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Migrant farm labor camps, certain town fringe areas, and a housing project became the locales of a field study to determine the prevalence of Shigella infections and to establish their relationships to a high infant mortality from diarrhea. Epidemiologic implications of revealed Shigella and Salmonella ratios are pointed up.

Diarrheal Diseases in Fresno County California*

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COUNTIES of the San Joaquin Valley have consistently shown a higher infant mortality rate from diarrhea and enteritis than the State of California as a whole for many years prior to this study. Responsible health authorities have been concerned and from time to time there has been considerable public alarm.[1] Available information did not define the nature or extent of the problem, since etiological diagnoses were rare and morbidity records inaccurate. These deficiencies meant that elements essential for intelligent control were lacking. The California State Department of Public Health, therefore, requested the Diarrheal Diseases Study Unit of the U. S. Public Health Service to assist in planning a study which would lead to a better understanding of etiology and frequency of diarrheal diseases in the Central Valley.

Fresno County, centrally located in the San Joaquin Valley and having many local conditions which facilitated initiation of the program, was selected as the site of investigation since its problems were typical of the whole area. This rich agricultural county has a number of crops harvested at various seasons of the year which require large numbers of laborers for short periods of time. Many families move from the Imperial Valley and Arizona through the Central Valley to northern states during the spring and summer following the seasonal maturation of vegetable crops, returning to the Central Valley in the fall for cotton picking on their way back to the southern part of the country where the cycle begins again. This migrant group, having no permanent home, has been particularly affected by diarrheal disease.

Previously demonstrated facts pertinent to this problem may be summarized briefly. Diarrheal diseases are caused by many etiological agents, some known, some unknown. Severe diarrheal disease

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is commonly caused by infection with a member of the genus Shigella. In turn, shigellosis has constituted a major part of the problem in all areas studied that were characterized by relatively high diarrheal disease morbidity and mortality rates. Shigellosis is not equally distributed through communities but occurs more commonly where such indexes as income, housing, and sanitation are below the community average. In addition, studies of normal population groups have demonstrated characteristic curves of Shigella prevalence, age and seasonal distribution in areas where shigellosis is a major problem. Similar, though less extensive data are available for communities where the disease is of minor importance. Analogous data on the incidence of diarrheal disease also are available.[2-9]

Known facts about diarrheal disease in the Central Valley were: deaths were almost exclusively in children, a large proportion between six months and two years of age, and these children belonged, in general, to families in the lowest income groups, living in areas with incomplete or no community sanitary facilities. These facts were compatible with a presumptive diagnosis of shigellosis as a major factor in the problem. An important objection to this diagnosis was the relatively small number of Shigella isolations reported from diagnostic laboratories in the area.

This objection could have been met directly by a study of sick children as seen in practice. Some indication of the fact that Shigellas could be found in Fresno and other areas of the Central Valley when looked for carefully in patients was obtained in 1949.[10] The practical difficulties of such a study together with the limited application of the results led to another approach. It was decided to conduct a normal population survey to measure the prevalence studied would establish the importance of shigellosis in the study area since they would permit a comparison of the findings with those of other areas in which Shigella prevalence had been related to diarrheal disease morbidity and mortality. Thus, the presumptive diagnosis would be tested and data collected by these surveys would be applicable directly to planning control activities.

PLAN OF STUDY

In preliminary discussions of this study, two approaches appeared possible: (1) to set up a complete unit for investigation of diarrheal diseases which would operate independently of existing organizations, or (2) to utilize personnel and facilities of various interested health agencies. The second approach was used for the following reasons. First, the results of this study would need to be applied as soon as possible after definitive results had been obtained. The effectiveness of application would be directly proportional to the extent that the working health organizations had participated in the study and were aware of the results. Permanent employees of the laboratory, nursing, and sanitary staffs of the health departments would be trained in the study methods used. Immediate use in their usual jobs would result and participation by these workers in various civic organizations would mean that relatively prompt development of indicated community control programs would follow. An informative report on the extent of such application was given in a recent article by Issler.[11] Second, a number of these agencies were interested and working on the problem for various reasons. Operating budgets of these agencies provided the opportunity for immediate action. It was agreed that the first method of approach would

second would more than offset this possible advantage.

