A STUDY OF SUMMER DIARRHOEA IN WHITE CHILDREN IN JOHANNESBURG

H. J. KOORNHOF, N. J. RICHARDSON, W. M. POLITZER, *South African Institute for Medical Research, Johannesburg;* H. L. UTIAN, *Transvaal Memorial Hospital for Children;* AND H. MALHERBE, *Poliomyelitis Research Foundation, Johannesburg*

Few controlled studies on infantile diarrhoea in White children have been conducted in South Africa. In 1948 Mitchell *et al.*[1] reported on neonatal Coloured and White babies with diarrhoea in a maternity hospital in the Cape Peninsula. Although coliform organisms were incriminated, serological typing of enteropathogenic *E. coli* (*EEC*) was not attempted and no other causal agents were identified. Coetzee and Pretorius,[2] in a controlled investigation, reported on the incidence of bacterial pathogens in gastroenteritis in children up to 4 years of age during the summer months of 1954 in Pretoria, selecting 25 White and 75 Bantu patients, with 109 normal controls. Salmonella and shigella organisms were recovered from 16·0% of the cases and *EEC* from 41·0% compared with 20·0% *EEC* in the non-diarrhoeal controls.

More work has been done on gastroenteritis in Bantu children. Investigating a small number of cases, Kahn and Robertson[3] concluded in 1952 that *E. coli* groups 055:B5 and 0111:B4 are unlikely to cause gastroenteritis in Bantu infants on the Witwatersrand. Kahn[4] in 1957 reported that in the Johannesburg area, approximately 20% of 600 Bantu children with diarrhoea under the age of 1 year had salmonella and shigella infections. Recently Roux *et al.*,[5] in an extensive survey of infantile diarrhoea in the Baragwanath Hospital, reported a high incidence (36·7%) of salmonella and shigella infections in infants with severe diarrhoea, while *EEC* were recovered from 30·0% of severe diarrhoeal cases and from 11·7% of non-diarrhoeal controls. At the same hospital, Kahn *et al.*[6] reported a high incidence of *EEC* (36·8%) in premature infants with diarrhoea, compared with 16·7% in control premature infants. In these 2 investigations known enteric viruses did not appear to play a significant part in the causation of gastroenteritis. Malherbe *et al.*[7] also found no significant difference at Baragwanath Hospital between the viral isolations from infants with 'non-specific' gastroenteritis and controls during both summer and winter months.

With the above findings in mind, it was decided to conduct a survey on summer diarrhoea at the Transvaal Memorial Hospital for White children. The purpose of the investigation was to assess the relative importance of known pathogenic salmonella and shigella organisms as well as viruses and *EEC* in the causation of diarrhoea in White children in Johannesburg. It was also decided to investigate the significance of volatile amine-producing *Streptococcus faecalis* organisms in infantile diarrhoea.[8, 9]

PROCEDURE AND METHODS

The investigation was spread over 5 summer months from November 1961 to March 1962. Faecal examinations for bacteria and viruses were performed on 355 children up to the age of 2 years. One ward comprised 30 beds for infant medical and surgical cases, and the other 20 beds for 'infectious diseases'.

On admission 1 rectal swab was taken from each patient and immediately used for bacteriological examination. Three more swabs, taken the next morning, were agitated in a fluid medium which was then despatched without undue delay for virus investigations. All swabs were taken by only 1 person specially assigned to this work. When diarrhoea developed in a ward further rectal swabs were taken. Where indicated, blood samples were taken for cultural and serological investigations.

The hospital serves mainly a low-income population. The patients were divided into 3 groups comprising 98 primary and 27 secondary diarrhoeal, and 230 non-diarrhoeal cases. The secondary diarrhoeal group consisted of patients in whom the diarrhoea could reasonably be associated with factors such as upper respiratory-tract infections and poor feeding. The diarrhoea was acute in the majority of instances and chronic in 3 cases only. The acute cases were divided into mild, moderate and severe on the basis of the degree of dehydration and wasting together with the need for intravenous fluid and the severity of collapse. All the infants classed as severe and most of those as moderate received intravenous fluid therapy.

Bacteriological Methods

A McCartney bottle containing about 8 ml. of nutrient broth was first inoculated, and the swab was then broken off into another McCartney bottle containing about 8 ml. of Selenite F medium.

