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High infant mortality is a serious and important problem in Guatemala. The extent to which the diarrheal diseases contribute to this high mortality is not known; specific etiological diagnoses have been few, and morbidity and mortality records have been sufficient only for general impressions. However, the published rates for infant deaths from diarrhea and enteritis are the highest in Central America (Pan Am. Sanit. Bur., 1954). Conclusions have been principally based upon cases admitted to the Guatemala General Hospital in Guatemala City. These cases have been mostly in children under 5 years of age from low income families and areas with inadequate sanitary facilities.

Although the type and distribution of the diarrhea strongly suggests shigellosis, isolations of *Shigella* have been reported only rarely by laboratories in Guatemala. However, statistics from other areas have also been found misleading when better techniques were used for the isolation and accurate identification of *Shigella* and *Salmonella* organisms (Watt *et al.*, 1953). The present study is a preliminary epidemiological and laboratory survey of the diarrheal diseases in Guatemala. It involved screening the general population for the common pathogens, *Shigella* and *Salmonella*. The presumption that *Shigella* is a major cause of diarrheal disease in this country was tested by comparing rates obtained in this survey with those from other areas in which prevalence of *Shigella* had been shown to be related to morbidity and mortality from diarrheal diseases.

PLAN OF STUDY AND MATERIAL SELECTED

Organization and operation. By the establishment of a bacteriological laboratory at the Instituto de Nutrición de Centro América y Panamá (INCAP), Guatemala City, it was possible to integrate the work of this study with existing INCAP field projects. With the cooperation of the mayor of each village, personnel of the Nutrition Field Unit of the Guatemalan Public Health Department ar-

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ranged to have the mothers bring the pre-school children, and the teachers the school children to a central place⁵. This was either the school, a clinic maintained by the health department or the mayor's office. In Guatemala City, the children in day-care centers and pediatric clinics were included by arrangement with the physician in charge.

Scope of operations. Guatemala is a country which has great variation in climate and altitude; the survey was planned to include as many different localities as the duration of the consultant assignment of the senior author permitted, and to determine the prevalence of *Shigella* and *Salmonella* in these areas.

Table 1 presents background information on the 12 locations surveyed and includes data on the ethnic types, total population, and sanitary facilities of each. The localities varied from an elevation of less than 100 feet with a hot humid climate to an altitude of 8,399 feet with a cold dry climate.

The following descriptions of two different communities illustrate the major types of living conditions for persons included in the surveys;

Amititlán is a town with a population of approximately 10,000 inhabitants, 91 per cent of them reported as Ladino⁶ and 9 per cent as Indian. The town is located near Lake Amatitlán at an elevation of 3,871 feet. There are 1,231 variously constructed houses, many of them with only dirt floors. There is a municipal water supply which serves only 192 of the houses; 828 have their own private wells and 211 use other supplies. These include lake water, community fountains, and various miscellaneous sources. Seventy per cent of the houses have either flush toilets or privies; the remainder, approximately 27 per cent, have neither. There is no information on about 3 per cent.

Santa María Cauqué is a small village with a population of about 700. It is located 20 miles from Guatemala City at an elevation of 6,493 feet. The population is 94 per cent Indian and 6 per cent Ladino. There are 206 houses in the village, mostly one-room adobe construction with dirt floors and no windows. There is no municipal water supply piped directly to the houses, but the village is furnished with water by 6 public fountains. Ten of the houses have open drains for sewers and the remainder have no provision for disposal of sewage.

Between the two extremes cited above, the rural communities selected showed various combinations of sanitary facilities, housing and population, but most of the living conditions were far below accepted minimum standards.

Children in Guatemala City were also surveyed in order to include a group with better community sanitary facilities. To obtain a good sized sample in a short time, specimens were collected from two sub-groups in Guatemala City.

⁵ The most productive method of conducting these surveys elsewhere has been found to be visits and interviews (for details of family experience with diarrheal illness) with each household family to be included in the study. However, because of the short time available for this survey it was found necessary to omit house-to-house visiting and instead to bring the participants to a central place.

⁶ Ladino is a Guatemalan term for a person of mixed origin who does not follow Mayan Indian customs of dress and modes of living. The term corresponds in part to that of Mestizo used for persons of mixed European and Indian ancestry, but includes Indians who have abandoned their own culture.

