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Acute diarrhoeal disease in children under 7 years of age in a peri-urban slum of Santiago, Chile

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SUMMARY

A group of 168 families who lived in a peri-urban slum in Santiago were surveyed for 9 months. All of them had a child under 7 years of age. Medical activities and data collection were carried out at a Field Station and by means of twice-weekly visits to each home, at which time cases of diarrhoea were recorded and investigated. Faecal samples for bacteriological, parasitological and rotavirus studies were obtained during each episode. The characteristics of clinical course, hygienic practices in the family, and monthly anthropometric measurements of infants and toddlers were also recorded. The mean monthly incidence of diarrhoea was 7·1 episodes per 100 children. Of the episodes, 44·2% were associated with pathogenic bacteria, 14·4% with rotavirus, 38·4% with parasites and in 27·9% no enteropathogens were identified. It was found that adequate hygienic habits were not associated with a decreased risk of developing diarrhoea and that about 60% of children did not have diarrhoea throughout the study period. The nutritional status was adequate in most cases: weight-for-age was below the 5th percentile in 11·5% of subjects and the height-for-age was normal in all. No moderate or severe cases of malnutrition were detected.

INTRODUCTION

Diarrhoeal disease is the most common cause of morbidity and mortality in the less-developed countries (Walsh & Warren, 1979; PAHO, 1980). Although these countries share some characteristics they are not a homogeneous group. Chile is one of them and has succeeded in lowering its infantile mortality rate from 130 per thousand in 1940 to 21·3 in 1983 (Monckeberg & Riumalló, 1983; Ministerio de Salud Pública, Chile, 1983). One of the main reasons for this reduction is the decrease in the number of deaths related to acute diarrhoea (Brunser *et al.* 1984). Even so, diarrhoea remains the first or second cause of hospital admissions of children under 2 years of age (Tieffenberg *et al.* 1983).

The actual incidence of acute diarrhoea has been investigated prospectively by continuous surveillance in only a few places in the world. Among the underdeveloped countries, such studies have been carried out in Bangladesh (Black *et al.* 1982*a*,

b), the Gambia (Rowland, 1983), Guatemala (Mata, 1978) and Brazil (Guerrant *et al.* 1983), where the incidence ranged from 4 to 8 episodes/child/year, while in developed countries this figure is under 2 episodes/child/year (M. Levine, personal communication). These data are not available in Chile, where most information comes from records kept at hospitals and health centres.

For these reasons, and taking into account the changes that have occurred in the health parameters in Chile during the last few decades, it was decided to study the frequency and aetiology of acute diarrhoea in the children of a group of families of low socioeconomic status living in Santiago.

METHODS

Subjects and procedures

The city of Santiago is located in the Central Valley of Chile (latitude 33° 50′) at an altitude of 760 m above the sea level, and is about 85 km from the sea. It has a moderate continental climate with four well-defined seasons. Temperatures during winter range between −3 and 14 °C. During summer they range from 14 to 32 °C. Rainfall is concentrated in the winter from April to October. The total rainfall averages about 350 mm per year. The summer weather from October to April is warm and dry.

The Chilean population is predominantly white caucasian with about 5% of native Araucano Indians. About 76% of the population live in urban areas. Santiago, the capital city, has about 4 000 000 inhabitants (approximately one-third of the total population of the country). The continuous influx of rural families from the country has resulted in a peri-urban belt of slums ('Campamentos' or 'Callampas') whose population represents about a fifth of the inhabitants of the city. As in all slums, housing is poor and sanitary facilities are deficient or non-existent.

The slum: Población Carlos Condell

This developed in the south-west of Santiago about 15 years prior to this study, when a group of families seized a piece of land from a farm and settled there. At the time of this study the houses were built along three roughly parallel streets, in plots each of about 150–200 m².