After a short incubation period (6 - 12 hours) S.S. agar, MacConkey agar and Chapman's plates were inoculated from the nutrient broth. The Selenite F culture was incubated overnight and planted on S.S. agar the following morning. From the S.S. plates, 3 lactose-negative colonies were transferred to composite media for biochemical reactions. The salmonellae were typed antigenically in detail and the shigellae according to their principal group antigen.

Staphylococcus colonies from Chapman's plates were picked off into a plasma-mannitol liquid medium, and if positive were phage typed according to the method of Blair and Williams.[10]

For the identification of enteropathogenic *E. coli*, 5 colonies were picked off into nutrient broth tubes and on to tryptose agar slants. Slide agglutination tests were done using the tryptose agar slopes and if a positive result was obtained with a smooth colony, the identity of the somatic antigen was confirmed by a tube-agglutination test, after the nutrient broth suspension had been boiled for 30 minutes.

Strep. faecalis for volatile amine studies was obtained by heating the original nutrient-broth culture for 30 minutes at 60°C with subsequent plating out on blood agar.

Volatile Amine Investigations

A modified procedure of Bachrach *et al.*[8] was used. *Strep. faecalis* strains were cultured in volatile amine medium[9] from which a 1:5 dilution was applied onto Whatman No. 1 filter paper. Ascending chromatography was carried out using as the solvent butanol:acetic acid:water, in a 2:1:1 proportion. After drying, the colour was developed by spraying with 0·5% ninhydrin in n-butanol. Methylamine hydrochloride, phenylethylamine and tyramine were employed as standards.

Virological Methods

Each rectal swab was agitated in 2 ml. of gelatin-buffer saline containing 750 units of penicillin/ml., 750 μg. of streptomycin, 500 μg. of neomycin and 200 units of mycostatin. The suspensions were transported to the laboratory at approximately 4°C and after centrifugation at 2,500 rpm for 30 minutes the supernatant fluids were used for virus recovery.

Specimens from both diarrhoeal and non-diarrhoeal children were inoculated into roller-tube primary-tissue cultures of vervet (*Cercopithecus aethiops*) monkey kidney and of human amnion held at approximately 37°C for 21 days; and were also inoculated intraperitoneally into 24-hour-old suckling white mice observed for 14 days. In addition, faecal suspensions from 59 patients with diarrhoea were tested in tissue cultures of 1 or more of several continuous culture cell lines of human or simian origin held at 34°C and 38°C.

Results

Table I shows the incidence of the probable bacterial pathogens, viruses, and volatile amines-producing *Strep. faecalis* according to the 3 age groups, 0 - 3 months, 4 - 11 months and 1 - 2 years.

Salmonellae and shigellae were isolated from 10 patients each in the primary diarrhoeal group and together accounted for 20·4% of the diarrhoea in this group, while in the control group the figures were 3·9% and 0·9% respectively. The salmonellae consisted of *S.typhi-murium* (3), *S. london* (2), *S.montevideo* (2), *S.kentucky* (1), *S.lindenberg* (1) and *S.johannesburg* (1). The 1 salmonella isolated from the secondary diarrhoeal group was a *S.typhi-murium* in a patient with acrodermatitis enteropathica who had a mild chronic diarrhoea. The shigellae were distributed as follows: *Sh. flexneri* (3), *Sh.newcastle* (3), *Sh.sonnei* (2), *Sh.large-sacksii* (2). No definite geographical distribution of salmonellae or shigellae could be demonstrated. The 2 *Sh.large-sacksii* isolations were from twin siblings.

In the control group the following salmonellae and shigellae were isolated: *S.johannesburg* (5), *S.typhi murium* (1), *S.london* (1), *S.derby* (1), and *S.fresno* (1), *Sh.flexneri* (1), and *Sh.sonnei* (1).

Enteropathogenic E.coli (*EEC*) showed a much higher incidence in the 0 - 3 months and 4 - 11 months age groups than in the 1 - 2-year group, the figures being 9 (23·1%) of 39 patients, 6 (19·4%) of 31 and 2 (7·1%) of 28 respectively. *EEC* were isolated from 3 (11·1%) of 27 patients in the secondary diarrhoeal group and from 18 (7·8%) of 230 in the control group.

