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Relationship of Environmental Factors To Enteric Disease

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(3)

Relation of Environmental Factors To the Occurrence Of Enteric Diseases In Areas of Eastern Kentucky

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Contents

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Introduction

The Cumberland Field Station of the Communicable Disease Center, Public Health Service, was established in Prestonsburg, Ky., in 1954, to investigate the associations between specific environmental conditions and the occurrence of diarrheal disease and to estimate the levels of control attainable by selective environmental changes. Studies were terminated and the station was closed in June 1957. The basis for undertaking the study, its objectives, the methods of operation, observations, analyses, and interpretations are described in this monograph.

Status of Diarrheal Diseases

Acute diarrheal diseases are a major cause of death in most countries of the world. According to Hardy (*1*), mortality rates in 1952 were less than 10 per 100,000 persons only in Australia, New Zealand, the United States, Canada, and the northwestern countries of Europe. In the western hemisphere diarrheal diseases are currently the primary cause of death in 9 countries and the secondary cause of death in 3 others. Children among seven-eighths of the world population, or more than two billion people, are at substantial risk of dying from diarrheal disease.

Mortality from diarrheal diseases in the United States, while declining steadily since 1900, continues to cause approximately 6,000 deaths annually. The great majority of these deaths occur in children under 2 years of age, and they presently represent the second leading cause of death from communicable disease in this age group. Comparison of average annual death rates from diarrheal disease among children under 2 years of age in various States for the 2-year period 1948–49 shows that the rate of decline in different States has not been uniform. In New Mexico, Arizona, Texas, and Kentucky, mortality rates from diarrheal diseases were 694, 578, 475, and 307 per 100,000, respectively. In the other 44 States, rates ranged from 196 in West Virginia to 30 per 100,000 in Oregon. By 1952–53, the average annual death rate had declined in New Mexico, Arizona, Texas, and Kentucky to 412, 461, 252, and 154 per 100,000, respectively. Variations in mortality rates among States are caused, in many instances, by exceedingly high rates of diarrheal disease in some occupational groups, such as transient agricultural laborers and coal miners, and in certain ethnic populations, such as the Latin Americans and the American Indians.

The decline in mortality from diarrheal diseases since the turn of the century is attributable to many factors related to improvements both in general sanitation and in medical care. Bacillary dysentery (shigellosis) has been shown to be the principal cause of mortality from acute diarrheal disease in several areas having high endemicity levels of enteric diseases. Shigellosis constituted a serious problem during World War II; typhoid fever, on the other hand, presented essentially no problem. The comparative success of typhoid fever control was essentially due to the availability of an effective immunization. The advent of chemotherapy and antibiotic treatment no doubt further reduced the prevalence of clinical and carrier states of shigellosis and salmonellosis without greatly reducing prevalence of diarrhea from other causes. Proportionately, therefore, typhoid fever, shigellosis, and salmonellosis constitute less of a national problem now than in former years because of improvements in environmental hygiene and patient care.

Directly and indirectly, such diverse influences as rural electrification, modern plumbing, safely packaged and stored foods, and demonstrations of healthful practices of living through the media of press, radio, and television are all reflected in the overall reduction of enteric diseases. The increased availability and quality of hospital facilities, diagnostic techniques, therapeutic agents, and supportive treatment have done much to reduce mortality from these diseases. Concurrent sanitation improvements by health personnel in water supplies, excreta disposal practices, control of insect and rodent vectors, milk and food handling, refuse disposal, and housing have reduced substantially the mortality and incidence of enteric disease, as shown by several studies. Investigations by the Communicable Disease Center in Louisville, Ky., during the period 1946–49 showed that the death rate from diarrheal diseases in the population under 2 years of age was 6 times as high in slum areas as in well-sanitated areas. Stewart and associates (*2*) reported that *Shigella* rates in Georgia communities varied in direct proportion to the number of housing deficiencies.

Programs designed specifically for prevention of diarrheal diseases have been relatively few. Enteric infections are, however, usually included in the justification for general community health projects. The multiplicity of factors involved in the spread of diarrheal diseases and the wide variety of etiological agents have long been recognized by public health workers, but precise information concerning much of the epidemiology of enteric infections is lacking. For these reasons, local projects have relied on generalized environmental improvements, and no great emphasis has been given to development of specific and more economical programs for suppression of diarrheal diseases.