TABLE 1
Summary of information on twelve locations surveyed according to selected environmental factors, elevation and population
Guatemala, 1955-1956

Location	Elevation (feet)	Population*			Total number houses	Water Supply†			Toilets‡				Sewage System†				
		Total	Per cent			Municipal	Private wells	Otherst	Flush toilets	Privies	None	Un- known	Municipal	Cess- pool	Open drain	None	Un- known
			Ladino	Indian													
Almolonga.....	6,808	3,735	3	97	534	1	74	459	—	440	94	—	—	1	23	510	—
Amatitlán.....	3,871	11,667	91	9	1,231	192	828	211	95	771	332	33	188	102	14	901	26
Coatepeque.....	1,594	8,449	90	10	1,262	418	611	233	184	820	154	104	244	21	893	—	104
La Esperanza.....	7,831	2,376	9	91	66	—	—	66	—	66	—	—	—	—	—	66	—
La Fragua.....	600	907	100	—	150	—	83	67	—	8	142	—	—	—	—	150	—
Guatemala.....	4,872	295,971	92	8	49,150	33,922	967	14,261	16,516	28,998	3,455	181	29,199	3,163	1,155	15,261	372
Masagua.....	367	575	92	8	123	17	37	69	1	43	56	23	—	2	98	—	23
Overo.....	85	538	100	—	89	—	75	14	1	30	54	4	—	1	84	—	4
San Mateo.....	8,399	840	—	100	60	—	—	60	—	29	31	—	—	—	—	60	—
Santa María Cauqué...	6,493	800	6	94	206	—	—	206	—	10	196	—	—	—	10	196	—
Sumpango.....	5,974	5,780	9	91	889	23	1	865	2	416	470	1	13	17	94	751	14
Villa Nueva.....	4,298	7,429	90	10	604	111	1	492	6	252	345	1	69	18	1	515	1

* Sexto Censo General de Población, República de Guatemala, 1950. Dirección General de Estadística. Oficina Permanente del Censo, p. 87-89.

† By number of houses.

‡ Public fountains, streams, etc.

A. Those attending "Guarderías". These are child-care centers operated by semi-private welfare agencies with government support as a service to working mothers. The older children attend school while those in the younger group have organized play and kindergarten. They are well cared for, as the centers are adequately staffed and medical care is provided.

B. Those attending "Dispensarios". These are out-patient pediatric clinics operated by the municipality. Both sick and well children are brought to the clinics, which are staffed by physicians, nurses and attendants.

METHODS

The usual method (Watt *et al.*, 1953); Hardy and Watt, 1948; Watt and Hardy, 1945; Hollister *et al.*, 1955) for determining the prevalence rates for *Shigella* and *Salmonella* in general populations was followed in this study. This consists of obtaining rectal swab cultures from children 0–10 years of age. The rectal swabs taken in the field were planted immediately on an SS agar plate. The swab was then placed in a tube of the enrichment medium Selenite F.

Bacterial colonies which gave reactions consistent with *Salmonella* or *Shigella* in triple sugar iron agar were subjected to two coarse screening tests; (1) semisolid mannite agar for checking motility and acid production, and (2) urea agar. Following the screening tests, suspicious colonies were examined by additional biochemical tests, e.g., indol, citrate, etc., and by group agglutinations. Colonies tentatively identified as *Shigella* or *Salmonella* were sent to the Bacteriology Section, Division of Laboratories, California State Department of Public Health at Berkeley, for final definitive serological typing.⁷

RESULTS

During the period October, 1955, to March, 1956, a total of 2,342 rectal swab cultures were examined from children 0–10 years of age. In Table 2, the survey cultures are tabulated by the 12 locations and by number and per cent from which *Shigella* was isolated. An over-all prevalence rate of 7.5 per cent was observed; this varied from 3.7 to 16.2 per cent in the different communities. The differences noted could be related to the species of organisms responsible, and to socio-economic, sanitary, seasonal, or other variables. Some of these possible factors are discussed below.

Species of Shigella isolated. The distribution of the various species of *Shigella* isolated are presented in Table 3 and show a wide-spread distribution of nearly all types. The most important finding was the high percentage of Group A organisms. Two isolations were *S. dysenteriae* 1 (Shiga type)⁸ and 20 were *S. dysenteriae* 2. In the 1952–53 survey in California (Fresno County, 1953, unpublished) no organisms belonging to Group A were identified. Group D (*S. sonnei*) com-

⁷ *Shigella alkalescens* was identified when found but has been excluded from all tabulations of *Shigella* prevalence.