Viruses were recovered from 9 (9·2%) of the 98 patients in the primary diarrhoeal group, 1 (3·7%) of 27 secondary diarrhoea patients and from 12 (5·2%) of 230 control patients. The viruses isolated from the diarrhoeal patients comprised Coxsackie A3 (1), Coxsackie A4 (2), Coxsackie B2 (3), ECHO-virus 4 (1), adenovirus (1) and reovirus (2). From the control group 4 Coxsackie A and 5 Coxsackie B viruses as well as 2 polioviruses and 1 reovirus were isolated.

Chromatographic analysis of the *Strep. faecalis* cultures for volatile amines showed spots corresponding to those of methylamine in 5 cases with gastroenteritis, 3 (3·1%) in the primary group and 2 (7·4%) in the secondary group, and in 9 (3·9%) control cases. Spots corresponding to phenylethylamine and tyramine were not observed.

Table II shows a further analysis of the primary diarrhoeal group isolations with regard to age, severity of diarrhoea and the nutritional state of the patients. Although the figures are too small for valid conclusions there are some trends that may be worth noting.

Salmonellae were recovered from 7 (14·0%) of 50 patients in the severe diarrhoeal group but from only 1 (5·6%) of 18 and 2 (6·7%) of 30 patients in the moderate and mild diarrhoeal

TABLE I. INCIDENCE OF POSSIBLE CAUSATIVE AGENTS ACCORDING TO AGE

		0–3 months				*4–11 months*				*1–2 years*				*All age groups*			
		Diarrhoea		*No diarrhoea*		*Diarrhoea*		*No diarrhoea*		*Diarrhoea*		*No diarrhoea*		*Diarrhoea*		*No diarrhoea*	
		No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Total tested	P	39		91		31		71		28		68		98		230	
	S	11				9				7				27			
Salmonella	P	4	10·3	1	1·1	4	12·9	5	7·0	2	7·1	3	4·4	10	10·2	9	3·9
	S	0	—			1	11·1			0	—			1	3·7		
Shigella	P	2	5·1	—	—	—	—	—	—	8	28·6	2	2·9	10	10·2	2	0·9
	S	0	—							0	—			0	—		
EEC	P	9	23·1	7	7·7	6	19·4	7	9·9	2	7·1	4	5·9	17	17·3	18	7·8
	S	2	18·2			1	11·1			0	—			3	11·1		
Total pathogenic bacteria	P	15	38·4	8	8·8	10	32·3	12	17·0	12	42·9	9	13·2	37	37·7	29	12·6
	S	2	18·2			2	22·2			0	—			4	14·8		
Virus	P	3	7·7	3	3·3	5	16·1	6	8·5	1	3·6	3	4·4	9	9·2	12	5·2
	S	1	9·1			0	—			0	—			1	3·7		
Volatile amines	P	0	—	—	—	—	—	5	7·0	3	10·7	4	5·9	3	3·1	9	3·9
	S	1	9·1							1	14·3			2	7·4		

P = Primary diarrhoea. S = Secondary diarrhoea.

TABLE II. ISOLATIONS RELATED TO SEVERITY OF DIARRHOEA AND NUTRITIONAL STATE

Primary diarrhoea group	Age groups	Severe: Nutritional state			Moderate: Nutritional state			Mild: Nutritional state		
		Poor	*Fair*	*Good*	*Poor*	*Fair*	*Good*	*Poor*	*Fair*	*Good*
Total number of children	0–3 months	8	4	10	2	2	4	3	—	6
	4–11 months	5	4	7	1	—	4	2	1	7
	1–2 years	5	1	6	1	—	4	2	2	7
Salmonella isolations	0–3 months	—	—	3	—	1	—	—	—	—
	4–11 months	3	—	—	—	—	—	—	1	—
	1–2 years	1	—	—	—	—	—	—	—	1
Shigella isolations	0–3 months	1	1	—	—	—	—	—	—	—
	4–11 months	—	—	—	—	—	—	—	—	—
	1–2 years	2	—	1	1	—	3	—	—	1
EEC isolations	0–3 months	3	—	2	1	—	1	—	—	2
	4–11 months	1	1	2	—	—	1	—	1	—
	1–2 years	—	—	1	—	—	—	—	—	1
Virus isolations	0–3 months	—	—	1	—	—	—	1	—	1
	4–11 months	3	—	—	—	—	—	1	—	1
	1–2 years	—	—	—	—	—	—	—	1	—

groups respectively. Similarly *EEC* were more frequently isolated from patients with severe and moderate rather than mild diarrhoea in the age group 0 - 1 year; the figures being 9 (23·7%) of 38, 3 (23·1%) of 13 and 3 (15·8%) of 19 respectively. Shigella infections in this survey were more commonly encountered in the 1 - 2-year group than in the 0 - 1-year group, the figures being 8 (7·8%) of 103 combined diarrhoeal and control patients and 2 (0·8%) of 252 respectively. They were also more prevalent in patients with moderate and severe diarrhoea, viz. 4 (22·2%) of 18 and 5 (10·0%) of 50 respectively, than in the mild diarrhoeal group; the incidence being 1 (3·3%) in 30 cases.

