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STUDIES OF DIARRHEAL DISEASE IN CENTRAL AMERICA

II. COMMUNITY PREVALENCE OF *SHIGELLA* AND *SALMONELLA* INFECTIONS IN CHILDHOOD POPULATIONS OF GUATEMALA*

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Preliminary observations have been reported[1] on the frequency of occurrence of *Shigella* and *Salmonella* in children in eleven rural Guatemalan villages and in an urban group of Guatemala City, during the months of October, 1955, through the following February. Single visits were made to each community. Over a usual period of five days, children of the village were surveyed and specimens of feces obtained by rectal swab for laboratory examination. No attempt was made to distinguish children who had diarrhea at the time of examination from those who did not. For the eleven villages, the prevalence of infection for children 10 years old and under, to include both cases and carriers, averaged 7.5 per cent for *Shigella* and 0.55 per cent for *Salmonella*.

The purpose of deriving these rates was to measure the potential for infection in Guatemalan populations. The infection rate for *Shigella* was greater than expected for the time of year examinations were made, and suggested strongly the importance of bacillary dysentery among the acute diarrheas of childhood in Guatemala.

The infection rate is a practical means of measuring community dosage, namely the number of existing foci of infection within a population from which an infectious agent may be transmitted to susceptibles. The greater the community dosage the more likely is the spread of infection. The situation is analogous to infection in the individual, where the dose, the numbers of infectious agent that gain entrance to the body, acts importantly in determining the risk of disease and the seriousness of its consequences. Closer evaluation of the potential for infection in a population requires a knowledge of community dosage under varying conditions of time, place, and person. The present study extends and enlarges the preliminary investigation by determining in series the numbers of infected persons present in prescribed populations at intervals of two months during a two-year period.

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METHODS

Seven rural communities were chosen as representative of the different kinds of populations and the varying climatic conditions in Guatemala. Three of the villages were in the central highlands at altitudes ranging from 7,000 to 8,000 feet above sea level, where the climate is relatively cool although humid. The people, predominantly Indian, numbered 2,723 including 787 children aged 10 years or less.

Two other villages were on the warm and humid Pacific slope, one at an altitude of 2,500 feet, the other at 3,800 feet. The village residents, population 2,527, were predominantly Ladinos, Guatemalans who do not follow Mayan Indian customs of dress, language, or mode of living. Ladino corresponds in part to Mestizo, widely used for persons of mixed European and Indian ancestry, but also includes Indians who have abandoned their native culture.

The sixth village of 623 inhabitants was on the Pacific coast at an altitude of 368 feet, with a climate that was hot and humid. The seventh village was on the Atlantic coast at 738 feet, and the climate was hot and dry. These two villages had a combined population of 1,456, of whom 504 were children aged 10 years or less. They were mainly Ladino.

For purposes of comparison, the three central highland villages of Santo Tomas Milpas Altas, Santa Cruz Balanya, and San Bartolome Milpas Altas are grouped as highland, and the lower Pacific slope villages of El Jocotillo and San Miguel Petapa, with the two coastal villages of

Masagua and La Fragua are considered lowland villages.

Farming was the main occupation in all communities, varying with locality from the more diversified activities in the central highlands where wheat, corn, vegetables and fruits are grown, through the coffee and banana country of the Pacific slope, to the strictly coastal regions where corn, the main product, is combined with cattle raising. The total population of the study villages was 6,715 and included 2,310 children.

Field operations began with the mapping of each village, a census by age and sex, and a sanitary survey covering the nature of water supplies, sewage and garbage disposal, sanitary services, types of housing, and animal populations.

Specimens of feces for bacteriological examination were collected by rectal swabs, beginning in March 1956 and continuing through February 1958. Each village was visited every 2 months by a survey staff that included a physician, a bacteriologist, a social worker, and a clerk. In each instance the social worker went to the village 3 or 4 days in advance of scheduled examinations to promote cooperation of the people.

RESULTS

Infection rates for *Shigella* among children aged 10 years or less in the seven Guatemalan rural areas averaged 6.0%, as shown in Table 1. This includes shigellosis of all forms, variously expressed as combined infection and infectious disease due to *Shigella*, as the sum of cases and carriers, or the total of manifest and inapparent infections.