⁸ A third, *S. dysenteriae* 1, was isolated from a fatal case of diarrhea in a 23 year-old male. This is not included in the survey tabulations.

TABLE 2
Total survey cultures by geographic areas with prevalence rates for *Shigella*
Guatemala, 1955-1956

Location	Total Cultures		
	Number	<i>Shigella</i>	
		Number	Per cent positive
Almolonga.....	69	3	4.3
Amatitlan.....	190	10	5.2
Coatepeque.....	217	15	6.9
Guatemala City.....	758	28	3.7
La Esperanza.....	109	8	6.4
La Fragua.....	138	15	10.8
Masagua.....	151	17	11.2
Overo.....	148	24	16.2
San Mateo.....	126	13	10.3
Santa María Cauqué.....	200	28	14.0
Sumpango.....	88	5	5.6
Villa Nueva.....	148	10	6.7
Total.....	2,342	176	7.5

prised 23.1 per cent of the isolations in Guatemala, while in the 1952-53 survey in Fresno County this group accounted for only 3.1 per cent of the isolations. However, in 1950, 13.3 per cent of isolations in California were Group D. The reason for the observed variations in groups is unknown and the predominance of a particular organism in any given area at any particular time is not explained.

Species of Salmonella isolated. Organisms belonging to the genus *Salmonella* were observed much less frequently in this study than were *Shigella*. Only thirteen isolations from 2,342 specimens were reported, an over-all rate of 0.55 per cent. Eight species were identified; four were *Salmonella newport*, three *Salmonella typhimurium*, and one each *Salmonella anatum*, *Salmonella denver*, *Salmonella derby*, *Salmonella manhattan*, *Salmonella panama*, and *Salmonella pharr*.

Since the observed prevalence rates for *Salmonella* were very low in the populations surveyed, the inference would be that this genus was of less importance in the diarrheal disease problem than *Shigella*. *Salmonella* prevalence rates were comparable to those found in general population surveys reported from the United States (Watt *et al.*, 1953).

Seasonal distribution. During the course of the survey a gradual decline in the prevalence rates for *Shigella* was noted from October to March. However, since most of the locations were surveyed during only one month, it is difficult to draw any conclusions as to the complete seasonal pattern of *Shigella* infection from these data.

Age distribution. As shown in Table 4, the prevalence rates for *Shigella* by age varied from a low of 2.7 per cent in the group under 1 year of age to a high of

TABLE 3
Species of the genus Shigella isolated from rectal swab cultures
Guatemala, 1955-1956

Species	Total number	Percentage
Group A		
<i>S. dysenteriae</i> 1.....	2	1.1
<i>S. dysenteriae</i> 2.....	20*	11.3
Group B		
<i>S. flexneri</i> 1a.....	16	9.0
<i>S. flexneri</i> 1b.....	9	5.1
<i>S. flexneri</i> 2a.....	8	4.5
<i>S. flexneri</i> 3.....	30	17.0
<i>S. flexneri</i> 4a.....	10	5.6
<i>S. flexneri</i> 5.....	8	4.5
<i>S. flexneri</i> 6.....	29	16.5
Group C		
<i>S. boydii</i> 1.....	2	1.1
<i>S. boydii</i> 2.....	1	0.5
Group D		
<i>S. sonnei</i>	41*	23.1
<i>Shigella</i> —serotype 2110-55†.....	1	0.5
Total	177*	

* 1 person had 2 types.

† A new provisional type recognized by CDC in 1955.

11.8 per cent in the 1-2 year group. The rates decreased in each succeeding age group surveyed. The prevalence rates for *Shigella* for all ages surveyed in Guatemala are compared in Table 4 with those recorded from other areas where similar survey and cultural methods were used (Watt *et al.*, 1953; Watt and Hardy, 1945; Watt and Lindsay, 1948). The pattern was completely consistent with that obtained from these areas but considerable variation in magnitude was noted throughout.

In Guatemala the prevalence rates for each group were somewhat higher than those found in California in the 1950 survey and definitely higher than in Texas, South Georgia and California, 1952-1953. When the rates in 11 of the 12 communities surveyed exclusive of Guatemala City were compared, they were approximately of the same magnitude as those found in New Mexico, 1937-1938 (Hardy and Watt, 1948) when this area was experiencing extremely high morbidity and mortality from diarrheal diseases.

