J. Hyg., Camb. (1963), **61**, 257
Printed in Great Britain

Salmonellae and shigellae in a group of periurban South African Bantu school children

By N. J. RICHARDSON and V. BOKKENHEUSER
Department of Bacteriology, South African Institute for Medical Research, Johannesburg, South Africa

(*Received* 26 *November* 1962)

INTRODUCTION

From surveys by Bokkenheuser & Greenberg (1959) and Bokkenheuser & Richardson (1960) it is known that salmonella infections are frequent in South Africa. The role played by shigellae in causing serious infantile gastro-intestinal disorders was emphasized by Kahn (1957) and Kahn *et al.* (1958).

Investigating salmonella and shigella infections in a group of 124 rural Bantu school children, Bokkenheuser & Richardson (1960) found that, over a period of 1 year, nearly all the children were infected once, and many of them several times, by these pathogens. Clinical symptoms seldom accompanied the infections.

The present paper records a study of a similar group of Bantu school children living in a periurban area.

MATERIAL AND METHODS

The Witkoppen Bantu school, situated in open country 15 miles north of Johannesburg was chosen for this investigation. The school accommodated about 300 boys and girls mainly of the Iswana ethnic group. The children were generally well dressed and in fair nutritional condition as judged by height and weight for the particular age-groups. Most of them lived nearby, although some came from homes as far as 6 miles away. The parents were mainly semi-skilled or unskilled labourers, e.g. farm workers, tractor drivers, builders or painters. Few families kept livestock (cattle, goats, pigs, chickens) but most grew some maize or vegetables, failing which these products were obtained from the local trading store. The chief elements of the diet were maize porridge and bread with occasional consumption of kaffir corn (*sorghum vulgare*), tea, coffee and milk. Vegetables together with wild spinaches (*morogo*, *m'fino*) were eaten according to season. In a few families meat was consumed daily, but in most only two to three times a week. Eggs, butter and fish were rarities. During attendance at school the children received one meal daily, usually 'poosa-munda' (dried fermented porridge reconstituted with water) and bread. Briefly, the diet was possibly adequate in energy value, high in carbohydrate, low in animal protein and fat as well as in calcium and certain vitamins.

The water was drawn from bore-holes, shallow surface-wells, rain-water tanks, rivers or streams.

To match the previous study (Bokkenheuser & Richardson, 1960) a group of 128 children aged between 7 and 18 years was selected. During the year of observation no alteration was made in their mode of life. A few occasionally attended a Bantu health clinic about $\frac{1}{4}$ mile from the school, but in one instance only for a gastro-intestinal disorder which, as far as could be ascertained, was not treated with antibiotics. It is not known whether the children were treated by witch-doctors or given tribal remedies including purgatives.

Over a period of 1 year, the children were examined eight times at fairly regular intervals and their general condition and oral temperatures were recorded. The consistency of the stools was noted, and the specimens were planted on SS-agar and selenite-F media within 10 min. of voiding. Plates and enrichment media were taken to the laboratory in Johannesburg and incubated. The following morning a loopful of the enriched culture was planted on SS-agar and incubated. If present, 3 lactose-negative colonies were transferred from each plate to composite media for biochemical reactions. The antigenic structure of salmonellae was determined in detail whereas the shigellae were classified by their principal group antigen.

The pathogenic organisms were tested for sensitivity to a range of antibiotics. Disks, 6 mm. in diameter and weighing 3·3 mg., were impregnated with the following antibiotics: penicillin G (10 units), streptomycin (100 μg.), erythromycin (50 μg.), chloramphenicol (50 μg.), tetracycline hydrochloride (50 μg.), neomycin (50 μg.) and novobiocin (50 μg.). The inhibitory activity of these disks was checked in parallel on blood agar plates, using *Staphylococcus aureus* (Oxford strain) as the control. A zone of inhibition of less than 2 mm. was taken to indicate a resistant organism.

RESULTS

In the group of 128 children the younger age-groups and females predominated slightly (Table 1). Of 891 faecal specimens, 54 (6·1 %) yielded a growth of salmonellae and 6 (0·7 %) of shigellae. The salmonellae comprised 18 serotypes and the shigellae 2 (sonne and flexner). During the year of observation 31·3 % of the children experienced either salmonellosis or shigellosis or both. Of these, 37 (28·9 %) were infected with salmonellae and 6 (4·7 %) with shigellae. The infection rates appeared slightly higher among females and in the younger age-groups.

Because some children were absent on the days of examination and others left school before the end of the survey, only 75 children were available for all eight investigations. Of these, 22 (29·3 %) yielded a growth of salmonellae and 2 (2·7 %) of shigellae. Ignoring for a moment infections of long duration and the question of reinfections, it emerges from Table 2 that salmonellae were recovered from 1·3–9·3 % of the children the year round and that no distinct outbreak was encountered. Although *Salmonella labadi* was the commonest salmonella type found, the striking feature was the sporadic occurrence of many different serotypes.