Agencies which finally contributed to this study are:

1. Fresno County
   a. County Health Department
      (1) Nursing Services
      (2) Sanitation Services
      (3) Laboratory Services
2. California
   a. State Department of Public Health
      (1) Division of Local Health Services
      (2) Bureau of Maternal and Child Health
      (3) Bureau of Acute Communicable Diseases
      (4) Division of Laboratories
      (5) Bureau of Vector Control
3. Federal
   a. Public Health Service
      (1) National Institutes of Health, National Microbiological Institute, Laboratory of Infectious Diseases
      (2) Bureau of State Services, Communicable Disease Center, Epidemiology Branch
   b. Armed Forces Epidemiological Board, Commission on Enteric Infections.

All of these shared some responsibility for the investigation and control of diarrheal diseases and agreed to assist in this study.[12] Personnel, funds, and equipment were thus assembled.

SCOPE OF OPERATIONS

The survey was designed to determine the prevalence of Shigella and Salmonella infection in the portion of the population which had experienced the largest number of deaths from diarrheal disease in recent years. This group of people were, for the most part, residents in either farm labor camps or "fringe areas" of the cities and towns of the county.

Families selected for study were classified primarily according to the nature, location, and ownership of their living quarters. Tabulations and discussions which follow will refer to three groups described in more detail below, called

1. *Camps*—Labor camps were housing areas owned by growers or community organizations located in or near farming districts producing seasonal crops. Rent was free or nominal in amount. Usually housing in any one camp followed a uniform pattern, but variation between camps was sometimes very great (*vide infra*). Better camps had well built, small homes with adequate sanitary and related facilities. On the other hand, some were simply clusters of shacks or tents with a minimum of sanitation. Pure water was available in all, but the distribution system varied from a complete bath and kitchen in the better camps to a few public faucets in poor camps. The latter group had privies as the only sewage disposal system. Residence was restricted to agricultural workers.

2. *Town-fringe areas*—Groups of dwellings near the edge of towns usually owned by the occupants, but because of low income they were of poor construction and crowded together. Sewer lines were lacking, but city water of good quality was available to all through community faucets and to some in individual homes. These fringe areas were in general quite similar to each other. There were no occupational restrictions on residence, but a majority of the inhabitants were agricultural workers; the remainder, for the most part, were unskilled or semiskilled laborers.

3. *Housing projects*—These were community sponsored housing areas publicly owned. Well built, individual family dwellings or apartments were the rule with good plumbing in each unit. Families were, on the average, in a higher income group than those found in camps and town fringe areas. Some were agricultural workers; others were engaged in clerical and similar occupations. The housing project families were selected for comparison with the camps and town fringe areas since relatively few severe diarrheal diseases had occurred in such projects; while both camps and town fringe areas had a recurrent problem due to these disorders.

A fourth group of families was studied for a short time because of convenience. These families attended child health conferences operated by the County Health Department. No consistent housing pattern existed but, in general, families served by these conferences were from low-income groups.

study, an attempt was made to obtain the participation of all resident families. This generally resulted in from 80 to 90 per cent cooperation. None of the families in attendance at the observed child health conferences failed to participate.

METHODS

A. *Prevalence of Infection*

The prevalence of Shigella and Salmonella infections was determined by a method used previously in several field studies,[6, 7, 13] consisting of rectal swab cultures obtained from children 10 years of age and under in homes and clinics. Material on the swabs was plated immediately to one SS agar plate and the swab was placed in a tube of tetrathionate broth (2 ml.). Plates and broth cultures were returned to the laboratory for incubation. Suspicious colonies were picked from SS agar plates to triple sugar iron agar slants following 24 hours incubation. The plates were incubated for another 24 hours at room temperature and picked again in an attempt to increase the positive findings. Tetrathionate broth cultures were streaked on SS agar after 24 hours incubation. These plates, in turn, were "fished" following the same routine as for the original SS agar plates.

