peking	—	3
Wu & Zia	1935	Peking	—	18
Huang <i>et al.</i>	1937	Peking	3	—
Ling <i>et al.</i>	1941	Shanghai	2	—
Raynal & Fournier	1947	Shanghai	2	—
Annual Report (Pasteur Institute)*	1949	Shanghai	19	—
Fournier & Ma	1949	Shanghai	—	1
Chih & Chien	1949	Chungking	—	3
Wu & Fournier	1950	Shanghai	—	1
Lu & Yeh	1955	Liaotung	41	4
Jen & Pan	1955	Peking	2	—
Ku <i>et al.</i>	1955	Wuhan	26	—
Liu	1956	Kweilin	54	—
Liao	1957	Kweiyang	—	108
Hsu & Chang	1957	Changsha	23	—
Fu <i>et al.</i>	1957	Chengtu	14	7
Wang <i>et al.</i>	1957	Ya-an	1	—
Fu <i>et al.</i>	1957	Shanghai	23	2
Tsou	1959	Wuhan	30	—
Totals			241	147

\* Quoted from Le Minor, 1964.

Table 8. *Distribution of Salmonella choleraesuis isolations in war-time China, based on Y. Aoki (1964)*

Authors	Year published	Region	No. of <i>S. choleraesuis</i> strains isolated
Kubota	1939	Canton	2
Shóji	1942	Wuhu	80
Ogawa-Satō	1943	Tsingtao	4
Nagaki	1943	Honan Prov.	13
Umemoto	1943	N. China	13
Komori	1943	S. China	12
Hiroki	1949	Manchuria	59
		N. China	54
		Lushun-Dairen	10
Hamano	1951, 1956	Manchuria	203
		N.E. & C. China	131
		Taiwan	7
Total			588



aemia complicating staphylococcal osteomyelitis of the femur from Ya-an city which lies on the western border of Szechwan Province west of Chengtu. The patient, who tended pigs for her family, developed osteomyelitis of the right femur involving the right hip joint. *Staphylococcus aureus* was isolated twice from discharge from the bone lesions; blood cultures, however, yielded *S. choleraesuis* which was agglutinated by the patient's serum.

Also in 1957, Fu, Wu, Lu & Ch'en (1957) recorded that 25 out of 147 cases of non-typhoid salmonellosis (17.0%) in Shanghai were due to *S. choleraesuis*. Two of these 25 belonged to the Kunzendorf variety. Eight (34.8%) of the patients were children, including a 10-day-old baby, which as far as we are aware, is the youngest patient on record. Four fatal cases due to the American variety were all in children; three were infants and one was a 6-year-old girl. It is interesting to note that all outbreaks reported in 1957 occurred in places quite remote from each other.

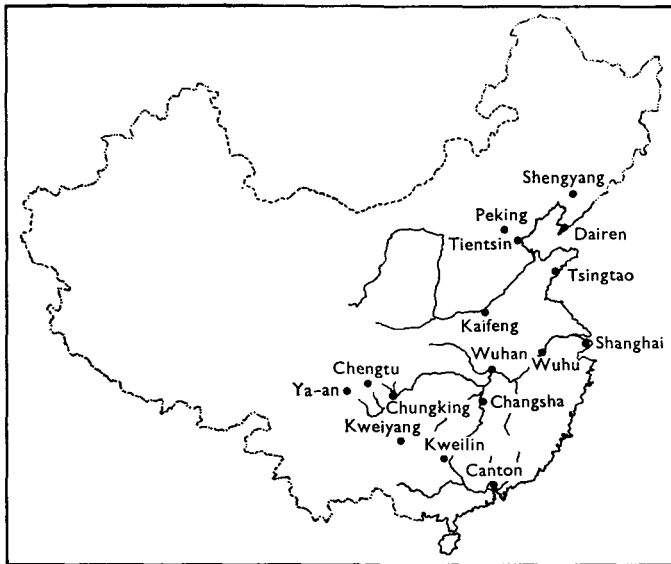


Fig. 1. Distribution of *S. choleraesuis* infection in the continent of China. Locations indicated are based on the reports presented in Tables 7 and 8.