In November 1980 a census form and other questionnaires were applied to characterize the people and their housing. The results showed that 98% of the houses were made of light materials (wooden boards, cardboard, flattened cans, etc.). Roofs were made of tar-impregnated paper or asbestos–cement sheets. Floors were made of board in 59% of houses, or packed dirt in 34% and other materials in 7%. Streets were unpaved and without pavements. All houses had electricity, the majority of them through illegal connexions to the electricity network in the area. Water for the slum was supplied by the Metropolitan Water Works to communal standpipes located on both sides of the streets, with approximately one tap for every eight houses. None of the houses had intradomiciliary potable water. The underground street water-mains were made of plastic materials and connexions between the main and the standpipes were precarious. Leakage from the taps and spills formed pools of mud at the bases of most of them. The water supply was

irregular, decreasing or even stopping sometimes around mid-day in the summer months.

At the back of the plot there was a latrine: 66% of the houses had cesspools, 23% had badly built latrines and 11% had no system for sewage disposal at all. Garbage was collected by the county pick-up system at irregular intervals and with a low frequency.

Medical care was provided by a Health Clinic of the National Health System, located about 15 blocks from the slum.

The people. The Census identified 228 families in the slum with 1079 individuals. There was a mean of $4{\cdot}8 \pm 1{\cdot}8$ subjects per family group (median = 5). Of all inhabitants 48·4% were under 15 years of age, 50·4% were between 15 and 65 years of age and 1·2% were over 65, with 48·8% men and 51·2% women. These figures are generally in agreement with those obtained by the 1982 National Census (INE, Chile, 1982).

The person who provided most of the income for the family group was considered as the head of the household. In 74·1% of the families this was the father, in 16·2% the mother and both in 5·7%. In 4% of the households the head was another member of the family. Seven per cent of males and 10·6% of females were illiterate, and 70·8% of fathers and 75·2% of mothers had completed the 8 years of elementary school.

Of the fathers, 39·6% were jobless, peddlers or self-employed with low irregular incomes; 36.4% of fathers were unskilled workers and 24% of them were skilled (factory) labourers. Of those who held steady jobs, 74·5% of fathers and 42·3% of mothers were covered by the state social-security systems. Of the 228 families, 24·4% shared the house with 'allegados' (relatives or friends who share the owners' house and may live with them for long periods of time). One hundred and sixty-eight of the 228 families had a child under 7 years of age. All these families agreed to participate in this study ($n = 283$ children, of which 53·4% were boys). The presence of a child under the age of 7 years was selected as the criterion for choosing the families who would form the study cohort because in Chile children are sent by law to school at this age; before it, in this socio-economic stratum, nearly all remained at home at the time of this study.

The number of individuals in the 168 study families ranged from 2 to 12 with a mean of $5{\cdot}2 \pm 1{\cdot}8$ and a median of 5. On average infants were breast-fed for about 3 months, which was comparable to the national average for this socio-economic stratum at the time of the study. As for the nutritional status of children in the cohort, birth weight and height were above the 10th percentile in all of them. Among the children under 2 years of age, 11·5% had weight under the 5th percentile (P5), 3·3% between P5 and P10, 10·7% between P10 and P25, 4·9% between P25 and P50 and 69·6% on P50 or above.

Under the National Food Supplementation Program implemented by the National Health Service, all children under 12 months received 2 kg of powdered milk per month and those between 1 and 2 years 2 kg of a protein-rich milk substitute.

Experimental design

Surveillance of the population was based on periodic home visits by trained personnel and other activities carried out in a field station where a paediatrician, a registered nurse and the field personnel worked. Members of the families, mainly the mothers, went to the Field Station to report cases of diarrhoea, for normal health assessments of children under 2 years of age, to seek medical advice, to deliver samples and to share daily gossip with the staff.

After they had agreed to participate in this project, parents with children under 7 years of age were requested to sign a written consent. They were then followed-up at least twice weekly for 9 months (Dec. 1980 to Aug. 1981, which included the summer, autumn and winter seasons). On each visit, the mother or guardian was asked about the presence of diarrhoea in any member of the family. When an episode was detected in a child under 7 years of age, faecal samples were obtained for bacterial, parasitological and rotavirus studies.