While the concept of generally improving environmental sanitation is a laudable public health objective, the costs of broad sanitation programs are prohibitive in many parts of the world where diarrheal disease control efforts are needed urgently. Development of specific measures usually requires precise information on the mechanism of transmission and the relation of various environmental factors to dissemination of enteric pathogens. With increasing costs of generalized community environmental improvements and with the foci of infection becoming more sharply defined in certain populations which have a characteristically high incidence of mortality from diarrheal disease, the necessity for precise preventive measures has become more practical and of increasing importance.

Objectives of the Study

To provide basic information for the development of specific control measures, plans were made to carry out investigations which would supplement the data available on the epidemiology of specific enteric pathogens. The first task was selection of a general region where incidence of diarrheal diseases was high but where intensity of infection and sanitation in different communities varied sufficiently to enable studies in contrasting situations. Plans were developed to obtain the following information from the study areas:

- Seasonal and annual incidence of enteric diseases in human populations of areas differing from one another in one or more measurable characteristics of environmental sanitation.
- Identity of causative agents responsible for diarrheal diseases in the different areas.
- Evaluation of levels of sanitation in households and communities where the above data were obtained.

The Study Area

After examining available data and reviewing candidate areas, the eastern coalfield region of Kentucky was selected as the location for the study. This area is a mature, stream-dissected plateau covering approximately 10,450 square miles. Soils of the area are principally Muskingum stony silt loam and, to a lesser extent, Hartsells fine sandy loam. The climate is characterized by long growing seasons with only moderately high temperatures, uniformly distributed rainfall averaging 44 inches a year, and winters with limited snow cover. Rates of mortality from diarrheal disease considerably in excess of the State and national averages had been consistently reported from the study area. Many of the numerous coal mining camps in the area had uniform housing and sanitary facilities. The houses were in comparatively isolated clusters near the mines. Although within many camps there was little variation in housing and sanitary facilities, individual camps varied in these respects.

The majority of the people in the study area obtain their livelihood directly or indirectly from the coal mining industry. Years ago the isolated, mountainous character of the region, inadequate roads, and limited transportation facilities necessitated construction of housing adjacent to mining operations. Coal mining camps are characteristically self-sufficient. Each camp is usually provided with schools, churches, stores, and water distribution and sewage collection systems. Unlike lumber camps and the towns surrounding many metal mines in western States, most coal camps are established communities. However, they usually lack governmental organization beyond that provided by the mining companies. Gradually, the conditions of poor transportation which made coal camps obligatory have been altered. Because of this change, a number of mine operators have sold the houses and utilities to individual miners. Also, many miners now live away from the camps; some supplement their income by small truck farming. Where these changes have occurred, lack of local civic government has frequently left camp residents without adequate utilities.

Over one-third of the working population of eastern Kentucky is engaged to some extent in farming, usually at subsistence level. The low income from farming is due in part to the small acreage of crop land per farm, loss of soil fertility through erosion and leaching, and inaccessability of markets. Many residents of small farms supplement their incomes by mining. Limitation of land suitable for cultivation, restricted number of all-weather roads, and limited transportation facilities, combined with need for supplemental income from mining, frequently have resulted in the concentration of rural housing in narrow valleys. Occupants residing in such concentrated areas are classified as living in rural hamlets. With some exceptions, rural homes are provided with insanitary pit privies and open dug wells.

Methods and Procedures

After headquarters were established at Prestonsburg, Ky., a preliminary survey was made of all large coal mining camps and several rural populations within a radius of 100 miles. The uniformity and quality of housing and sanitary facilities in each location and the general suitability of each area for further study were determined. Detailed maps were made showing the location of each house in the areas selected for further work. Initial visits to each dwelling unit were then made by public health nurses and enumerators trained to obtain from each family census data, past histories of morbidity, and type and use of sanitary facilities in the home. Sanitary surveys were made of community water supplies, and water samples were tested routinely for bacteriological quality. In addition, seasonal estimations of fly abundance were recorded.

Measurement of Diarrheal Diseases

Reports of diarrheal disease were obtained by public health nurses and enumerators during monthly visits to households with children under 15 years of age. A manual was developed to standardize interviewing and recording, and field personnel were given a period of training at the beginning of employment. Possible bias in reporting due to personality differences was minimized further by regular rotation of assignments among the interviewers.

Visits were made to each household within the week following monthly collection of rectal swab cultures from preschool children. The interviewer obtained information on diarrheal disease and other illness experienced by each member of the family during the preceding month. Data were obtained from a reliable informant, usually the housewife. Prior to the

Collection of data on occurrence of diarrheal disease in group A area.