It is noteworthy that bacterial pathogens were isolated from 45·3% of cases with severe and moderate diarrhoea and from only 25·0% of those with mild diarrhoea.

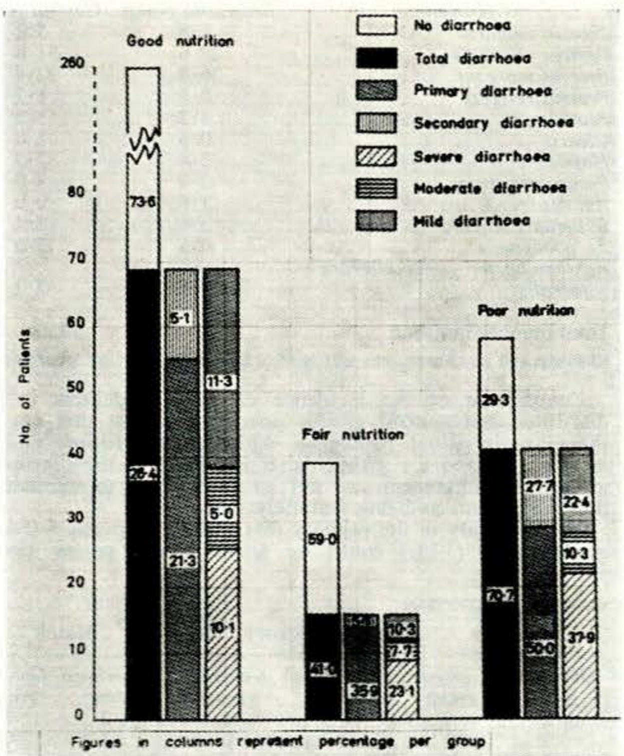

Fig. 1. Histogram showing diarrhoea and nutritional state of patients.

A histogram (Fig. 1) shows the relationship between the nutritional state of the patients and the incidence of the various clinical forms of diarrhoea. The incidence of diarrhoea in patients with good, fair and poor nutritional states shows a steep rise from 26·4% to 41·0% and 70·7% respectively. It can also be seen that the incidence of severe diarrhoea is proportionately higher in the poor nutritional group. Analysis of shigella and salmonella infections in the 3 nutritional groups shows the same trend of severe infections in undernourished children in the 4 - 11-month and 1 - 2-year groups (Table II).

Antibiotics given before bacteriological investigations were performed had no significant effect on the bacteriological isolations. Our results suggest that antibiotic treatment may have played a role in reducing the severity of salmonella and shigella infections but the duration of the various forms of diarrhoea was not appreciably affected.

The incidence of the various serological types of enteropathogenic *E.coli* is shown in Table III. Types 055 : B5, 0126 : B16,

TABLE III. DISTRIBUTION OF EEC TYPES IN DIARRHOEA AND CONTROL GROUPS

		0–3 months		4–11 months		1–2 years	
		Diarrhoea	*Control*	*Diarrhoea*	*Control*	*Diarrhoea*	*Control*
Total tested		50	91	40	71	35	68
055	B5	2	1	3	1	1*	1
0126	B16	2	1	1	—	1	—
026	B6	1	1	2	1	1	1
0111	B4	2	2	1	1	—	—
086	B7	2	—	—	—	—	—
0119	B14	1	—	—	1	—	—
0128	B12	1	—	—	2	—	—
0127	B8	—	2	—	—	—	2
0125	B15	—	—	—	1	—	—
Total isolations		11	7	7	7	3	4
Percentage isolations		22	7·7	17·5	9·9	8·3	5·9

*Hospital ward cross-infection.