A total of 35 strains was recovered from these children. Double infection of specimens was not observed. In 14 of the 22 children, however, 2–4 different types were isolated during the observation period. In some cases the same salmonella

Table 1. *Salmonella and shigella infections by age and sex*

Age (years)	Number of individuals	Number of specimens	Specimens infected with: Salmonellae No.	Specimens infected with: Salmonellae %	Specimens infected with: Shigellae No.	Specimens infected with: Shigellae %	Individuals infected with: Salmonellae No.	Individuals infected with: Salmonellae %	Individuals infected with: Shigellae No.	Individuals infected with: Shigellae %	All infected individuals No.	All infected individuals %
7–10	67	474	31	6·5	4	0·8	22	32·8	4	6·0	24	35·8
11–18	61	417	23	5·5	2	0·5	15	24·6	2	3·3	16	26·2
Total	128	891	54	6·1	6	0·7	37	28·9	6	4·7	40	31·3
Females	73	508	37	7·3	3	0·6	23	31·5	3	4·1	26	35·6
Males	55	383	17	4·4	3	0·8	14	25·5	3	5·5	14	25·5

Table 2. *Seasonal distribution and duration of salmonella and shigella infections in 75 children*

Month of examination	Recovered salmonellae: *S. montevideo*	*S. derby*	*S. newport*	*S. london*	*S. tabadi*	*S. typhimurium*	*S. anatum*	*S. thompson*	*S. weybridge*	*S. paratyphi* A	*S. johannesburg*	*S. adelaide*	*S. chester*	*S. pomona*	Percentage salmonella-infected individuals	Recovered shigella	Percentage shigella-infected individuals	Total infected individuals No.	Total infected individuals %
March	1	1	2	—	—	—	—	—	—	—	—	—	—	—	5·3	—	—	4	5·3
April	—	—	—	1	—	—	—	—	—	—	—	—	—	—	1·3	1	1·3	2	2·7
June	—	—	—	—	2	1	1	—	—	—	—	—	—	—	5·3	—	—	4	5·3
July	—	—	—	—	1	—	—	2	—	—	—	—	—	—	4·0	—	—	3	4·0
August	—	—	—	1	1	—	1	—	2	1	—	—	—	—	8·0	—	—	6	8·0
October	—	—	—	—	1	1	—	—	—	—	1	1	2	1	9·3	—	—	7	9·3
November	—	—	—	—	2	1	1	—	—	—	—	—	2	—	8·0	—	—	6	8·0
January	—	1	—	—	1	2	—	—	—	—	—	—	—	—	5·3	1	1·3	5	6·7
Total	1	2	2	2	8	5	3	2	2	1	1	1	4	1	—	2	—	—	—

type was isolated several times from the same individual (Table 3). Some types (*S. johannesburg*, *S. typhimurium* and *S. thompson*) were recovered in successive samples, while others (*S. labadi* and *S. anatum*) reappeared in the same individual with longer intervals. In half of these children the temperatures were normal (98·4° F.) throughout, whereas in the other half the temperatures were raised by 1° F. at those times when their stools yielded pathogens. The faeces were usually semi-solid to hard, only two specimens were soft, none was liquid. In agreement with this the children appeared to be in good health.

Table 3. *Repeated recovery of the same salmonella type from indivual children*

Number of child	Time of collection					
	June	July	August	October	November	January
6	La	—	—	—	La	—
7	La	—	La	—	La	—
100	—	La	—	La	—	La
30	Ch	—	—	Ch	—	—
62	—	—	—	Ch	Ch	—
64	—	—	—	Jo	Jo	—
79	—	—	Tm	Tm	—	—
99	An	—	An	—	An	—
120	—	—	—	Th	Th	—

La, *Salmonella labadi*; Ch, *S. chester*; Jo, *S. johnannesburg*; Tm, *S. typhimurium*; An, *S. anatum*; Th, *S. thompson*.

Table 4. *Clinical observations related to infection*

	Number of specimens	Consistency of faeces: Hard No.	Hard %	Soft No.	Soft %	Liquid No.	Liquid %
Pathogens not recovered	831	289	35	533	64	9	1
Salmonella infected	54	23	43	30	56	1	2
Shigella infected	6	1	17	3	50	2	33
Total infected	60	24	40	33	55	3	5

	Number of specimens	Temperature (°F.): < 98·4 No.	< 98·4 %	98·4–99·8 No.	98·4–99·8 %	100+ No	100+ %
Pathogens not recovered	831	317	38	414	50	100	12
Salmonella infected	54	13	24	33	61	8	15
Shigella infected	6	1	17	4	67	1	17
Total infected	60	14	23	37	62	9	15

Taking all infected individuals into account (Table 4) one is impressed by the mildness of the condition. Diarrhoea was infrequent and, as compared to the controls, there was no evidence of the pathogens affecting the consistency of the stools. Furthermore, the infections were not associated with a marked rise in

temperature. It is noteworthy that during the year none of the children gave a history of diarrhoea.

The salmonella and shigella strains were tested for sensitivity to a range of antibiotics. On occasions where several colonies of the same type were isolated from a specimen, they were all examined and the average sensitivity recorded. As might be expected (Table 5), both salmonellae and shigellae were generally resistant to penicillin and novobiocin. But, in addition, the salmonellae showed considerable resistance to erythromycin and some to chloramphenicol and tetracycline.