Infection rates varies greatly according to the age of the children. During the first 6 months of life, shigellosis was not of material consequence although the acute diarrheas are generally recognized as unduly frequent at that time.[2] Infection rates for *Shigella* were essentially 5 times greater during the second 6 months, although still not excessively high at 3.1%. For children in the second year of life, they were 7.6%, more than double the value for the first year. The greatest frequency was in the age group 2 to 4 years, 8.4%. Although diarrheal disease is much more frequent in Guatemala during the third year of life than in the fourth and fifth,[3] the rates for *Shigella* infection were much the same in all 3 years. Numerically the rates were slightly higher in the second year and less thereafter, but the differences were not significant; accordingly, the data for children aged 2 to 4 years are grouped. Older children of 5 to 10 years had appreciably lower rates, 5.2%, than these preschool children.

TABLE 1

Shigella *from rectal swabbings of child populations of highland and lowland villages by age, Guatemala, March 1, 1956 to February 28, 1958*

Ages	Total		Highland villages		Lowland villages	
	Number examined	Shigella present (%)	Number examined	Shigella present (%)	Number examined	Shigella present (%)
Total	9910	6.0	3990	4.7	5920	6.8
0–5 months	347	0.6	150	0.7	197	0.5
6–11 months	512	3.1	239	2.9	273	3.2
1 year	877	7.6	334	6.6	543	8.3
2–4 years	434	8.4	923	6.8	1511	9.4
5–10 years	5740	5.2	2344	4.0	3396	6.1

TABLE 2

Shigella *infection rates in Indian and Ladino populations, seven rural villages, Guatemala, March 1, 1956 to February 28, 1958*

	Total population		Indians		Ladinos	
	Number	Shigella present (%)	Number	Shigella present (%)	Number	Shigella present (%)
Total	9910	6.0	3990	4.7	5920	6.8
Males	4853	6.0	2057	4.6	2796	6.9
Females	5057	5.9	1933	4.6	3124	6.7

As shown in Table 1, shigellosis of children was less frequent in highland villages, with an average infection rate of 4.7%, than in lowland communities where the infection rate was 6.8%, a highly significant difference evidenced in both years of the study. Culturally as well as climatically, the two regions contrast strongly. The highland villages are predominantly Indian and the lowland villages Ladino. Nevertheless, the lower infection rates for *Shigella* in highland villages would appear related more to climate and other factors of the physical environment than to differences among the people. Indians and Ladinos have cultural differences, but sanitary practices, economic status, and literacy are much the same. Table 2 shows that infection rates for the sexes were essentially equal in Indian and Ladino groups.