026 : B6 and 0111 : B4 were most prevalent in the patients with diarrhoea. Type 0125 : B15 which was frequently encountered in both control and diarrhoeal patients at Baragwanath Hospital but regarded by the authors[4-6] as of doubtful pathogenicity was only found in 1 patient (in the control group) in this survey. Table III shows clearly the higher incidence of *EEC* in infants under 1 year compared with patients in the 1 - 2 year and the control groups.

The distribution of *Staphylococcus aureus* phage types in the various age groups and their relationship to the severity of diarrhoea are shown in Tables IV and V. In both the diar-

TABLE IV. STAPHYLOCOCCAL PHAGE TYPES ACCORDING TO AGE AND SEVERITY OF DIARRHOEA

Staph. group		*0–3 months*			*4–11 months*			*1–2 years*		
		Severe	*Moderate*	*Mild*	*Severe*	*Moderate*	*Mild*	*Severe*	*Moderate*	*Mild*
Staph. Gr. I	P	4	2	1	1	—	1	1	—	—
	S	—	—	1	—	—	—	—	—	—
Staph. Gr. II	P	—	—	—	—	—	—	—	—	—
	S	—	—	—	—	—	—	—	—	—
Staph. Gr. III	P	1	1	1	1	—	—	—	—	1
	S	—	—	—	—	—	1	—	—	—
Staph. untypable	P	3*	2	1	1	—	2	1	—	1
	S	—	—	1	1	—	—	—	—	—
Total Staph. isolation in percentage			36			20			11·8	

*One isolation not typed. P = Primary diarrhoea. S = Secondary diarrhoea.

TABLE V. STAPHYLOCOCCAL PHAGE TYPES ACCORDING TO AGE IN THE CONTROL GROUP

Staph. group	*0–3 months*	*4–11 months*	*1–2 years*
Staph. Gr. I	8	8	3
Staph. Gr. II	1	0	0
Staph. Gr. III	5	3	2
Staph. untypable	6*	6	1
Total staph. isolation in percentage	25	21·2	11·8

*One isolation not typed.

rhoeal and control groups it will be seen that there is a progressive drop in the incidence of *Staph. aureus* from 36·0% and 25·0% respectively in the 0 - 3-month age groups, to 11·8% in the 1 - 2 year age groups. This trend follows the pattern of nasal staphylococcal-carrier rates in children. The incidence of the various phage types is given in Table VI.

TABLE VI. STAPHYLOCOCCAL PHAGE TYPES

	Group I	*Group II*	*Group III*	*Untypable*
Diarrhoea group..	10·2%	0%	5·1%	10·2%
Control group ..	8·7%	0·4%	4·3%	5·7%

Our results do not suggest that *Staph. aureus* played a role in gastroenteritis in this survey. Group III strains which are usually regarded as potential causal agents in food poisoning and staphylococcal enterocolitis, showed a similar incidence in the diarrhoeal and control groups. The virtual absence of Group II strains which are commonly associated with mild skin infections, is an interesting finding.

TABLE VII. MULTIPLE INFECTIONS

	Diarrhoeal group	*Control group*
Enteropathogenic *E.coli* with:		
Salmonellae only	1	0
Shigellae only	1	0
Salmonellae and viruses ..	1	0
Viruses only	1	0
Staph. aureus only	6	4
Staph. aureus and viruses ..	1	0
Salmonellae with:		
Staph. aureus only	0	2

Multiple infections with bacteria and viruses occurred infrequently and are shown in Table VII.

The seasonal distribution of the potentially pathogenic organisms is given in Table VIII.

The majority of salmonella and shigella infections occurred in the early summer, comprising 10 (37·0%) of 27 diarrhoea cases in November. In this month a wave of shigella infections followed shortly after an initial wave of salmonella diarrhoea, but the rest of the summer period did not show any definite pattern.

There was only 1 example of possible ward cross-infection in this investigation, when a patient developed diarrhoea several days after admission. An *E.coli*, type 055:B5, was isolated from the patient.

The incidence of various Gram-negative bacilli normally found in faeces and not usually regarded as pathogenic is given in Table IX.

TABLE IX. PERCENTAGE INCIDENCE OF BACTERIA USUALLY NOT REGARDED AS PATHOGENS

Organism	*Diarrhoea group*	*Control group*
Proteus vulgaris	8·8	5·2
Proteus mirabilis	29·6	31·8
Proteus morgani	36·8	27·4
Proteus rettgeri	0·8	1·3
Providencia	3·2	3·9
Cloaca	0·8	3·0
Hafnia	2·4	2·2
Paracolobactrum	2·4	3·0
Alkalescens-Dispar	1·6	0·9
Ballerup-Bethesda	5·6	7·4
Ps. pyocyanea	0·8	3·0
Achromobacter — Alkaligenes faecalis	4·8	2·2
Total number in group ..	125	230

Klebsiella and *E.coli* organisms were isolated from the majority of specimens.