The low prevalence rates observed in the under-1-year age group in a number of surveys have aroused considerable discussion (Watt *et al.*, 1953; Fresno County, 1950, unpublished; Floyd *et al.*, 1956); similar low rates were obtained in Guatemala. The rates in individuals under six months of age were consistently lower than in the second six months. In Table 5, the prevalence rates for the group less than 1 year of age observed in several areas of the United States are compared with those found in Guatemala. This age group was further sub-

TABLE 4
Prevalence rates for Shigella by age and year
Guatemala, California, New Mexico, South Georgia and Texas

Age in years	Guatemala*	Guatemala exclusive of Guatemala City*	California camps*		New Mexico		South Georgia		Texas	
	1955-56	1955-56	1950	1952-53	1937-38	1948	1939	1949	No Fly control	Fly control
									1946-47	1946-47
<i>Total cultures</i>										
Under 1	182	99	532	1,120	264	1,866	127	1,059	2,577	2,567
1	202	134	455	821	56	1,936	111	1,235	2,332	2,411
2-4	734	366	1,408	2,603	279	3,994	322	3,159	5,932	6,274
5-9	1,224	985	1,130	1,723	408	3,631	606	2,402	4,161	4,331
<i>Shigella positive</i>										
Under 1	5	3	119	26	17	26	4	10	43	28
1	24	20	40	46	10	78	8	25	131	60
2-4	63	51	86	148	36	157	13	71	310	158
5-9	84	74	72	76	59	72	23	44	144	91
<i>Per cent positive</i>										
Under 1	2.7	3.0	3.6	2.3	6.4	1.4	3.2	0.9	1.7	1.1
1	11.8	14.9	8.8	5.6	17.9	4.0	7.2	2.0	5.6	2.5
2-4	8.6	13.9	6.1	5.6	12.9	3.9	4.0	2.2	5.2	2.5
5-9	6.9	7.5	6.4	4.4	14.5	2.0	3.8	1.8	3.5	2.1

* Includes children 10 years of age.

divided into 3-month categories. In general, the rates increased with age, demonstrating a relationship between age and prevalence of *Shigella* infection which remained consistent in areas of both high and low endemicity.

Various theories have been advanced to explain this age distribution (Fresno County, 1950, unpublished; Floyd *et al.*, 1956). Increasing chance of exposure to infection with age has been given as one possible explanation. The results of an analysis of 1120 children under 1 year of age in California indicated that the opportunity for exposure did affect the prevalence rates. In households with *Shigella*-infected siblings the rates in children under 1 year were higher than in households with non-infected siblings, and lowest in households with no siblings. Other theories related to the presence of transplacental immunity, the significance of breast feeding in reducing exposure, improving nutritional status, and increasing immunity through the mother's milk, etc., or a combination of these factors, are not supported with sufficient data.

Prevalence rates in relation to selected variables. Watt and his associates (1953) have noted that shigellosis constitutes a major part of the diarrheal disease problem in areas characterized by low incomes, poor housing and inadequate sanitary

TABLE 5

*Prevalence rates for Shigella in children under 1 year of age by date of survey
Guatemala, California, Texas, South Georgia and New Mexico*

Months of age	Total all areas	Guatemala	California		Texas	South Georgia	New Mexico
		1955-56	1950	1952-53	1946-48	1949	1948
Total cultures							
Total under 1 year...	7,837	182	1,032	1,120	2,577	1,060	1,866
<6 months.....	3,676	65	511	532	1,254	451	863
0-2 months.....	1,548	19	178	224	559	205	363
3-5 months.....	2,128	46	333	308	695	246	500
>6 months.....	4,161	117	521	588	1,323	609	1,003
6-8 months.....	2,130	66	295	318	682	265	504
9-11 months.....	2,031	51	226	270	641	344	499
<i>Shigella</i> positive							
Total under 1 year...	136	5	26	26	43	10	26
<6 months.....	31	0	8	7	9	1	6
0-2 months.....	11	0	1	2	3	0	5
3-5 months.....	20	0	7	5	6	1	1
>6 months.....	105	5	18	19	34	9	20
6-8 months.....	44	2	9	8	13	4	8
9-11 months.....	61	3	9	11	21	5	12
Per cent positive							
Total under 1 year...	1.7	2.7	2.5	2.3	1.7	0.9	1.4
<6 months.....	0.8	0.0	1.5	1.3	0.7	0.2	0.7
0-2 months.....	0.7	0.0	0.6	1.0	0.5	0.0	1.4
3-5 months.....	0.9	0.0	2.1	1.6	0.9	0.4	0.2
>6 months.....	2.5	4.2	3.4	3.2	2.5	1.4	1.9
6-8 months.....	2.0	1.5	3.1	2.5	1.9	1.5	1.6
9-11 months.....	3.0	5.8	4.0	4.0	3.3	1.5	2.4

