SALMONELLAE AND SHIGELLAE IN A GROUP OF BANTU SCHOOL CHILDREN IN THE EASTERN TRANSVAAL LOWVELD

N. J. RICHARDSON AND H. J. KOORNHOF, *Department of Bacteriology, South African Institute for Medical Research, Johannesburg*

The results of previous surveys undertaken at this Institute by Bokkenheuser and Richardson[1, 2] showed that in a group of rural (Rustenburg area) and periurban (Witkoppen, Johannesburg) Bantu school children, many were infected with salmonellae and shigellae. It was suggested that nearly all the children in the areas covered by the surveys will have at least one infection of these pathogens over a year.

In separate studies carried out at the same schools, Walker and De Lacy[3] investigated the nutritional state of the children and examined their urine and faeces for evidence of bilharzia and other parasites. Continuing their work in the Lowveld of the Eastern Transvaal, they found that although the incidence of bilharziasis was very much higher in these children than in the other 2 groups, the mean height and weight of the children was higher; for the 15-year-old children the difference being 15 - 20 lb. in weight and 2 - 3 inches in height.

This paper records a mid-winter and mid-summer investigation in the Lowveld for evidence of salmonella and shigella infections. A comparison of the frequency of these bacterial pathogens compared with the incidence in the former 2 groups, might explain the relatively satisfactory physical state of the Komatipoort children.

SUBJECTS AND METHODS

The school chosen for this study was 2 miles from Komatipoort, which is on the border of the Republic and Mozambique, about 80 miles west of Lourenco Marques. The settlement in which the school is situated was built by the Railway Administration to house the numerous Bantu personnel and their families required in that area. This is referred to as the Railway location. The settlement serving the town itself, known as the Komatipoort location, is a ¼-mile east of the town on the banks of the Crocodile River, and about 1½ miles from the Railway location. The school serves both locations. A few of the children came from nearby farms.

The water supplies for the locations differ considerably. The water for the Railway location is piped to each house from the town reservoir, whereas that of the Komatipoort location is drawn from the Crocodile River and carried in tins to the family dwellings.

The diet of these children, according to Dr. Walker (personal communication) is roughly as follows: The main source of calories is cereal foods, almost wholly maize, although small amounts of wheat and kaffir-corn (*Sorghum vulgar*) is eaten. Meat is consumed usually once or twice a week. The consumption of eggs and dairy produce is low. Regard-

ing vegetables and fruit, there is a greater consumption of these foodstuffs compared with the previously mentioned areas. The consumption of sugar, formerly very low, is now on the increase. Such a diet is possibly adequate in calories, at least for the older children. It is somewhat low in gross protein, certainly low in protein and fat of animal origin. Of the mineral salts, calcium intake is low; and of the vitamins, the intakes of riboflavin and ingested vitamin D are insufficient. The prevalence of skin lesions was low, particularly among the older children.

To afford a comparison with the 2 previous studies,[1,2] similar techniques were employed. For the first collection in winter, 147 children ranging between 7 and 17 years of age were randomly selected. For the summer collection all those of the same group, who were at school on the day of the investigation, were again tested. Oral temperatures and the consistency of the stools were noted. The faeces were then planted on SS agar and selenite F media for bacteriological examination. Since Komatipoort is 300 miles from the laboratory in Johannesburg, the selenite media were incubated *in loco* at 37°C overnight and the following morning were subcultured onto fresh SS agar plates. The 2 sets of plates were then taken back to the main laboratory in Johannesburg where they were incubated overnight at 37°C. All primary and secondary plates were examined for the presence of non-lactose fermenting colonies. Three colonies from each plate, if present, were tested for biochemical reactions and those conforming to salmonella were typed serologically. Shigella were only typed according to their group antigen. When present, therefore, a maximum of 6 colonies from each child was examined.

Each organism was tested against a range of antibiotics for sensitivity. The following discs were used: penicillin (3 μg.), ampicillin (25 μg.), streptomycin (100 μg.), tetracycline hydrochloride (50 μg.), chloramphenicol (15 μg.), erythromycin (50 μg.), colistin (10 μg.), novobiocin (50 μg.), kanamycin (50 μg.), nitrofurantoin (100 μg.). A zone of inhibition of less than 2 mm. was taken to indicate a resistant organism.