To obtain information about possible epidemiological mechanisms operating in the community in relation to diarrhoea, a set of everyday hygienic practices and family uses were arbitrarily defined as representative of the habits at home. These were explored by means of questionnaires and observations at home to evaluate frequency of hand-washing, presence of vectors (flies, rats, cats, dogs, poultry), presence of food left-overs, cleanliness and protection against vectors of the kitchen utensils, foodstuffs, garbage bin and latrine.

Microbiological studies

Bacteria. In individuals with diarrhoea a total of three faecal specimens, one every day from the start of the episode, were obtained by means of rectal swabs moistened in Stuart's transport medium (Culturette, Marion Scientific Inc., Kansas City, MO, USA). They were kept at the Field Station up to 3–4 h at room temperature and transported under the same conditions to the laboratory for immediate processing. Cultures were carried out using routine techniques (Martin & Washington, 1980) to identify enteropathogenic *Escherichia coli* classic serotypes (EPEC), *Salmonella* and *Shigella* strains.

Parasites. Three faecal samples, one every other day, were collected during each episode of diarrhoea. For this purpose mothers were provided with three wide-mouth vials containing PAFS (phenol–acetic-acid–formaldehyde–salt) solution. Once the collection was completed the vials were picked-up and sent to the laboratories, where they were processed according to a modification of Burrows' technique and studied for ova, cysts and trophozoites (Burrows, 1967).

Rotavirus. One sample of approximately 3 g of faeces was collected in an empty vial from each case of diarrhoea. They were kept at the Field Station and transported on ice to the laboratories, where they were frozen at −30 °C until processing. Rotavirus identification was carried out by detecting the 11 segments of viral RNA by gel electrophoresis (Spencer, Avendaño & Araya, 1983). In brief, stool samples were diluted with twice their volume of distilled water, homogenized, extracted with one volume of Freon®, centrifuged and the upper aqueous layer precipitated overnight with polyethylene glycol (mol.wt. 6000). The suspension

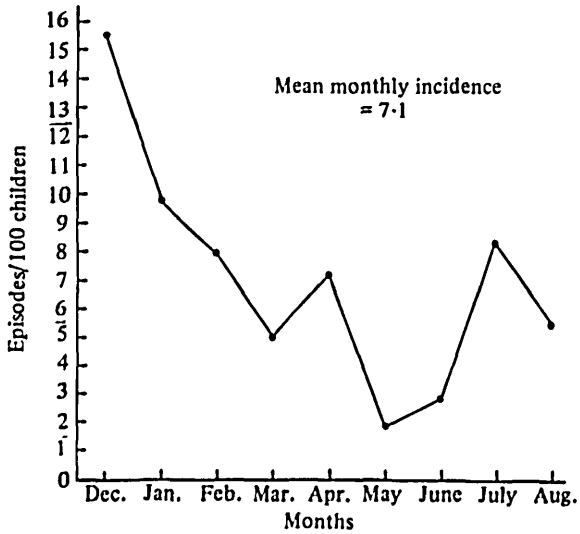

Fig. 1. Mean monthly incidence of diarrhoea in children under 7 years of age, Población Carlos Condell (December 1980 to August 1981).

was centrifuged and the pellet resuspended in 50 mM Tris-HCl buffer, pH 7·5, containing 1 mM β-mercaptoethanol, 50 mM-NaCl and 0·1% sodium dodecyl sulphate. The mixture was incubated for 45 min at 45 °C and adjusted to a final volume of 500 μl. This was extracted with the same volume of 1:1 (v/v) phenol–chloroform previously saturated with 100 mM Tris-HCl buffer, pH 7·5, containing 100 mM-NaCl. The aqueous phase was precipitated with 2 vols. of absolute ethanol. The pellets obtained by centrifugation were subjected to electrophoresis in 8% bis-acrylamide gel, at 70 V for 16 h. RNA segments were identified by staining the gel with 0·1% ethidium bromide and observed and photographed under UV light as required.

RESULTS

Fig. 1 shows the number of episodes of diarrhoea detected each month in the children of the cohort. The mean monthly incidence varied from 1·9 to 15·6 episodes per month per 100 children, with an average of 7·1.