facilities. In the present preliminary study the general information obtained on some of these variables is summarized in Table 1. Although the relationship of certain variables to *Shigella* prevalence rates was examined by application of the general observations to a proportion of the population, namely those 0-10 years of age, the environmental observations apply to the community as a whole.

Data from the 12 communities surveyed were grouped according to toilet facilities, availability of water supply, sewage disposal system, ethnic type and elevations. The findings are presented in Table 6. The prevalence rates were higher in each instance where the sanitary facilities were poor or lacking, where there was no closed sewage system or where promiscuous defecation was practiced. The Indian group had a higher prevalence rate than the Ladino group. This difference is probably not due to host susceptibility but rather to chances for exposure to infection. The Ladinos have somewhat better housing, more

TABLE 6
*Prevalence rates for Shigella observed in 12 locations grouped
 according to selected variables
 Guatemala, 1955-1956*

Variables	Number of cultures	<i>Shigella</i>	
		Number	Per cent positive
Toilet facilities			
Privies and flush toilets in 50 per cent or over of houses.....	1,343	64	4.8
Under 50 per cent of houses.....	999	112	11.2
Water supply			
Private wells and municipal supply in 50 per cent or over of houses.....	1,451	92	6.3
community supply in over 50 per cent of houses...	891	84	9.4
Sewage system			
Mixed—municipal, cesspools, open drains and none.....	1,401	68	4.8
Open drains and none.....	941	108	11.4
Ethnic type of population			
50 per cent or over, Ladino.....	1,750	119	6.8
50 per cent or over, Indian.....	592	57	9.6
Elevation			
Under 1,000 feet.....	437	56	12.8
1,000-2,999 feet.....	217	15	6.9
3,000-4,999 feet.....	1,096	48	4.5
5,000 feet and over.....	592	57	9.6

privies, and more private water supplies. It can be noted, however, that the observed prevalence rate for the predominantly Ladino community is close to the over-all rate of 7.5 per cent and high when compared with the results of most surveys done in the United States. Although the rates were high at the low elevations where the climate was hot and humid, the correlation with altitude was not at all consistent, and again the important factors were availability of water and better community facilities at whatever altitude.

Of the 12 communities surveyed (Table 1) Guatemala City, Coatepeque and Amatitlán possess more and better facilities in comparison to the other nine. On the basis of approximately equal numbers of cultures the prevalence rate for *Shigella* was found to be 4.4 per cent in the three larger communities with better sanitation, while in the remainder it averaged 10.4 per cent.

In general, the results obtained in this preliminary study fit the pattern observed in the other areas studied by these methods, i.e., when sanitary facilities are poor or lacking and when water is less available for personal use, the prevalence rates for *Shigella* are definitely higher (Hollister *et al.*, 1955; Stewart *et al.*, 1955).

SUMMARY

This preliminary study was designed to determine the prevalence of *Salmonella* and *Shigella* in human population groups without reference to the presence or

absence of frank diarrheal disease. Twelve communities in Guatemala were selected for study, and children 0–10 years of age examined by means of rectal swabs. Data on the external environment were obtained by observation and by compilation of locally available statistics.

The high prevalence rates for *Shigella* were shown to be comparable with rates obtained in selected specific areas of the United States during periods when *Shigella* infection was determined to be the major cause of diarrheal disease deaths. Although not all of the diarrheal problems in Guatemala are related to shigellosis, the data strongly suggest that organisms of the genus *Shigella* cause the major portion of diarrheal diseases in the communities studied in Guatemala and that diarrheal diseases caused by *Shigella* represent a major public health problem in the country.

The high rates in Guatemala, as in the United States, were associated with the lack of sanitary facilities, with poor housing, with limited water supply and with poor personal hygiene.

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