Water samples were taken from 2 houses in the Railway location, from the school drinking water tank, and the Crocodile River. These were kept in a refrigerator and then transported to the laboratory in insulated ice-boxes for bacterial counts. In addition to these samples, Moore pads[4] were sunk in the Crocodile River and the Komati River which joins the Crocodile about a mile below the town. They were submerged for 24 - 36 hours, placed in a Ball jar and, on arrival at the laboratory in Johannesburg, were placed in double strength selenite F media and subcultured onto Wilson-Blair plates. Colonies resembling salmonella were tested biochemically and, if positive, typed serologically.

RESULTS

In the group of 147 children chosen for the study, there were slightly more males than females with an even distribution of the age groups (Table I). Salmonella isolations from 245 faecal specimens totalled 7 (2·9%) and shigella 4 (1·6%). One child, indicated in Table I, had a double infection of salmonella and shigella. Thus, out of the total of 147 individuals there were 8 infected children, 6 of whom had salmonella (4·2% of the total), and because of the double infection, shigella was isolated from 3 of them (2·1% of the total). It is interesting but of doubtful significance that the salmonella isolations came from males in the lower age group (7 - 10 years), and the shigella from females in the upper age group (11 - 17 years).

Only 99 of the 147 children were present at the second examination in summer. The data of both the winter and summer investigations are presented in Table II. The *S. typhi* and the *Sh. flexneri* isolated in July were again recovered from the respective patients in November. The child from whom *S. typhi* was isolated on these 2 occasions was outwardly in good health and undoubtedly was a typhoid carrier. Of the remaining 6 children, 3 had *S. typhimurium*, 2 *Sh. flexneri*, and one each *S. weston* and *S. guinea*. One of the children had a double infection with *S. typhimurium* and *Sh. flexneri*. Dividing the children up into their areas of domicile, it can be seen that the majority of the isolations came from children living in the Komatipoort location and surrounding farms.

Oral temperatures of all the children were taken at the time of sampling and the consistency of the faeces noted. As seen from Table III, there were no pathogens isolated from the liquid stools, while 7 pathogens were recovered from the hard stools and 4 from the soft stools. Most of the children in this survey had elevated temperatures. In the group from which no pathogens were isolated, 13 (5·6%) had normal temperatures of 98·4°F or less, 136 (58·6%) between 98·4°F and 99·9°F, and 83 (35·8%) above 100°F. In the infected group, 10 of 11 children had temperatures above 98·4°F. The significance of this finding is doubtful because of the high incidence of raised temperatures in the group as a whole.

TABLE I. SALMONELLA AND SHIGELLA INFECTIONS BY AGE AND SEX

Age in years	Number of individuals	Number of specimens	Isolations from specimens: Salmonella No.	Isolations from specimens: Salmonella %	Isolations from specimens: Shigella No.	Isolations from specimens: Shigella %	Individuals infected with: Salmonella No.	Individuals infected with: Salmonella %	Individuals infected with: Shigella No.	Individuals infected with: Shigella %	All infected individuals No.	All infected individuals %
7—10	77	123	6	4·9	—	—	5	6·5	—	—	5	6·5
11—17	70	122	1	0·8	4	3·3	1*	1·4	3*	4·3	3	4·3
Total	147	245	7	2·9	4	1·6	6	4·2	3	2·1	8	5·4
Females	65	112	1	0·9	4	3·6	1*	1·5	3*	4·6	3	4·6
Males	82	133	6	4·5	—	—	5	6·1	—	—	5	6·1

*One individual with a double infection of salmonella and shigella.

TABLE II. SEASONAL DISTRIBUTION OF SALMONELLA AND SHIGELLA INFESTATIONS IN 99 CHILDREN ACCORDING TO AREA OF DOMICILE

Area of domicile	Railway location				Komatipoort location				Farms			
No. of children	39				45				15			
	Salmonella		Shigella		Salmonella		Shigella		Salmonella		Shigella	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
July (winter) isolations	—	—	1*	2·6	1*	2·2	—	—	—	—	—	—
November (summer) isolations	1	2·6	1*	2·6	3*†	6·7	2†	4·4	2	13·3	—	—

*Same case. †Double infection in same specimen.