The total number of episodes observed and the proportion of children affected per age group are shown in Table 1. While 85·7% of infants below 6 months of age had at least one episode of diarrhoea, only 22·2% of the children between 3 and 4 years of age and 13·9% of those between 6 and 7 years were affected by this condition during the study period. In comparison, the analysis of the total number of episodes detected in children under 6 months of age showed that most infants had at least one episode of diarrhoea. About 38% among children between 1 and 3 years of age had no diarrhoea, but of those who did, many had two or more episodes. Because the total period of surveillance was 9 months, incidences were calculated per month and per 100 children. If these calculations are extrapolated to indicate the number of episodes in one year, each child under 7 years of age

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Table 1. *Age distribution of children affected by episodes of diarrhoea, Población Carlos Condell (December 1980 to August 1981)*

Age (months)	Population under study	No. of episodes of diarrhoea	No. (%) of children affected
⩽6	21	23	18 (85·7)
6–11	19	20	8 (42·1)
12–23	49	53	33 (67·3)
24–35	43	38	24 (55·8)
36–47	36	13	8 (22·2)
48–59	33	10	8 (24·2)
60–71	39	9	6 (15·4)
72–83	43	6	6 (13·9)
Total	283	172	111 (39·2)

Table 2. *Episodes of diarrhoea per family and per individual, Población Carlos Condell (December 1980 to August 1981)*

Number of episodes	Number of families (%)*	Number of individuals (%)†
0	84 (50)	172 (60·7)
1	43 (25·6)	77 (27·2)
2	22 (13·1)	19 (6·7)
3	10 (6·0)	10 (3·5)
4 or more	9 (5·3)	5 (1·9)
Total	168 (100·0)	283 (100·0)

* Mean number of episodes per family: 2·0 ± 1·8 (range 1–12).
† Mean number of episodes per individual: 1·5 ± 1·1 (range 1–9).

Table 3. *Presence of acute diarrhoea in children under 7 years of age in families grouped by their hygienic practices, Población Carlos Condell (December 1980 to August 1981)*

Factor	Present (%)	Absent (%)	Relative risk	*P*
Clean latrine	40·47	45·91	1·13	>0·50
Latrine covered	40·54	51·72	0·78	>0·25
Latrine protected against vectors	40·0	45·20	1·13	>0·50
Garbage bin covered	50·0	43·93	0·87	>0·50
Clean kitchen utensils	47·22	38·46	0·81	>0·50
Food leftovers	35·0	46·66	0·75	>0·75
Hand washed 7 times daily	42·85	44·57	0·96	>0·75
Vectors	44·94	43·97	1·03	>0·90

would have had an estimated 0·8 episodes of diarrhoea per year, although for children under 2 years this figure is 1·4. Table 2 illustrates the general distribution of cases of diarrhoea per family and per individual. Table 3 shows the relation between hygienic practices and uses and the presence of diarrhoea in families categorized according to the adequacy of their behaviour.

The monthly rates of detection of bacterial, parasitic and viral agents associated to the episodes of diarrhoea are shown in Table 4. The recovery rate of enteropa-

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Table 4. *Monthly recovery of pathogens from faeces in* 172 *episodes of acute diarrhoea in children under* 7 *years of age, Población Carlos Condell (December* 1980 *to August* 1981)

Month	No. of episodes of diarrhoea	Bacteria		Rotavirus		Parasites		No. of pathogen identified		Total recoveries
		No.	(%)	No.	(%)	No.	(%)	No.	(%)	
Dec.	38	14	(36·8)	3	(7·9)	15	(39·5)	11	(28·9)	27
Jan.	25	9	(36·0)	4	(16·0)	8	(32·0)	8	(32·0)	17
Feb.	21	14	(66·7)	3	(14·3)	10	(47·6)	3	(14·3)	18
Mar.	14	9	(64·3)	5	(35·7)	9	(64·3)	2	(14·3)	12
April	20	8	(40·0)	0		7	(35·0)	6	(30·0)	14
May	5	2	(40·0)	0		1	(20·0)	2	(40·0)	3
June	8	5		0		1	(12·5)	2	(25·0)	6
July	25	11		6	(24·0)	12	(48·0)	8	(32·0)	17
Aug.	16	4		4	(25·0)	3	(18·8)	6	(37·5)	10
Total	172	76	(44·2)*	25	(14·5)*	66	(38·4)*	48	(27·9)*	124 (72·1)*

* Mean recovery rate during the study.