Bacterial colonies which gave the proper reactions in triple sugar iron agar were submitted to two coarse screening tests: (1) semisolid mannite agar for checking motility and acid production, and (2) urea agar. The remainder of the biochemical tests were performed by the Fresno County Public Health Laboratory and the final definitive typing * was done at the California State Division of Laboratories. The field laboratory staff was thoroughly indoctrinated in methods used in previous surveys to insure comparability of results.

B. *Incidence of Diarrheal Disease*

Home visits to all families in the study were used to obtain illness records. Information was obtained and recorded as nearly as possible in the informant's own words. Questions about diarrheal disease were asked in a uniform manner, with the use of colloquial synonyms whenever negative replies were obtained to initial questions. All reported diarrhea was recorded together with a list of symptoms. Reported cases which occurred in some other area than that being studied were excluded from all tabulations recorded here. A form was utilized which had been developed by the Public Health Service for particular studies in Texas.[8] Some families were visited one time only and the visit was timed to occur during the week after cultures had been taken. Many groups of families had cultures taken at intervals of from four to six weeks. In each of these groups a record of illness since the last visit was also obtained. Interviewers were given a detailed series of instructions before histories were taken on the use of forms and on methods of asking questions. Incidence rates are based on diarrheal disease occurring in the study area and reported for the six weeks prior to the interview.

RESULTS

Collection of information began early in July, 1950, and continued for six months. The results are analyzed below under the following headings: prevalence of infection, comparison of Fresno County prevalence rates with other areas, and incidence of diarrheal disease.

Prevalence of Infection—Table 1 gives the total survey cultures taken, number of Shigellas found and computed prevalence rates for the four different population groups under study. Data for child health conferences and housing projects were obtained in July

TABLE 1

Survey Cultures in Four Population Groups with Prevalence Rates for the Genus Shigella, Fresno County, Calif., July–December, 1950

Population Group	Total Cultures	Shigella	
		No. Positive	Per cent Positive
Camps	3,624	222	6.1
Towns (Fringe Areas)	2,574	100	3.9
Housing Projects	278	1	0.4
Child Health Conferences	589	1	0.2
Total	7,065	324	4.6

TABLE 2

Survey Cultures Taken in Labor Camps and Town Fringe Areas and Shigella Isolations in Each Month, Fresno County, Calif., 1950

Month	Camps			Town Fringe Areas		
	Total	Shigella Positive	Per cent Positive	Total	Shigella Positive	Per cent Positive
July	199	15	7.5	273	16	5.9
Aug.	831	24	2.9	981	30	3.1
Sept.	464	14	3.0	425	19	4.5
Oct.	877	84	9.6	483	27	5.6
Nov.	780	57	7.3	217	1	0.5
Dec.	473	28	5.9	195	7	3.6

TABLE 3

Survey Cultures, July–September and October–December Quarters, in Labor Camps and Town Fringe Areas, Fresno County, Calif., 1950

Population Group	July–September			October–December		
	Total	Shigella Positive	Per cent Positive	Total	Shigella Positive	Per cent Positive
Camps	1,494	53	3.5	2,130	169	7.9
Towns (Fringe Areas)	1,679	65	3.9	895	35	3.9

TABLE 4

Age Distribution of Survey Cultures, Camps, and Town Fringe Areas Combined, and Shigella Isolations, Fresno County, Calif., 1950

Age Group Year	Cultures Taken	Shigella Positive	Per cent Positive
— 1	823	25	3.0
1	746	47	6.3
2–4	2,342	132	5.6
5–9	2,121	112	5.3
10 +	164	6	3.7

TABLE 5

Age Distribution of Survey Cultures, Camps, and Town Fringe Areas Separately, and Shigella Isolations, Fresno County, Calif., 1950

Age Group Year	Camps			Town Fringe Areas		
	Total	Shigella Positive	Per cent Positive	Total	Shigella Positive	Per cent Positive
— 1	532	19	3.6	291	6	2.1
1	455	40	8.8	291	7	2.4
2–4	1,408	86	6.1	934	46	4.9
5–9	1,130	72	6.4	991	40	4.0
10 +	97	5	5.2	67	1	1.5

the study. Crude rates presented must be corrected for seasonal variation in prevalence as well as for differences in age composition of the various population groups before specific conclusions are drawn.