TABLE III. CLINICAL OBSERVATIONS RELATED TO INFECTION

	Number of specimens	Consistency of faeces: Hard No.	Hard %	Soft No.	Soft %	Liquid No.	Liquid %
Pathogens not recovered	235	170	72·3	55	23·4	10	4·3
Salmonella-infected	7*	5	71·4	2*	28·6	—	—
Shigella-infected	4*	2	50·0	2*	50·0	—	—
Total infected	11	7	63·6	4	36·4	—	—

	Number of specimens	Temperature (°F): 98·4 No.	98·4 %	98·4—99·9 No.	98·4—99·9 %	100+ No.	100+ %
Pathogens not recovered	232	13	5·6	136	58·6	83	35·8
Salmonella-infected	7*	—	—	2*	28·6	5	71·4
Shigella-infected	4*	1	25·0	3*	75·0	—	—
Total infected	11	1	9·2	5	45·4	5	45·4

*One double infection from a single specimen.

Of the 23 salmonella and shigella strains isolated from the survey, all were resistant to benzyl penicillin and novobiocin and 53% of the salmonellae to erythromycin. All were sensitive to chloramphenicol and ampicillin as well as to the tetracyclines, streptomycin, kanamycin, nitrofurantoin and colistin.

Results of the water sample analysis showed that the water which was piped to the Railway location from the town supply and the water in the school tank were of a reasonable quality and fulfilled the standards laid down by the South African Bureau of Standards[5] for small towns with a population of up to 2,500 persons. In contrast, samples taken from the Crocodile and Komati Rivers were highly unsatisfactory, presumptive coliform counts ranging from 70 - 600/100 ml., with corresponding faecal *E. coli* ranging from 50 - 250 organisms/100 ml.

From the investigations of the Moore pads submerged in the 2 rivers it is interesting to note that *S. typhimurium* was isolated on both occasions. Other salmonellae isolated were *S. teko, S. rowbarton, S. dublin, S. poona, S. greenside, S. adelaide* and *S. mission*. Because some pads were removed by passers-by, replacements could only be left in the river flow for about 14 hours. It is noteworthy that salmonellae were also recovered from these pads.

DISCUSSION

According to reports in the current literature, the incidence of salmonellosis during the last decade appears to be on the increase.[6-9] During 1946 - 1955 there was a 7-fold increase in the USA while reports from England and Wales showed that over the period 1950 - 1955 there was a 2½-times increase in the frequency of salmonella isolated.[10]

Although there have been no long-term comparative surveys in South Africa, Bokkenheuser and Greenberg,[11] found that there was an increase of from 1·8% isolations in 1956 to 4% in 1957 using the same bacteriological techniques. The following year, Bokkenheuser and Richardson,[12] on investigating the excretion from Bantu food-handlers, found that 4·3% of these had salmonella infections and 0·6% shigella.

In the more detailed previously mentioned studies on groups of Bantu school children, Bokkenheuser and Richardson[1, 2] found that in a school in a rural area (Rustenburg), 54 of 75 children (72·0%) tested 7 times during the year had either salmonellosis or shigellosis and in another school on the outskirts of Johannesburg (Witkoppen) 37 of 75 (50·0%) children were infected with these organisms on 8 investigations carried out during the year. Although the findings of the 2 investigations at the Komatipoort school cannot be compared with those of the other surveys, the results of the salmonella and shigella isolations, 8 out of 99 children (8·0%), suggest that there is a lower incidence of salmonellosis and shigellosis in this Lowveld school. Further evidence in favour is suggested by comparing the observations on the seasonal collections of these 3 schools (Table IV).

TABLE IV. COMPARATIVE SEASONAL INCIDENCE IN THE 3 AREAS

	Rustenburg: Salmonella	Rustenburg: Shigella	Witkoppen: Salmonella	Witkoppen: Shigella	Komatipoort: Salmonella	Komatipoort: Shigella
Winter*	0%	4%	4%	—	1%	1%
Summer*	22·6%	8·0%	8·0%	—	6%	3%

*The Rustenburg collections took place in August and December while the Witkoppen and Komatipoort figures are those of July and November.

Concerning the consistency of the stools, there was no evidence of a softening effect on those specimens which yielded pathogens. None were isolated from the 10 liquid stools. There were appreciably more children with elevated temperatures than in the other 2 studies. Of the 7 children with salmonella infections, 5 had temperatures over 100°F. Apart from the raised temperatures, which are of doubtful significance, the children showed no clinical signs of infection, indicating that their conditions were mainly mild and subclinical.