Table 5. *Distribution of enteropathogens by age interval, Población Carlos Condell (December* 1980 *to August* 1981)

	Age group in months (no.)					
	<6 (15)	6–11 (23)	12–23 (62)	24–47 (46)	48–83 (26)	Total No. 172
E. coli (EPEC)	7	6	9	13	6	41
Shigella spp.	1	5	13	15	5	39
Salmonella typhi			1			1
Rotavirus	4	2	7	5	7	25
Giardia lamblia	1	4	18	18	9	50
Hymenolepis nana	0	1	1	9	14	25
E. histolytica	0	0	3	2	0	5
Ascaris lumbricoides	0	0	1	2	0	3
Total no. of enteropathogens detected	13	18	53	64	41	189

thogens varied from month to month, but at least one potential enteropathogen was detected in 82·8% of all children. The rate of identification of pathogenic bacteria ranged from 25% in August (winter) to 66·7% in February (summer). As an average, at least one pathogenic bacterial species was isolated from about half the cases of diarrhoea. Although, as expected, the highest incidence of the disease was observed during the warm summer months, bacterial enteropathogens were found in a high percentage of cases during all months. Parasites were identified in 39·1% of cases. Rotavirus identification varied greatly from month to month but detections were made during both cold and warm months: 11·9% of episodes in summer, 12·8% in autumn and 20·4% in winter. The period of study did not include the spring. The enteropathogens detected during the episodes of diarrhoea and their age distribution are shown in Table 5.

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DISCUSSION

The demographic characteristics of the people of Población Carlos Condell were comparable to those reported by the National Census of 1982 (I.N.E., 1982) for the peri-urban slums in Santiago: couples tend to be young, each family is formed by about five individuals, sanitary conditions of the housing are inadequate, but the rate of literacy is high, although somewhat less than in the average Chilean population.

The continuous surveillance system used for the collection of data in this study resulted in the early detection of the episodes of diarrhoea. (Most of them were detected within 24–36 h of appearance of symptomatology.) The satisfactory relationship which developed between the research team and the people of Población Carlos Condell helped to promote this. None of the affected children became ill enough to require hospitalization.

The monthly incidence of diarrhoea in this study was considerably lower than in reports from other less-developed countries, even during summer months, when the highest rates are observed (Black *et al.* 1982*a*, *b*; Rowland, 1983; Mata, 1978; Guerrant *et al.* 1983). As expected, diarrhoeal episodes were more frequent among younger children. Although the families were comparable from the demographic and socio-economic points of view, two subgroups, each of approximately the same size, became apparent with respect to the occurrence of diarrhoeal disease: one group of families in which episodes were detected and the other in which none of the members developed the disease throughout the follow-up period. When the habits of personal hygiene, cooking, storage of foodstuffs or food left-overs, the cleanliness of the latrine and its surroundings of these two groups were compared, no significant differences could be demonstrated, and no risk factors for developing diarrhoea could be described.