Comparison of the incidence of these organisms in the diarrhoea and control groups does not suggest that any of these are intestinal pathogens. Although *P. vulgaris* and *P. morgani* showed a slightly higher incidence in the diarrhoeal group, the differences are not so marked as to incriminate these organisms as being definitely pathogenic.

The mortality in the primary diarrhoeal group was 5 (5·1%), of which 3 (3·1%) could be attributed to severe gastro-

TABLE VIII. MONTHLY INCIDENCE OF PATHOGENS

	November		*December*		*January*		*February*		*March*	
	Diarrhoea group	*Control group*	*Diarrhoea group*	*Control group*	*Diarrhoea group*	*Control group*	*Diarrhoea group*	*Control group*	*Diarrhoea group*	*Control group*
Salmonellae	5	4	1	1	2	3	1	1	2	0
Shigellae	5	1	0	0	1	1	3	0	1	0
EEC	3	3	7	4	3	5	4	4	3	2
Viruses	3	3	2	5	3	0	1	2	1	2

enteritis. The latter 3 patients were admitted in a moribund state and died shortly afterwards. From 1 of these *S. london* was isolated, and 2 failed to yield pathogens. The other 2 patients in the primary diarrhoea group died of concurrent diseases. There was 1 death in the secondary diarrhoeal group in a patient who had a mild diarrhoea and died of staphylococcal septicaemia.

DISCUSSION

The results of this investigation show that salmonellae and shigellae played a significant role in summer diarrhoea in White children in Johannesburg during the period covered by this survey. The high incidence in early summer (37·0% in this study) follows the accepted pattern in temperate zones. The incidence of 20·4% over the full period is less than at the Baragwanath Hospital (36·7%) reported by Roux *et al.*[5] Our salmonella isolations are well in excess of that reported in North America and European countries, e.g. Ramos-Alvarez and Sabin[11] in Cincinatti, Armstrong[12] and Walker *et al.*[13] in Canada and D'Alessandro and Dardanoni[14] in Italy. Although shigellosis is reported to be the most common enteric infection in children from countries where good nutrition prevails,[15] our relatively lower incidence follows the pattern seen in less well developed countries where diarrhoeal disease of diverse aetiology is more prevalent.[15]

Accounts by Bokkenheuser and Richardson[16, 17] on the frequent faecal isolations of salmonellae and shigellae from Bantu school children in country and peri-urban regions in the Transvaal, as well as the findings at Baragwanath Hospital in clinical cases, clearly show the high incidence of these organisms in Bantu children. It is not surprising that these infections were also very prevalent in White children in this investigation, especially if one considers that these children came from the lower socio-economic groups. It is interesting to note that the carrier rates of salmonella and shigella organisms in the control group of this survey (3·9% and 0·9%) are similar to those reported by Bokkenheuser and Richardson[18] (4·3% and 0·6% respectively), investigating Bantu food handlers of the Transvaal Mining Industry.

The association of the incidence and severity of diarrhoea with poor nutritional states in patients is an expected finding and is in agreement with the higher infant mortality of gastroenteritis in malnourished Coloured children reported by Robertson and Kemp.[19]

The role of antibiotic treatment in diarrhoea of bacterial origin is controversial and difficult to assess. No attempt was made in this survey to determine the effect on the course of the gastroenteritis by antibiotic treatment after admission. An analysis of the effect of antibiotic treatment before admission yielded inconclusive results because of the small number of patients in the pre-admission treatment group and the unreliability of the information obtained from the parents.

The role of *EEC* in summer diarrhoea is still incompletely understood. The significantly higher incidence in children under the age of 1 year in the diarrhoeal group compared with the control group, and the apparent association with a severe form of diarrhoea, suggest that they are important intestinal pathogens in infants. However, unknown concomitant factors precipitating the diarrhoeal episodes probably exist. Outbreaks of infantile diarrhoea in institutions indicate that the virulence of these organisms may be an important factor.