The only significant difference in the antibiotic sensitivity of both salmonellae and shigellae, was that in the Rustenburg investigation only 7·1% were resistant to erythromycin, whereas 53% were resistant at Komatipoort. This is in agreement with the findings of 62·7% at Witkoppen.

It is well known that domestic and wild animals are capable of harbouring salmonellae[10, 11] and are thus potential dangers in infecting humans. Both in the Rustenburg and Witkoppen studies faeces-contaminated water was suspected of being involved in the infection of the children. In one of the schools (Rustenburg) most of the drinking water was obtained from shallow wells heavily contaminated with faecal bacteria. In close proximity to

these protected wells, were open ones for the exclusive use of cattle and other animals. Similarly in the Witkoppen area, the results of water analysis, although better than Rustenburg, still showed the water to be of poor quality. The suspicion that the water supply is a factor in the transmission of salmanellosis is strengthened by the results of the present survey. In the classification of the children into their areas of domicile, 6 of the 8 children from whom pathogens were isolated came from either the Komatipoort location or from the surrounding farms. Water for these families is drawn either from wells or from the 2 rivers bordering Komatipoort. The remaining 2 children came from the Railway location which draws its piped purified water from the town reservoir. It is surprising to find that in view of the presence of salmonellae in the river water, the incidence of salmonellae in the children drinking this water was not very much higher. It is also noteworthy that during winter the incidence of salmonellosis in the children was negligible in spite of the fact that salmonellae were recovered from the rivers during that time. This higher incidence in summer is in accordance with trends observed in other surveys.[11] This may be due to insufficient organisms being available in winter for an infective dose and possibly an increased host susceptibility in summer.

Studies carried out by Walker and De Lacy[3] and De Meillon *et al.*[13] on the incidence of bilharzia in the 3 schools showed that *S. haematobium* was virtually absent at the Rustenburg school due to the water being derived from small shallow wells, that Witkoppen had about 20% infestation, and Komatipoort approximately 85%. The fact that the chidren of the Komatipoort school have mean height and weight figures higher than those of the school child populations of Rustenburg and Witkoppen is difficult to explain. It is possible that the increased consumption of vegetables and fruit has a bearing on their general health, together with the apparent lower incidence of salmonellosis and shigellosis.

For further comparison a study on the incidence of salmonellae and shigellae is being carried out in Bantu school children from a higher socio-economic group in Johannesburg where piped water is normal and there is easy access to hospital or clinics in case of illness.

The well-known very high mortality from acute diarrhoeal disease in early life in indigenous populations in under-developed countries[14, 15] must be accompanied by a high morbidity. In a survey carried out on White children at the Transvaal Memorial Hospital for Children in Johannesburg,[16] it was evident that salmonellae and shigellae were more prevalent in children in a poor nutritional state. A high incidence of diarrhoea and diarrhoeal pathogens in infants is therefore very likely to be an important factor contributing to a poor physical stature in children. A comparative study on the incidence of infantile diarrhoea in these 3 areas should yield very interesting results and could confirm or refute this suggestion.

Undoubtedly, the education of the Bantu, particularly those in the rural areas, as to the importance of fundamental hygiene practices, the dangers of drinking impure water, and the necessity of having an adequate and balanced diet, will help towards reducing the incidence of salmonellosis and shigellosis in the community.

SUMMARY

Faeces from outwardly healthy Bantu children in a school at Komatipoort, Eastern Transvaal, were examined in winter (July) and summer (November).

Eight of 99 children investigated on both occasions had either salmonella or shigella infections. *S. typhi* was isolated from one child on both occasions, indicating a carrier state.

In accordance with previously undertaken surveys there were fewer isolations of these pathogens in winter than in summer.

Piped water from the town reservoir which was bacteriologically satisfactory, and heavily contaminated river water, both used for drinking purposes, were examined. Using the Moore pad technique, 8 different types of salmonella were recovered from the 2 rivers bordering the area.

Although not entirely comparable with 2 other surveys in the Rustenburg (rural) and Johannesburg (periurban) area, the results of this investigation suggest that the incidence of salmonellosis and shigellosis in Komatipoort is lower.

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