The proportion of episodes associated with an enteropathogen was high (average 72·1%). In 50% this was a bacterial agent and, of these, EPEC was the most frequent single isolate (23·8% of cases, 50·6% of bacterial recoveries). This investigation did not include the search for enterotoxigenic *E. coli* (ETEC). However, the findings probably represent the majority of the episodes of diarrhoea associated with *E. coli* since in subsequent studies carried out by us in a comparable group of population, ETEC and entero-invasive *E. coli* (EIEC) were detected in about 8–10% of cases (Espinoza *et al.* 1984). This low figure is remarkably different from the results reported in studies from Bangladesh (Black *et al.* 1982*a*, *b*) and Brazil (Guerrant *et al.* 1983) and other countries (Rowland, 1983; Mata, 1978), where ETEC seem to represent the most frequent bacterial agent associated with acute diarrhoea. The high incidence of EPEC detected in this study resembles other local results obtained in hospitalized children in Santiago (Prado *et al.* 1984). The pathogenicity of EPEC has been a matter of controversy for some time: data published by Rothbaum *et al.* (1982) and others (Ulshen & Rollo, 1980) show that this micro-organism is indeed capable of inducing damage to absorptive epithelial cells in affected individuals and causes acute diarrhoea in adult volunteers (Levine *et al.* 1978). It is worth mentioning that in previous studies carried out in asymptomatic subjects we have demonstrated that EPEC were detected significantly less frequently in asymptomatic children (Figueroa *et al.* 1983).

The frequency with which shigella were detected was comparable to that of EPEC. This may be due to the fact that during July and August a considerable number of cases of diarrhoea were associated with this agent, suggesting an outbreak of shigellosis. Even if the possibility of an outbreak is accepted and all the episodes considered to be part of it are left out of consideration, the rate of detection of shigella still remained high, therefore this agent was the second most frequent enteropathogenic bacteria associated with diarrhoeal disease in this study. These findings agree with reports on hospitalized children in Santiago and mean that shigellae are highly prevalent in this area.

Parasites were detected in a high proportion of cases of diarrhoea, with *Giardia lamblia* being the most frequent (26·5 % of cases, 68·5 % of recoveries of parasites). In studies on asymptomatic children of low socio-economic strata in Santiago, this parasite has been identified in proportions ranging from 35 to 60 % of the subjects, depending on the age group under consideration. This high incidence of carriage makes it difficult to confirm a causative role for this agent when it is identified during an episode of acute diarrhoea. In Población Carlos Condell the detection rate was lower in children under 2 years of age. It has been recognized that the incidence of giardiasis increases with age as the children become more mobile and gregarious and thus have a higher chance of becoming infected. All the rates of infection found in this study were considerably higher than those detected in developed communities (Wright *et al.* 1977). In agreement with other reports from the city of Santiago, roundworms were an infrequent finding (Table 5) and *Hymenolepis nana* was clearly more frequent after 2 years of age.

For rotavirus the mean monthly recovery rate was found to be 13·7 % among the cases of acute diarrhoea. This figure was obtained by detecting viral RNA in faecal specimens. Electrophoresis avoids the false positives that have been attributed to some ELISA methods and may be one explanation for the finding of lower rates in our study. However, the method used for detection, which extracts and concentrates viral RNA from 3 g of faeces, supports the reliability of the findings. Another explanation may be that other reports from Chile refer to hospitalized children, among whom rates ranging from 0 % to 82 % have been reported (Avendaño *et al.* 1983). Cases of rotavirus-associated diarrhoea were also detected during the dry, warm summer months. However, the highest rates were found during the rainy, winter months (July, August).

As already mentioned, the number of episodes of acute diarrhoea detected per child and per year appears to be substantially lower in this study than the figures reported from other less-developed areas of the world. It is difficult to provide a simple explanation for this finding but some factors peculiar to Chile are worth discussing as they may shed light on this point. For the last 35 years a centralized public health care system with wide national coverage has succeeded in achieving a significant decrease in the infant mortality rate. Great emphasis has been placed on the early detection and treatment of malnourished children by means of food supplementation programmes and the establishment of non-governmental agencies to take charge of their recovery. Thus, while in 1968 the percentage of children under 7 years of age with protein-calorie malnutrition was 70 % (Monckeberg & Valiente, 1976), in 1980 this figure had dropped to 11 % (Monckeberg, 1983). These figures compare favourably with those reported for other less-developed areas. It

is tempting to suggest that the low rate of acute diarrhoeal disease detected in this study may be related to the better nutritional status of the population. If this is so, improved nutrition may be an important component of the prevention both of this disease and its potentially severe consequences.

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