Survey cultures and Shigellas obtained from residents of labor camps and from fringe areas of towns in Fresno County are shown in Table 2 by month for the six-month period, July through December, 1950. Somewhat higher rates seen in both town fringe areas and camps in July compared with August and September suggest that these early cultures measured the latter part of a seasonal high commonly encountered in the United States in the spring and early summer in mild climates. There is evidence of an increase in rates in labor camps in October which continued for some time, but the short duration of this study precludes any definite interpretation of these variations as true indications of a consistent seasonal trend.

The fall increase in prevalence of Shigella infection in labor camps is emphasized when the rates are grouped by quarters (Table 3). The rate for labor camps in the July–September quarter was doubled in the October–December quarter (3.5 per cent to 7.9 per cent). On the other hand, the town rates were the same for both periods (3.9 per cent to 3.9 per cent) and at a level comparable to the July–August period in the camps. The statistically significant difference in rates observed between the two population groups ($P = 0.0001$) for the entire period is thus the result of high rates observed in the camps in October, November, and December.

Survey cultures were principally from children under 10 years of age, the distribution by age group being shown in Table 4. Observed rates varied from 3.0 per cent positive in the first year of life to 6.3 per cent in the second year with a slight decline in prevalence for the next few years.

Similar data are shown in Table 5 for camps and town fringe areas separately. The difference in rates between the two areas is apparent not only in the totals shown above but also in each age group examined.

Prevalence rates for children observed in housing projects and in child health conferences were significantly lower than those found in either the town fringe areas or the camps during a comparable period of time. Data supporting this conclusion are in Table 6 which shows the age distribution of the children cultured in child health conferences and in housing projects. The age-specific infection rates found in town fringe areas and in camps during July and August are applied to the other two populations in order to obtain theoretical (or expected) infections, i.e. the

TABLE 6

Comparison of Prevalence Observed in Child Health Conferences and Housing Projects with Theoretical Prevalence Derived from Observations in Town Fringe Areas and Camps

Age Group Year	Child Health Conference				Housing Projects			
	July and August		Theoretical Prevalence Applying 2 month rates		July and August		Theoretical Prevalence Applying 2 month rates	
	Total Cultures	No. Positive	Fringe Areas	Camp	Total Cultures	No. Positive	Fringe Areas	Camp
— 1	179	1	1.4	..	27	..	0.2	..
1	99	..	3.0	1.9	23	..	0.7	0.4
2–4	190	..	8.9	7.9	108	..	5.1	4.5
5–9	78	..	3.1	4.3	107	1	4.3	5.9
10 +	3	..	..	..	12	..	..	..
Not Stated	..	..	..	..	1	..	..	..
Total	549	1	16.4	14.1	278	1	10.3	10.8

difference in rates existed. If the town fringe area rates had occurred, 16 positives would have been expected in the child health conference group as compared with a single observed positive. Similarly, in housing projects, 10 positives would have been expected but only one was observed. Entirely comparable differences were found when the camp rates were applied similarly. This relative scarcity of Shigella infection in housing project and child health conference families was established by the end of August so that investigation of these families was discontinued to free laboratory and interviewer time for more intensive study of groups where important amounts of shigellosis had been found.

The low prevalence rate found in housing projects is consistent with observations made relative to much larger geographic areas. Shigellosis has virtually disappeared from communities in the United States with a uniformly high level of sanitation and housing. The shift from high to low prevalence occurs during a period of general improvement and the relative influence of various factors has not been defined because improvements in individual housing, water supply, garbage and sewage disposal, higher standards of living, and better

A comparison of prevalence of infection in housing projects with findings in different groups of camps suggests that, in addition to these changes due to interrelated factors, Shigella prevalence may be much more directly influenced by modification of a single sanitary factor than has been demonstrated up to this time.