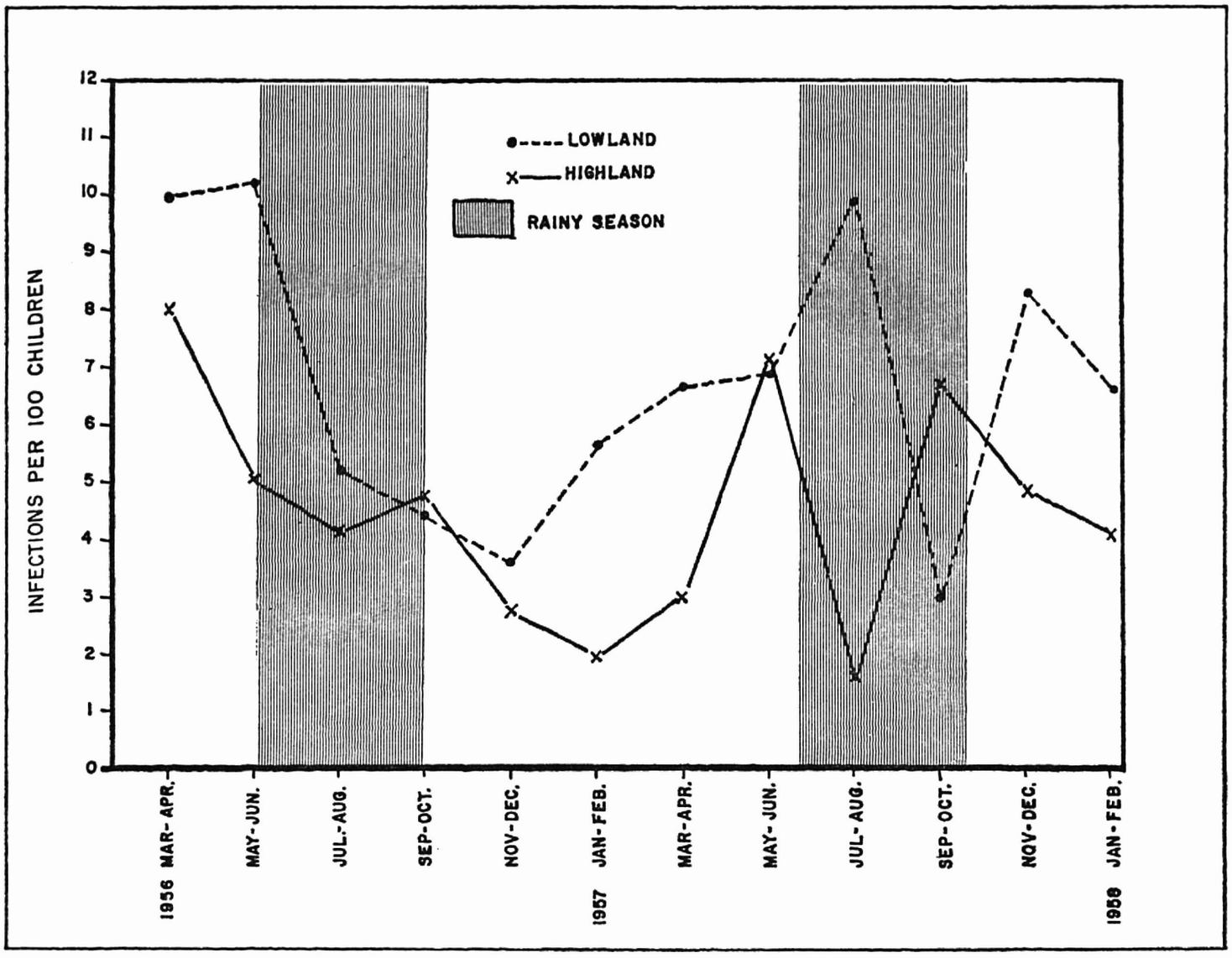

FIG. 1. *Shigella* infection, rates per 100 children aged 0–10 years in seven rural communities in Guatemala, by 2-month periods, March 1, 1956 to February 28, 1958

The experience of these 2 years suggests that maximum infection rates for *Shigella* are reached in the months of March to June, and that the seasonal increase begins earlier in the highlands than in the lowlands by about 2 months, Figure 1. In general, this corresponds to the last months of the long dry season. In both highlands and lowlands the frequency of infection tended to fall with some abruptness as the rainy season got underway. Irregularities in behavior, comparing one year with the other, were identified in several instances as due to intercurrent epidemics of modest proportions. While age-specific rates of infection for children under 5 years tended to follow the seasonal pattern, there were noteworthy exceptions which suggest the practical usefulness of exact data on the seasonal frequency of bacteriologically confirmed bacillary dysentery, especially in evaluating the interrelation of intestinal infection and kwashiorkor.

Strains of *Shigella* from all four groups were isolated during the course of these investigations. *Sh. flexneri* was most frequent, with *Sh. sonnei* next in order, and followed by *Sh. dysenteriae*, while *Sh. boydii* made a relatively scant showing (Table 3). Type 1 *Sh. dysenteriae*, the original Shiga bacillus, was identified only twice, and both times in lowland populations (Table 4). Type 2, the Schmitz (*Sh. ambigua*) bacillus, a common type in the study, appeared regularly in all four lowland communities. Only three strains were isolated from children of two highland villages, the third village remaining free during the 2-year period.

The dominant *Sh. flexneri* group was represented by nine serological types, of which Type 6 was twice as common as any other. Type 2b occurred only in the lowlands, as did the rare Type 4b. Type 3 was twice as common in the lowlands as in the highlands, not because of any greater endemic prevalence but because of two epidemics in the same village, Masagua, one in August 1956, and the other in May 1957. Type 4a appeared in only one highland village, apparently

TABLE 3

Shigella *in child populations of highland and lowland villages, by bacteriologic groups, Guatemala, March 1, 1956 to February 28, 1958*

Shigella groups	Highland villages		Lowland villages	
	Number strains isolated	% of total	Number strains isolated	% of total
All *Shigella*	186	100.0	405	100.0
Sh. dysenteriae	3	1.6	61	15.1
Sh. flexneri	117	63.0	260	64.2
Sh. boydii	12	6.4	9	2.2
Sh. sonnei	51	27.4	72	17.8
Shigella undifferentiated	3	1.6	3	0.7

TABLE 4

Shigella *infections (cases and carriers) of children aged 0–10 years in highland and lowland communities of rural Guatemala, by groups and serologic type, March 1, 1956 to February 28, 1958*