Our results suggest strongly that *EEC* are responsble for diarrhoea in children under the age of 1 year, but the high incidence in the control group makes an assessment of the true extent of *EEC* diarrhoea very difficult. Our finding that diarrhoea associated with *EEC* tends to be severe, is in agreement with that of Ramos-Alvarez and Sabin[11] in their Cincinatti diarrhoeal survey.

Volatile amine-producing strains of *Strep. faecalis* were more common in the control group than in the patients with diarrhoea. Streptococcal strains in this survey produced methylamine and not phenylethylamine or tyramine as reported by Bachrach *et al.*[7, 8] We could therefore not establish that volatile amine-producing *Strep. faecalis* strains were responsible for infantile diarrhoea in this survey. However, it should be pointed out that we did not do quantitative estimations of faecal volatile amines, as described by the authors.

Reports on the role of viruses as a cause of infantile diarrhoea are conflicting. Ramos-Alvarez and Sabin[11] and D'Alessandro and Dardanoni[14] reported a high incidence of enteroviruses in infantile diarrhoea patients and also in the control patients. The Italian authors found no significant difference in viral isolations between the diarrhoeal and control groups while the Cincinatti team found a 6-fold higher incidence of ECHO-viruses in the diarrhoeal group compared with control patients, but no significant difference in the incidence of coxsackie A and B viruses in the 2 groups. Walker,[13] on the other hand, at the Hospital for Sick Children, Toronto, found a low incidence of viruses in infants in his control group, and failed to isolate any viruses from 208 children with diarrhoea.

There is no conclusive evidence that enteric viruses played a significant role in the causation of diarrhoea at the time of this survey. It is, however, reasonable to expect a wide variation of virus infections from one year to another, and it is possible that our findings reflect such an epidemiological variation.

Only a few multiple infections were demonstrated in this survey and definite patterns were not observed. Although multiple isolations were more common in the diarrhoeal than in the control group, our figures do not suggest that viruses and *EEC* play a significant role in precipitating diarrhoea in mixed infections. An association of adenovirus and shigella infections as reported by Gardner *et al.*[20] in England, was also not demonstrated. In our diarrhoea group adenovirus was isolated from only 1 patient who had a multiple infection with *S. london* and *E.coli* 055 : B5, as additional pathogens.

Isolations of enteric viruses from the secondary diarrhoeal patients showed no significant difference from the control group. These findings are in accordance with those of Malherbe *et al.*[7] in their Baragwanath survey. The incidence of potentially pathogenic bacteria, including *EEC*, was also not significantly higher in these patients.

Although we could not clearly establish the relative roles of the various factors concerned with infantile diarrhoea, it is obvious that a multiplicity of factors operate in its pathogenesis. The recognized pathogens, salmonellae, shigellae and *EECs*, probably play a dominant part in the initiation of the diarrhoea, but this survey shows that the nutritional state of the patient contributes to the pathogenesis and severity. Parenteral infections may also be associated with diarrhoea, but predisposing conditions are often not evident in mild diarrhoea. In fact, little is known of the mechanism and interplay of these factors as well as other considerations such as the disturbance of the normal equilibrium of the intestinal flora, changes in the virulence of pathogens, and possibly functional and enzymatic disturbances of the gastro-intestinal tract.

SUMMARY

Aetiological factors involved in diarrhoeal disorders in White children belonging mainly to the lower socio-economic group were studied at the Transvaal Memorial Hospital for Children, Johannesburg, over 5 summer months from November 1961 to March 1962. Bacteriological and virological investigations were performed on 355 children under the age of 2 years. Of these children 125 suffered from diarrhoea and 230 were non-diarrhoeal control cases.

Salmonellae and shigellae commonly caused diarrhoea in these patients. The incidence of salmonella and shigella infections in 98 children with primary diarrhoea was 20·4% over the full period and 37·0% in the month of November. They were more frequently associated with severe diarrhoea, and shigella infections were more common in the 1 - 2-year age group.

Enteropathogenic *E.coli* appeared to play a definite role in infants under 1 year of age. In patients with diarrhoea the incidence was 21·3% in children under 1 year of age, and 7·1% in those 1 - 2 years old. In the non-diarrhoeal control patients the incidence was 7·8%. These organisms were also more commonly isolated from patients with severe and moderate diarrhoea.

Salmonellae, shigellae and *EEC* were associated with 45·3% of severe and moderate diarrhoea cases, while only 25·0% of the mild diarrhoeal patients yielded recognized bacterial pathogens.