More recently, Tsou (1959) analysed the clinical manifestation of 30 cases of *S. choleraesuis* infection occurring in Wuhan, Wupeh Province. Most of the patients were under 3 years. All, except one case, were of the primary typhoid-septicaemia type and no death was recorded.

This review indicates clearly that *S. choleraesuis* infection is distributed widely in China (Fig. 1). Its reported extent reaches from the North Eastern Provinces (Manchuria) down to Canton in Kwangtung Province which lies in the south and in the vicinity of Hong Kong, and also from Shanghai on the eastern coast to as far west as Ya-an in Szechwan Province. Aoki (1964) emphasized that there was a great difference between the incidence of salmonellosis in peace and in war, but to judge from its frequency before, during and after the Second World War, one may concede that *S. choleraesuis* is endemic in China.

*East Asian countries*

Although *S. choleraesuis* infection is prevalent in China, it is relatively rare in the surrounding East Asian territories. Sakazaki & Nakaya (1964), in a systematic epidemiological and ecological study of salmonellas between 1940 and 1963 in

Table 9. Comparison of the percentage of *S. choleraesuis* infection in man in different regions of the world

	Authors	Places	Date of isolation	Total no. of strains of salmonella serotypes (excluding <i>S. typhi</i> )	Total no. of strains of <i>S. choleraesuis</i>	Percentage of <i>S. choleraesuis</i> to salmonella serotypes	Remarks
A	Silberstein & Gerichter	Israel	1949-62	17,335	0	0	P. 340, Table 4
	Van Oye	Central Africa	1946-60	1,557	0	0	P. 356, Table 1
	Le Minor	Madagascar	1949-60	125	4	3.2	P. 367, Table 1
	Le Minor	Nigeria	1955-59	456	0	0	P. 368, Table 2
	Le Minor	Senegal	1950-62	216	8	3.7	P. 376, Table 5
	Bynoe & Yurack	Canada	1953-62	12,314	30	0.3	P. 400, Table 2
	Galton, Steele & Newell	United States	1934-63	30,589	746	2.4	P. 428, Table 3
	Olarte & Varela	Mexico	1940-62	1,538	32	2.1	P. 467, Table 24
	Peluffo	South America	Not given	2,610	86	1.5	P. 494, Table 10
	Fukumi	Japan	1951-53	119	0	0	P. 516, Table 7
	Le Minor	Vietnam	1952-61	482	41	8.5	P. 531-4, Tables A, 1
	Atkinson	Australia	1950-62	7,182	51	0.7	P. 544, Table 1
B	Various authors	China	1927-57	908	291	32.0	
C	Huang & Chan-Teoh	Hong Kong	1953-63	132	30	30.3	

A. Quoted from Van Oye (1964). Page and table numbers refer to those whence the data derived

B. Average calculated from data in Table 6.

C. Quoted from Huang & Chan-Teoh's (1964).

Japan, typed 3892 strains. Of these, only 12 strains were *S. choleraesuis* (seven from animals and five from man) and all were isolated before 1950. According to these authors *S. choleraesuis* has not been found in Japan since 1950 and their work was confirmed by Fukumi (1964). Aoki (1964) stated that Hagakawa and his

colleagues had reported in 1944 that only three of 1210 strains of salmonellas (0.25%) collected by them from Java, Sumatra, Malaya, Thailand, Vietnam, the Philippines and Taiwan during the war were *S. choleraesuis*. The rare occurrence of the organism in the South Pacific region was evidenced by the work of Lindberg & Bayliss (1946) who typed 202 strains of salmonellas isolated between 1944 and 1945 and found only one strain of *S. choleraesuis*. Cheng (1964) investigated the salmonella serotypes from man, fowls and animals in Taiwan; he recovered 39 strains of *S. choleraesuis* from pigs but not from man. In wartime records, however, Hamano (Aoki, 1964) found seven out of 351 (1.99%) of the total *S. choleraesuis* strains he had studied were isolated in Taiwan (Table 8), but even in those disturbed times the incidence of *S. choleraesuis* in Taiwan was three to ten times less than that in the mainland of China. Nguyen & Fournier (1960), describing a case of liver abscess in South Vietnam, stated it was not unusual to recover this organism from bacterial liver abscess there. Courmes & Bres (1954), on the other hand, found only one strain of *S. choleraesuis* among 173 strains of salmonellas they typed in the same country. According to Le Minor (1964) the percentage of *S. choleraesuis* among all salmonella serotypes in South, Central and North Vietnam were 1.4, 2.6 and 1.7% respectively. Zimmerman, Cooper & Graber (1952) studied an outbreak of salmonellosis among prisoners of war in Korea and reported that 43 out of 357 strains (12%) of salmonellas they had isolated were *S. choleraesuis* var. *kunzendorf*. Chun (1964) reviewed salmonella and shigella infections among civilians and military personnel in Korea, and reported that *S. choleraesuis* occurred in 0.4% of one survey and in 4.7% of another carried out in 1952-54. But not a single case was seen in a third survey performed in 1961-63 long after the Korean war. Considering the report of Lu & Yeh (1955) of a high incidence in neighbouring Manchuria, we are inclined to think that the incidence reported by Zimmerman *et al.* and in Chun's first two surveys was unusual in Korea and was exceptionally influenced by war-time conditions.