Table 7 lists the cultures taken in A: housing projects, a moderate-income group with plumbing in each individual housing unit and generally good sanitation; B: camps with housing facilities comparable to A but a difference in socioeconomic level; C: camps with poor housing, without indoor plumbing, but with fewer than 15 people per water outlet; and D: camps like C, but with more than 15 people per water outlet. Thus A and B differed socioeconomically, but were otherwise comparable; B and C were similar economically, but differed with respect to housing and multiple sanitary factors as flush toilets, screening, etc.; C and D were alike in all attributes of economics and sanitation except accessibility of water. Quality of water was comparable in all groups. In Groups A and B, water was in the homes and yards, in Group C, occupants of one or two houses used a

TABLE 7

Shigella Prevalence Found in Housing Projects and Labor Camps Compared According to Availability of Water Supply and Economic Status

Group	Economic Status	Water Supply	Cultures Taken	No. Positive for Shigella	Prevalence Rate
A	Moderate	In Family Home	278	1	0.4
B	Low	In Family Home	376	8	2.1
C	Low	Out of Home < 15 per Faucet	2,182	116	5.3
D	Low	Out of Home > 15 per Faucet	1,051	97	9.2

"Probability" of a difference as great or greater being due to chance when comparing

A with B = 0.08 (exact probability)
B with C = 0.01
C with D < 0.0001

group of houses with a consequent greater distance from living quarters to water source.

Prevalence rates show a progressive rise from group A to group D, and while the differences shown between individual groups are not all statistically significant, the trend is consistent, conforms with general knowledge, and suggests that these are not simply chance variations. Considered in this light, the difference between *D* and *C* is related to the single factor of water availability or its consequent, water use; the difference between *C* and *B* is related to a combination of water use, better housing, etc., and the difference between *B* and *A* is the result of higher income with the multiple variables associated with a family budget that provides for more than the essentials of food and clothing.

Comparison of Fresno County prevalence rates with other areas—All of these data on Shigella prevalence were collected primarily to provide an objective basis for comparison with other areas of the country in which Shigella prevalence rates have been specifically related to diarrheal disease morbidity and mortality. Data collected by the areas are chronologically listed in Table 8; New Mexico 1937–1938 and 1948, Georgia 1939 and 1949, and Texas 1946–1948. The initial study (New Mexico, 1938) showed that in this area of high mortality from diarrheal disease (100 per 100,000), shigellosis caused the majority of these deaths.[6] This fact was also demonstrated in South Georgia, an area of moderate diarrheal mortality (18 per 100,000) in 1939. Both of these areas were studied 10 years later.[8, 9, 14] Diarrheal disease mortality had decreased significantly in both areas (New Mexico 50 per 100,000, Georgia 8 per 100,000) and so had the Shigella prevalence rates. Two levels of Shigella prevalence in Texas were found during diarrheal disease control studies[8]; high rates were those observed in communities without organized fly control, while low rates were from communities with major fly control activities. The prevalence of Shigella infection was shown to be related directly to diarrheal disease morbidity and mortality in the course of the investigations.

Prevalence of Shigella infection in California camps was higher than that seen in Texas, in South Georgia in 1939

TABLE 8

Shigella Prevalence Rates by Age and Year Found in New Mexico, Georgia, Texas, and California

Age in Years	Total	Shigella Positive	Per cent Positive	Total	Shigella Positive	Per cent Positive
	New Mexico, 1937–1938			New Mexico, 1948		
–1	264	17	6.4	1,866	26	1.4
1	56	10	17.9	1,936	78	4.0
2–4	279	36	12.9	3,994	157	3.9
5–9	408	59	14.5	3,631	72	2.0
	South Georgia, 1939			South Georgia, 1949		
–1	127	4	3.2	1,059	10	0.9
1	111	8	7.2	1,235	25	2.0
2–4	322	13	4.0	3,159	71	2.2
5–9	606	23	3.8	2,402	44	1.8
	Texas, No Fly Control, 1946–1947			Texas, Fly Control, 1946–1947		
–1	2,577	43	1.7	2.567	28	1.1
1	2,332	131	5.6	2,411	60	2.5
2–4	5,932	310	5.2	6,274	158	2.5
5–9	4,161	144	3.5	4,331	91	2.1
	California Camps, 1950			California Fringe Areas, 1950		
–1	532	19	3.6	291	6	2.0
1	455	40	8.8	291	7	2.4
2–4	1,408	86	6.1	934	46	4.9
5–9	1,130	72	6.4	991	40	4.0