Table 5. In vitro *resistance to antibiotics of isolated strains*

		Percentage of strains resistant to						
Genus	Number of strains	Penicillin	Strepto-mycin	Erythro-mycin	Chloram-phenicol	Tetra-cycline HCl	Neo-mycin	Novo-biocin
Salmonella	51	84·3	0	62·7	3·9	2·0	0	100
Shigella	6	100	0	0	0	0	0	100

Table 6. *Origin and quality of drinking water*

	Escherichia coli/100 ml.						Colony count per ml.	
	Faecal			Presumptive				
	0	1–4	> 4	0	1–10	> 10	< 100	> 100
Origin of water	Number of specimens							
Well (machine pump)	4	1	—	1	1	3	—	5
Well (windmill)	4	—	1	3	—	2	1	4
Surface well	—	—	8	—	—	8	—	8

Because drinking water might be involved in the transmission of the infection, inquiries were made into its origin and quality. The water at the school was drawn by hand-pump from an enclosed well. On repeated examinations the total number of colonies developing per ml. ranged from 3–53. Presumptive *Escherichia coli* ranged from 0–2 per 100 ml., and faecal *E. coli* was absent. In view of the reasonably satisfactory quality of the school water, samples were obtained from the homes, which drew their supply from different sources (Table 6). While the machine and windmill water was of mediocre quality, the water drawn from the surface wells was decidedly unsatisfactory (South African Bureau of Standards, 1951).

DISCUSSION

The results of incidence surveys of infections depend on a number of factors (Bokkenheuser & Richardson, 1960) among which the most important are: (*a*) the number of samples investigated; (*b*) the time-lag between collection and planting of the specimens; (*c*) the selection of a suitable portion of the specimen; (*d*) the fastidiousness of the micro-organisms; (*e*) the media employed; and (*f*) the

https://doi.org/10.1017/S0022172400020969 Published online by Cambridge University Press

number of colonies examined from each specimen. It follows, therefore, that statistically significant differences in the recovery rates of two pathogens do not necessarily reflect corresponding differences in incidence of infection. Moreover, it is almost impossible to establish the incidence of mild, benign infections unless specimens of faeces are examined very frequently. With these reservations, it may be stated that both shigella and salmonella infections occurred among the Witkoppen school children and that at least salmonella infections were quite frequent. Infections were observed at all times of the year but no outbreak was encountered.

The infected children showed no clinical signs of illness and with one or two exceptions there was no history of acute or chronic gastro-intestinal disturbances. A striking observation was the reappearance of certain salmonellae in the same individuals. Although it may be that these children (Table 3) were reinfected once or twice with the same serotype, it is more likely that some of them were carriers of long standing.

The poor quality of the water, particularly that drawn from surface wells, made it highly probable that drinking water was involved in the transmission of the infections.

Information from this survey and that from the Tlaseng Bantu school children (Bokkenheuser & Richardson, 1960), obtained with the same technique, tend to supplement each other. Salmonella and shigella infections occurred in both groups and it is likely that nearly all the children experienced one, and many of them several, infections annually by these pathogens. The infections occurred throughout the year and were usually asymptomatic. While there was evidence of a periodic increase in incidence in the Tlaseng study, it is conceivable that carriers of salmonellae were present among the Witkoppen children. In both groups the quality of the drinking water was very poor and might well be incriminated in the transmission of the infections. The salmonella strains isolated from the Tlaseng children in 1958–59 were highly sensitive to erythromycin and chloramphenicol. In contrast, the strains recovered 2 years later from the Witkoppen children were highly resistant to erythromycin and showed evidence of increasing resistance to chloramphenicol. Their frequency of resistance to chloramphenicol and tetracycline corresponded to the rates reported from Holland (Manten, Kampelmacher & Guinee, 1961).

Although salmonella and shigella infections were extremely benign among African school children, it does not follow that they do not take their toll among the most susceptible groups—the infants and the aged.

SUMMARY

1. Faeces from apparently healthy Bantu school children of a periurban district of Johannesburg were examined eight times at regular intervals over a period of 1 year.

2. Of 75 children, 29·3 % experienced at least one salmonella infection and 2·7 % one shigella infection. It is suggested that over a year nearly all children will have one, and many of them several, infections with these pathogens. The infections occurred at a low rate throughout the year.

3. In most cases the infections were asymptomatic. A few of the children showed evidence of being salmonella carriers of long standing.

4. Eighteen different salmonella types were recovered. *Salmonella typhi*, *S. paratyphi* B and *S. paratyphi* C were absent. The organisms were highly resistant to penicillin, erythromycin and novobiocin and a few strains were also resistant to chloramphenicol and tetracycline.

5. The drinking water was of poor quality and may well be implicated in the transmission of the infections.

Our thanks are due to the Director of this Institute, Dr J. H. S. Gear, for permission to publish this paper; to Mr R. G. Robinson for assessing the micro-organisms' sensitivity to antibiotics; and to the South African Council of Scientific and Industrial Research, Pretoria, for a grant enabling us to meet the transport expenses.

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