Table 9 summarizes the incidence of *S. choleraesuis* reported in several different areas of the world. It reveals that the percentage of *S. choleraesuis* among all other salmonella serotypes (excluding *S. typhi*) is uniquely high in China and in hospital patients in Hong Kong.

#### DISCUSSION

In this series, 22 out of 49 strains (45%) of *S. choleraesuis* were isolated from patients under 10 years of age. This accords with the reports of other Chinese workers (*loc. cit.*). Of the 22 strains in children 16 were isolated from blood cultures, three from pus, two from faeces and one from c.s.f. Fevers of septic and typhoid type were encountered more often in children, whereas localized suppurative infections were the frequent clinical manifestations in adults. The low resistance of young children may be due to absence of previous contact and immunity against a potentially septicaemic organism. The relatively frequent occurrence of infection in adults debilitated by chronic organic diseases supports the view that resistance is generally effective, although it may be sapped by a heterologous infection or by neoplastic diseases, etc. (Saphra & Winter, 1957). The low mortality rate of one

detected fatal case in our series, compared with the relatively high death-rate prevailing a decade or two ago, can be attributed to modern therapy. According to Saphra & Winter (1957) the death-rate formerly approached 20·3 %.

*In vitro* sensitivity tests show a wide choice of inhibitory drugs against *S. choleraesuis*. Because of the fulminant nature of the untreated disease and the irregularity of the clinical picture, early and accurate bacteriological diagnosis is essential. Premature administration of antibiotics before the collection of specimens for bacteriological study defeats the objective and more cases might be discovered if the frequency of the organism was better appreciated and more effort made in its isolation.

It has been suggested that paratyphoid C should be included in the TAB vaccine used in regions where *S. choleraesuis* or group C salmonella infection is prevalent (Wu & Zia, 1935; Saphra & Winter, 1957). There are, however, better ways of obtaining protection against *S. choleraesuis* infection. Smith (1965) showed that a live vaccine made from rough variants of *S. choleraesuis*, though possessing a considerable degree of virulence for mice, could protect the survivors from experimental oral infection. Furthermore, his vaccine also produced an appreciable degree of immunity in pigs. According to Tenbroeck *et al.* (1931), *S. choleraesuis* was much more virulent than *S. paratyphi C* to rabbits. This has been confirmed by us. Whatever type of vaccine against *S. choleraesuis* may be developed in the future, the organism itself should be used in preference to *S. paratyphi C*.

The differentiation of *S. choleraesuis* into two varieties has been criticized. Wilson & Miles (1964) cited Kauffmann's view that the designation 'Kunzendorf variety' should be abolished. The occurrence in our material of the two H<sub>2</sub>S positive diphasic strains confirms that the test for H<sub>2</sub>S production can no longer be considered valuable for taxonomical classification of *S. choleraesuis* into varieties though it has some use in the epidemiological study of a strain. There is no substantial difference in pathogenicity between the monophasic and diphasic varieties either. The reports of fatal cases by Wu & Zia (1935) and by Fournier & Ma (1949) verified the virulence of the H<sub>2</sub>S-positive monophasic variety.