Enteric viruses were isolated from 9·2% of patients in the primary diarrhoea group, 3·7% of patients with secondary diarrhoea and 5·2% of control non-diarrhoeal patients. They did not appear to play a significant role in gastroenteritis in this survey.

Volatile amine-producing *Strep. faecalis* strains were as prevalent in the controls as in the primary diarrhoeal patients; the incidence being 3·9% and 3·1% respectively.

The nutritional state of the patients was shown to be important in both the incidence and the severity of gastroenteritis. In the undernourished children 70·7% suffered from diarrhoea and 37·9% developed a severe form of gastroenteritis, compared with figures of 26·4% and 10·1% respectively for patients in a good nutritional state.

The carrier rates in the non-diarrhoeal control group were: salmonella 3·9%, shigella 0·9%, *EEC* 7·8%, and *Staph. aureus* 19·1%.

We wish to thank Dr. S. C. Heymann, Paediatrician-in-charge; Dr. S. N. Javett, Senior Paediatrician; and other members of the staff of the Transvaal Memorial Hospital for Children for their cooperation and assistance in making this survey possible. We are grateful to Prof. J. H. S. Gear, Director of the South African Institute for Medical Research and of the Poliomyelitis Research Foundation, for facilities granted. Our thanks are also due to Dr. Rosemary Sichel and the staff of the SAIMR branch laboratory of this Hospital for their help in organizing the collection and despatch of the specimens, and to the Medical Superintendent of the Hospital for the use of the clinical records. For the virological investigations carried out in the laboratories of the Poliomyelitis Research Foundation we are indebted to Dr. V. Measroch and the technical staff of the Coxsackie Virus Unit; Mrs. W. Pech and other members of the technical staff of the Poliovirus Isolation Unit; and members of the technical staff of the Enteric Virus Research Unit.

REFERENCES

1. Mitchell, E. E., Van den Ende, M., Gant, I., Rabkin, J. W., Selzer, G. and Parker, R. G. F. (1948): Clin. Proc., **7**, 251.
2. Coetzee, J. N. and Pretorius, H. P J. (1955): S. Afr. J. Lab. Clin. Med., **1**, 188.
3. Kahn, E. and Robertson, G. H. (1952): S. Afr. Med. J., **26**, 671.
4. Kahn, E. (1957): *Ibid.*, **31**, 47.
5. Roux, P., Kahn, E., Malherbe, H. and Cassel, R. (1963): *Ibid.*, **37**, 256.
6. Kahn, E., Malherbe, H., Cassel, R. and Schrire, L. (1963): *Ibid.*, **37**, 261.
7. Malherbe, H. and Roux, P. (1963): *Ibid.*, **37**, 259.
8. Bachrach, U., Sterk, V. V., Gery, I. and Rozansky, R. (1960): Amer. J. Hyg., **72**, 1.
9. Bachrach, U., Segal, M. and Rozansky, R. (1958): Proc. Soc. Exp. Biol. (N.Y.), **97**, 874.
10. Blair, J. E. and Williams, R. E. O (1961): Bull. Wld Hlth Org., **24**, 771.
11. Ramos-Alvarez, M. and Sabin, A. B. (1958): J. Amer. Med. Assoc., **167**, 147.
12. Armstrong, J. G. (1958): J. Pediat., **53**, 704.
13. Walker, S. J., McLean, D. M., Roy, T. E., McNaughton, G. A. and Tibbles, J. A. R. (1960): Canad. Med. Assoc. J., **83**, 1266.
14. D'Alessandro, G. and Dardanoni, L. (1961): Riv. Inst. sieroter. ital., **36**, 129.
15. Gordon, J. E., Chitkara, I. D. and Wyon, J. B. (1963): Amer. J. Med. Sci., **245**, 345.
16. Bokkenheuser, V. and Richardson, N. J. (1960): J. Hyg. (Lond.), **58**, 109.
17. Richardson, N. J. and Bokkenheuser, V. (1963): *Ibid.*, **61**, 257.
18. Bokkenheuser, V. and Richardson, N. J. (1959): S. Afr. Med. J., **33**, 784.
19. Robertson, I. and Kemp, M. (1963): *Ibid.*, **37**, 888.
20. Gardner, P. S., McGregor, C. B. and Dick, K. (1960): Brit. Med. J., **1**, 91.