Infectious agent	Total		Highland villages		Lowland villages	
	Number infections	% of total	Number infections	% of total	Number Infections	% of total
Total	591	100.0	186	100.0	405	100.0
Sh. dysenteriae						
1	2	0.3	—	—	2	0.5
2	62	10.5	3	1.6	59	14.7
Sh. flexneri						
1	42	7.1	11	5.9	31	7.6
1b	26	4.4	14	7.5	12	3.0
2a	57	9.6	24	13.0	33	8.1
2b	24	4.1	—	—	24	5.9
3	60	10.1	11	5.9	49	12.2
4a	20	3.4	3	1.6	17	4.2
4b	1	0.2	—	—	1	0.2
5	10	1.7	3	1.6	7	1.7
6	137	23.2	51	27.4	86	21.3
Sh. boydii						
1	6	1.0	1	0.5	3	0.7
2	4	0.7	4	2.2	2	0.5
4	4	0.7	3	1.6	1	0.2
5	1	0.2	—	—	1	0.2
7	5	0.8	4	2.2	1	0.2
?	1	0.2	—	—	1	0.2
Sh. sonnei	123	20.8	51	27.4	72	17.9
Shigella undifferentiated	6	1.0	3	1.6	3	0.7

by accidental introduction; three strains were isolated in the same month, August 1957, and never thereafter. By contrast, this infectious agent was endemic in all villages of the lowland group.

Sh. flexneri Type 6 accounted for 39% of *Shigella* isolated in the village of El Jocotillo, all of them in two well-marked outbreaks, one in March 1956, and the other in February 1957. Type 6 was observed less frequently in the other lowland towns, but without exception the infections that did develop tended to be grouped as small outbreaks. The experience of the highland villages was the same. Most of the Type 6 infections in Santo Tomas were in June 1957; 25 of 31 identified infections in Santa Cruz occurred within a 4-month period in 1956, 20 of them in April alone. This infectious agent was never a prominent feature of shigellosis in San Bartolome. It was not identified in cultures taken over a period of 8 months. Five of the seven Type 6 infections recorded in that village then appeared within a single month, after which the infectious agent disappeared for another 10 months. In highland and lowland villages Type 6 was characteristically an epidemic strain.

Sh. sonnei ranked next to the flexner group in frequency of occurrence. In all three highland villages, *Sh. sonnei* was involved characteristically in endemic infections and at a relatively high level; no epidemics were noted. The prevalence of infection in the lowlands was of much the same magnitude as in highland villages, but in every lowland village this circumstance was due to the interjection of one or more epidemics in the course of a low order of endemicity. *Sh. boydii* was an uncommon infectious agent in these village populations with no manifest differences in behavior in highlands and lowlands.

Shigella was consistently present in all villages studied, but in no village did a single serological type exclusively characterize the long-term situation. Even in the smallest villages, two or more types commonly were encountered in the course of a single survey. As already noted, certain types sometimes greatly outnumbered the others, but even in the largest epidemic, the Type 6 *Sh. flexneri* outbreak in Santa Cruz Balanya, a few other types of *Shigella* were isolated concurrently.

In two instances, both in children of 2 to 4 years, two different types of *Shigella* were found

in feces of the same individual. Another two children in the pre-school group had mixed infections of *Shigella* and *Salmonella*. Although several serologic types of *Shigella* ordinarily were identified among existing foci of infection in a village, double infections in an individual were rare.

Salmonella was identified in only 0.2% of the 9,910 examinations of feces from rural Guatemalan children. In all, 23 strains were isolated. They included 11 species, namely *S. derby*, *S. san diego*, *S. urbana*, *S. anatum*, *S. atlanta*, *S. typhi* phage Type 38, *S. give*, *S. minnesota*, *S. newport*, *S. muenchen* and *S. poona*. With one exception, all were sporadic infections scattered through the seven villages at irregular intervals over the 2 years of observation. *S. typhi* phage Type 38 was an exception. Two groupings of two infections each were found in the same village of Santa Cruz Balanya. They occurred about 10 months apart and were family outbreaks.

Infections of *Salmonella* by age were equally divided between children of the first and second 5 years of life, in contrast to the preponderance of *Shigella* infections among preschool children. Numbers were essentially equal in highland and lowland villages which correspond, as previously noted, to predominantly Indian and Ladino populations. No seasonal pattern can be established from these small numbers, but infections were commonest in the months of March to June. During September to December, there were months in which no *Salmonella* was isolated in any of the villages.