figures in New Mexico. The fringe area rates, slightly lower than those in the untreated Texas towns, were quite comparable to those seen in New Mexico in 1948 and definitely higher than those observed in Georgia in 1949. Thus, shigellosis rates in one population group in California were second only to the extremely high rates seen in New Mexico almost 15 years ago. (It is significant that diarrheal disease problems in this population group, the residents of labor camps, were a primary factor in initiating these studies.) Prevalence rates in general population groups equal to those seen in the fringe areas have not been observed in the Public Health Service studies in the *absence* of an important diarrheal disease problem nor have there been any such reports in the literature on the subject.

Salmonellosis was a relatively infre-

times in 7,065 cultures, a prevalence rate of 0.4 per cent. These positives were proportionally distributed in the various age groups cultured. The numbers were too small to justify any other analyses of the data. The ratio of 11 Shigella to each Salmonella found and a low prevalence rate of Salmonella indicate that salmonellosis was both relatively and absolutely a minor part of the problem in the groups studied.

These facts do not mean that all diarrhea problems are related to shigellosis. They do provide a sound base for the inferences that (a) Shigellas were causing the major portion of diarrheal disease in labor camps and town fringe areas studied and that (b) diarrheal diseases caused by Shigella represent a major public health problem to these two populations.

Incidence of Diarrheal Disease

TABLE 9

Diarrheal Disease Attack Rates per 1,000 per Annum by Age Groups in California Camps and Town Fringe Areas (July–December, 1950) and in Texas Untreated Areas (March, 1946–February, 1948)

Age Group	California			Texas		
	Observed Person Months Experience	Cases	Rate per 1,000 P. A.	Observed Person Months Experience	Cases	Rate per 1,000 P. A.
–1	1,275	86	809	4,384	222	608
1	1,206	81	806	4,028	263	784
2–4	3,264	100	368	10,888	224	247
5–9	4,481	75	201	13,612	68	60
10–14	3,659	35	115	11,036	30	33
15–34	9,056	94	125	31,696	81	31
35 +	6,326	88	167	23,462	76	39
Unknown	355	2		230	2	
Total	29,622	561	227	99,336	966	117

of incidence of diarrheal disease found in these same California populations. Table 9 lists age-specific attack rates observed in camps and town fringe areas in California during the period of study. Since prevalence rates found in California were most nearly like those from the Texas area without fly control, incidence figures for this area are provided for comparison. The similarity of reported incidence of diarrheal disease in the two areas is remarkable. Just as prevalence rates of Shigella infection were slightly higher in each group in California, so were incidence rates of diarrheal disease.

One further comparison is particularly interesting in light of higher shigellosis prevalence in camps than in town fringe areas during the quarter from October through December shown in Table 3. The reported incidence of diarrheal disease (Table 10) remained relatively stable in the fringe area populations and a marked increase was recorded for the camp residents. The increase affected all age groups, not just the younger group for which prevalence data were available. The two population groups in camps and town fringe areas were quite comparable in average income, and similar respects, but important differences were noted. Camp populations in July, August, and September were small isolated groups who remained after seasonal emigration; crowding was marked in occupied houses, but a large percentage of the houses were vacant and relatively few new residents were moving into the areas. In October, the fall immigration was in full force and a tremendous in-

TABLE 10

Quarterly Attack Rates for Diarrheal Disease; Adjusted for Age; Camps and Town Fringe Areas per 1,000 per Annum

Area	All Ages Combined		Less than 10 Years	
	July through September	October through December	July through September	October through December

crease in camp populations occurred. Population in the town fringe areas was, by contrast, quite stable. These families were never so isolated as were camp populations in midsummer, nor did the crowding ever approach the intensity seen in the camps in the fall.