Table 9 shows that the percentage of *S. choleraesuis* among salmonella serotypes (excluding *S. typhi*) in our series (30·3 %) is very close to the average percentage in China (32·1 %). Though our finding does not represent the overall incidence of *S. choleraesuis* in Hong Kong, the strains had been subjected to thorough bacteriological study. The incidence might have been higher if group C salmonella or unidentified salmonella strains reported by other laboratories in Hong Kong were subjected to further typing. It is no coincidence that Hong Kong lies on the edge of the Chinese continent and that over 90 % of the population have the same customs as the people in the mainland of China. Pork makes up a large part of the protein in the diet and clearly plays a part in disseminating the organism. Confirmatory evidence is found in the fact of low incidence in other regions of the world where pork is a less important element in the diet or even not used. In Israel, where pork is excluded from foodstuffs, *S. choleraesuis* infection is evidently completely absent (Table 9).

Pigs are the main carriers of *S. choleraesuis* (Saphra & Wassermann, 1954) and

processed pork or sausages are the usual source of the infection (Hobbs, 1964). It is animals weakened by diseases such as hog-cholera or pneumonia or otherwise stressed that develop septicaemia due to the organism (Cheng, 1964). Pork and pig offal derived from uncontrolled butchery are, therefore, dangerous for human consumption. Even under conditions of controlled butchery in Hong Kong *S. choleraesuis* can be identified occasionally in material from pigs. Where pigs in poor condition are particularly examined, a considerable number are found to carry the organism (Lo, Huang & Chan, to be published). Whether active or not porcine infection is common in animals brought for slaughter here because over 50% have agglutinins against CO and CH in their sera. Pigs are thus a dangerous potential source of human *S. choleraesuis* infection in Hong Kong. Ding, Liu & Chih (1956) reported that the highest rate of isolation of *S. choleraesuis* from sick hogs was from the mesenteric lymph-nodes, and next from the liver; meat rarely gave positive cultures. Smith (1959) also maintained that the rate of isolation from the mesenteric lymph-nodes of healthy pigs was high; he isolated *S. typhimurium* and *S. anatum* more commonly. The liver, kidneys, lungs and intestines of pigs are very often used in the local cuisine of Hong Kong. When such articles of diet are derived from sick animals which have escaped detection and inspection they are certainly dangerous for consumption. Moreover, blood clot from pigs is also eaten by people here. The clot is sliced into small cubes and steamed in rice gruel. The temperature of the gruel may kill organisms on the surface of the clot, but cannot be relied on to kill those within the cubes. Although direct evidence of this mechanism of transmission of *S. choleraesuis* is not available yet, it seems likely that the habit of eating pig offal accounts in part at least for the prevalence of *S. choleraesuis* infection in the local population. The occasional infections reported in dogs (Galton, Scatterday & Hardy, 1952), cats (Huang Chan-Teoh, 1964) and rats (Fournier, 1939) suggest that these animals may play a part in transmission too.

Because *S. choleraesuis* generally attacks only young or debilitated persons, we think that the invasiveness of *S. choleraesuis* is not as high as has often been suggested. Saphra & Winter (1957) maintained that much salmonellosis went untreated, undiagnosed and bacteriologically unidentified and that only the severe parenteral and fatal infections stimulated adequate efforts, for instance when pus, blood, exudates and spinal fluid were examined. This is probably true for *S. choleraesuis* infection and, if so, would provide an explanation for what seems an unexpectedly high fatality rate in the older series. On the other hand, it is important that the infection should not be overlooked in communities like Hong Kong where it ranks as the second commonest of the salmonelloses—for persons with low resistance often succumb to it once they are infected.

#### SUMMARY

The literature of human infection with *Salmonella choleraesuis* in China was fully reviewed with special reference to those written in Chinese language which are inaccessible to many readers. Compared with other regions of the world the ratio

of *S. choleraesuis* to other salmonella infection in Hong Kong is high and is parallel to that in China. Dietetic habits of the local population apparently contribute to the high incidence. The clinical manifestations of 47 cases were outlined and details of the biochemical reactions and *in vitro* drug sensitivities of these strains were described. Two diphasic H<sub>2</sub>S-positive strains were encountered.

The authors are most grateful to Prof. James B. Gibson for his helpful advice and constructive criticism.

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