DISCUSSION

This study was designed to answer the single question of whether or not sufficient foci of infection of *Shigella* and *Salmonella* existed in rural Guatemalan populations of children to justify a hypothesis that these infectious agents were a significant factor in the prevailing acute diarrheal diseases of childhood. The answer was in the affirmative for shigellosis and negative for salmonellosis. The community dosage of *Shigella* was high, as great as in several other regions where shigellosis has been proved to be the main factor in the diarrheal diseases of childhood.

The prevalence of cases of bacillary dysentery, the incidence of the disease per unit of population per year, and the relative frequency of carriers of *Shigella* remain to be determined. A distinct need is the study of a series of clinical cases of acute diarrheal disease to learn what proportion is due to *Shigella*. In order to develop adequate control measures it is also necessary to learn the average number of diarrheal episodes per child per year, according to age and sex and season, as influenced by environmental conditions, living habits, state of nutrition, kinds of people, and the quality of medical care.

Some indication of these epidemiological constants has come from this study of the periodic prevalence of the infectious agent. The observed frequency of *Shigella* infection by age seemingly establishes the fact that bacillary dysentery is not an important part of the extremely common diarrheas of the first year of life; *Shigella* infection was at a low level for infants of that age. Other evidence from clinical sources and through officially reported deaths[2] attests to an unusual frequency of acute diarrheal disease in Guatemala in the second and third years of life, and extending in lesser degree into the fourth and fifth years.

Prevalence rates of *Shigella* infection were found to be at a remarkably constant peak through all of these ages, especially 2 to 4 years, while other studies indicated that cases and deaths from acute diarrheal disease declined as age increased.[3] Admittedly, no good quantitative data exist on the frequency of diarrhea, or of bacillary dysentery. Carefuly determinations clearly should take priority in pursuing the general problem of interactions between nutrition and infection.[4] The indicated method is field study, prospective in type, with long-continued observation of fixed populations.

It is clear from the data that shigellosis is more of a problem in the warmer lowlands of Guatemala than in the cooler highlands. Conceivably, both host and environmental factors are active. Certainly the physical and biological environment of the lowlands favors occurrence of the diarrheas and the dysenteries. The climate is warm and even hot, flies are more of a factor than in the highlands, and both the quantity and quality of the water supply suffer by comparison. The populations of the two areas also are different. Ladinos predominate in the lowlands and the highland population is almost entirely Indian. Further information is needed on differences in cultural behavior which may be reflected in the frequency of diarrheal disease. There are lowland villages

of Indians and highland villages of Ladinos, which should permit evaluation.

The seasonal behavior of *Shigella* infection is indefinite and irregular. Levels of infection seem to be highest in March and April, months that are warm and dry, with the seasonal increase beginning a month or so earlier in the highlands than in the lowlands. The rainy season favors low rather than high levels of infection. The interpretation of seasonal influences on infection rates for *Shigella* is complicated by the frequent appearance of epidemics which seemingly may come at any time of the year.

All four groups of *Shigella* were recognized in the course of the studies. The regular pattern in community infection was that of multiple foci of a number of types. *Sh. dysenteriae* was limited essentially to the lowlands. Flexner Type 6, the commonest strain, was demonstrated as characteristically epidemic in its manifestations. *Sh. sonnei*, ranking next in frequency, was typically endemic in behavior in the highlands, to such extent as to warrant characterization as hyperendemic. In the lowlands endemicity was at low levels but over-all frequency approximated that in the highlands by reason of commonly occurring small epidemics.

These findings have practical importance. The demonstration of *Sh. flexneri* Type 6 in a Guatemalan community suggests a likely epidemic. *Sh. sonnei* in a highland village is an ordinary and anticipated event, but its appearance in the lowlands, sometimes introduced through migratory labor, has led repeatedly to outbreaks. Still other types of *Shigella* are characteristically endemic in the lowlands and absent in the highlands, and their introduction into the highlands has epidemic potential, as in the case of *Sh. flexneri* Type 4a. Type differentiation of *Shigella* thus contributes to a rational control effort.

SUMMARY

Field studies in seven villages in representative parts of Guatemala produced evidence of a high community dosage of *Shigella* and a relative infrequency of *Salmonella*. Rectal swabs, taken every 2 months from approximately 1,000 children over a period of 2 years and cultured bacteriologically, gave an average infection rate of 6.0% for *Shigella*, with a range from 0 to 17.2%. The rate for Salmonella was 0.2%.

By periodic prevalence determinations, a seasonal increase in *Shigella* infection was identified during March through May, although a secondary autumnal increase sometimes occurred. The major frequency of infection was among children aged 2 to 4 years. Infection rates were higher in the lowlands than in the highlands. Less infection occurred among Indians than among non-Indians.

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