Rises in reported diarrheal diseases and in prevalence of infection found in camps following increase in crowding bring to mind similar observations in institutional populations. In a study of institutional inmates,[15] it was observed that new admissions to a group infected with Shigella experienced a significantly higher incidence of clinical disease in the beginning and, as time went on, continued to show a higher infection rate than the portion of the group in residence longer. Further Shigella infection was shown to recur in epidemic form in one group to which new inmates were being added at a fairly rapid rate; whereas in another group, similar in size but with few new admissions, infection continued to spread at a low, even rate without recurrent epidemics. The comparison of camp and town fringe area populations to these institutional populations receiving new susceptibles at different rates provides an intriguing explanation of differences in observed reaction to infection in California.

DISCUSSION

The prevalence of Shigella found in two population groups in Fresno County was equal to or greater than that observed in several sections of the country in which such rates had been demonstrated to be directly related to morbidity and mortality from diarrheal disease. It was further shown that in these comparison areas, reduction in prevalence, either the result of long-range nonspecific improvement or the result of community activity specifically reductions in morbidity and mortality from diarrhea.

Diarrheal disease mortality in New Mexico and Georgia declined 50 per cent over a 10-year period and comparable reductions in shigellosis were noted. Prevalence rates reliably reflected mortality changes in these two areas. Similarly, prevalence, morbidity, and mortality were equally effective indexes of change brought about by community activities in Texas.

Thus, crude mortality figures are useful measures of the relative importance of shigellosis even in populations having only broad similarities, but serious misinterpretation can result from the use of such data when major disproportions in the populations at risk are involved. This danger is illustrated perfectly by a comparison of Fresno County diarrhea mortality rates with those reported for Hidalgo County, Tex., the area reported on above. The populations studied in these two counties had similar prevalence and incidence rates in contrast to reported mortality from diarrheal disease in Fresno County of 20 per 100,000 and 250 per 100,000 in Hidalgo County in 1949.

The apparent contradiction is accounted for largely, if not entirely, by the difference in total population at risk. The compared incidence and prevalence rates were obtained from populations believed to be at greatest risk of enteric infection. In Hidalgo County at least three-quarters of the population belonged in such a group; in Fresno County the population at risk was a decided minority, even at times of peak density and a large part of this group was present only for short harvest periods.

Counties or states may show steady decline in mortality rates and attain a level which compares favorably with the country as a whole, but have improve-

rates comparable to those seen 50 and more years ago.

Health officers who wish to define and effectively attack a diarrheal disease problem need to know the frequency of occurrence of infection specific for various groups of citizens in their jurisdiction. They also need to be able to speak, for very practical reasons, in terms of numbers of sick people and of deaths. Shigella prevalence rates are much more useful to them when translated into morbidity and mortality due to Shigella.

formula then becomes $P = \frac{I \times D}{R}$, and solved for I, it is $I = \frac{P}{D} \times R$.

Table 11 shows the essential information and results of such a computation in columns 1 through 4. The prevalence rates (Column 1) given are those found in camps and fringe areas in the study. The duration of infection (Column 2), four weeks, or 1/13 year, is an average found in institutional groups in which

TABLE 11

Computation of Expected Cases of Shigella-Caused-Illness from Prevalence Rates Found by Population Survey

Column	*1*	*2*	*3*	*4*	*5*	*6*
Age in Years	*Prevalence of Infection Per 1,000* [1] *P*	*Average Duration of Infection in Years* [2] *D*	*Shigella Disease/ Infection* [3] *R*	*Computed Shigella Disease Rate/1,000 P. A.* [4] *I*	*Person Yrs. Experience* [5] *Y*	*Computed Shigella Disease Expected Cases* [6] *E*
–1	30	1/13	9/10	350	106	37
1	63	1/13	2/3	590	100	59
2–4	56	1/13	2/5	290	272	79
5–9	53	1/13	1/4	170	373	63
Total						238

1. P—from Table 4
2. D—Watt [17]
3. R—Watt and Hardy [7]
4. $I = (\frac{P}{D}) R$
5. Y—from Table 9
6. $E = YI$

Information needed to make such a conversion from prevalence of infection to incidence of disease is available from several sources and is brought together below. As stated by Densen,[16] "The general relationship of *prevalence* (P) and *incidence* (I) may be expressed as $P = I \times D$ when D is the average *duration* of disease in an individual case expressed in the same time units as I." An additional factor is needed in the formula when infection does not consistently result in disease and the known P is prevalence of infection. This factor is the ratio of individuals sick from the untreated shigellosis was observed by daily stool cultures.[17] The ratios (R) of infected individuals having diarrheal disease to total infections is available from a study of normal populations.[7] Substituting these values in the formula for each age group and solving (Column 4) gives the expected incidence rate *due to Shigella* corresponding to discovered prevalence.

It is perhaps unnecessary to point out how these computed rates (I) can be used. Nevertheless an example is included in the table (Table 11) using person-years experience (Y) (Column

tion in each group by its corresponding computed incidence rate of Shigella disease (I) gives the number of cases of *Shigella diarrheal disease* expected (E) in the population when they suffer from such rates. Total expected cases derived in this manner is 238 and our survey recorded 342 cases of diarrheal disease from all causes. (Table 9, under 10 years of age.) The ratio of Shigella diarrheal disease (computed) to total diarrheal disease (reported on survey) is 238–342 or 70–100. For practical purposes, crude rates, which have the virtue of simplicity of computation, may serve equally well if used with recognition of the potential inaccuracies of interpretation. The decided difference in the ratio of sick to well from one age group to another could easily result in a misleading product where major disparities in age distribution exist. Crude rates for this example ($P = 52$, $R = 1/2.5$, $Y = 851$) give expected cases as 230, an equally useful value.

How then does this ratio (70 cases of Shigella diarrhea to 100 total diarrhea cases) obtained by computation, compare with the results of specific etiological studies of the acute diarrheal diseases by various workers over a period of years? The resemblance is striking. The proportion of acute diarrheal disorders found positive for Shigella as reported by Flexner and Holt,[2] TenBroeck and Norbury,[3] Davidson,[4] Hardy and Watt,[6] and Watt [18] varied from 60 to 75 per cent. An even greater proportion of the diarrheal disease deaths reported in the literature cited were caused by shigellosis. Thus it would be reasonable to conclude that if shigellosis were eliminated from camps and town fringe areas, the diarrheal diseases currently found would be reduced by two-thirds and deaths by an equal or greater amount. Direct comparison of prevalence rates and diarrheal disease incidence were quite similar to Fresno County rates. Community activities directed against spread of Shigella resulted in a reduction in the prevalence of these organisms. Diarrheal disease morbidity and mortality rates fell at the same time to approximately the extent expected from the computations.

SUMMARY

This study was designed to provide a better understanding of the etiology of diarrheal diseases in the Central Valley in California. Rates of Shigella infection were determined in normal populations of representative areas (labor camps and fringe areas of towns) having the greatest number of reported diarrheal deaths in recent years. For comparison, a population (housing projects) in which diarrheal disease mortality was not considered to be important was selected. A distinct difference in prevalence rates was found in this comparison. Shigellosis demonstrated in camps and town fringe areas was equivalent to or greater than the prevalence reported from most of the areas in which a major portion of diarrheal disease morbidity and mortality was caused by Shigellas. It was inferred from these comparisons that shigellosis was of similar importance in the California populations having this high prevalence rate.

Incidence of diarrheal disease discovered in the course of these investigations supported these inferences, since the relationship of incidence to prevalence was consistent with that reported in other studies of etiology.

Variations in prevalence demonstrated in labor camps suggested that the problem in these groups was analogous to that seen in institutional populations since a major increase in prevalence of Shigella and incidence of diarrheal disease occurred following immigration

data suggested that modification of a single environmental factor, water use, may significantly lower Shigella prevalence when the risk of acquiring this infection is great.

The relationship of Shigella infection to disease caused by this genus is discussed and illustrated by a computation using discovered prevalence, P; duration of infection, D; and the ratio of sick individuals to total infections, R. Rates thus determined led to the estimate that 70 per cent of the discovered diarrheal disease in these camps and town fringe areas was due to Shigella. The significance of this computed percentage is enhanced by comparison with etiological studies in the literature which have shown 60 to 75 per cent of acute diarrheal disorders to be caused by Shigella.

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