Collection of data during initial visit in group B area.

revisits, basic information obtained on the initial visit, such as study area, family name, location, household number, and names of each member of the household were typed on a recording form. Whenever necessary, adjustments in age from one statistical age group to the next were made in the office and checked in the field at the time of the revisit. During each revisit, any change in household composition or environmental facilities was recorded.

Once a year, the complete census procedure which had been followed on initial visits was repeated so that significant changes in availability and use of sanitary facilities could be recorded.

Determination of Enteric Infections

The prevalence of *Shigella* and *Salmonella* infection in preschool children was determined by obtaining rectal swab cultures at monthly intervals. Specimens were obtained from the children at the homes in the manner described by Hardy and Watt (*3*). Inoculum was obtained by inserting a sterile cotton swab into the rectum. An SS agar plate was immediately streaked with the material on the swab and the swab was then placed in a tube of tetrathionate broth. The inoculated plates and the broth cultures were returned to the laboratory and incubated. Suspect colonies were picked from SS plates to triple sugar iron agar slants after incubation at 24 and 48 hours.

The swab in tetrathionate broth was incubated at 37° C. for 24 hours and then streaked on brilliant green agar plates. These plates were subsequently examined in the same manner as the original SS plate. Bacterial colonies whose reactions in triple sugar iron agar indicated the possibility of their being *Shigella* or *Salmonella* were examined biochemically and serologically as described by Edwards and Ewing (*4*). Representative samples of the positive cultures were forwarded to the International Typing Center at the Communicable Disease Center in Atlanta, Ga., for confirmation.

Determination of Intestinal Parasites

Stool specimens for parasitological examinations were collected semiannually from individuals of all ages in the various study areas. Half-pint waxed cardboard cartons were distributed to the homes with simple instructions for obtaining fecal samples unmixed with extraneous material. Return visits were made daily for as many as 3 days to get specimens from as many individuals as possible. Samples were transported directly to the laboratory, refrigerated, and examined within a few days. Fecal smears were examined and helminthic egg counts were performed according to the Beaver direct smear method (*5*).

Stool samples from a few selected areas were concentrated by the formalin-ether technique to facilitate examination for protozoa

Streaking of rectal swab specimen in group C area.

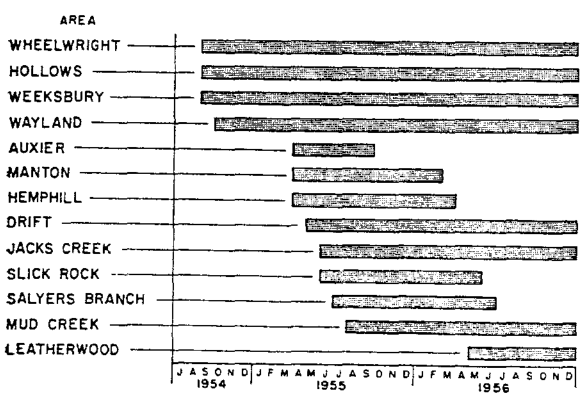
Collection of stool specimens in group C area.

and helminths. These specimens were placed in 5 percent formalin as soon as they reached the laboratory.

Determination of Fly Abundance

Monthly measures of fly abundance were made to determine the relative importance of flies as vectors of *Shigella* and other diarrheal agents. Fly populations were measured with the Scudder fly grill (*6*) during the fly seasons between the period August 1954 to September 1956. Samples were obtained from groups of houses, corresponding roughly in size to city blocks, representative of all types of housing and conditions of environmental sanitation. After inspecting all concentrations of flies that could be located within a sample block, the five highest grill counts were recorded. Sampling techniques were similar to those developed and tested by Lindsay and associates (*7*).

Figure 1. Time period of study of enteric disease in eastern Kentucky, by area.

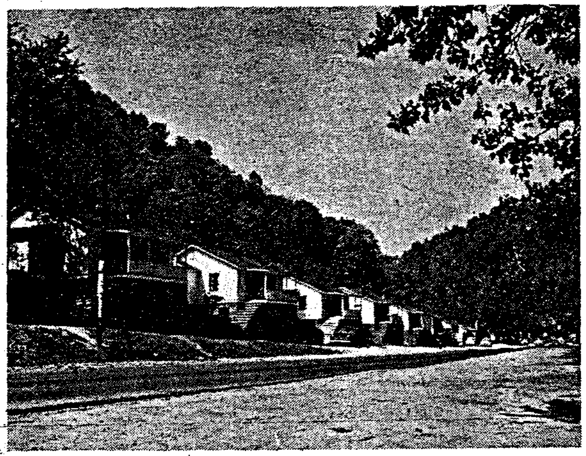


Evaluation of Water Quality

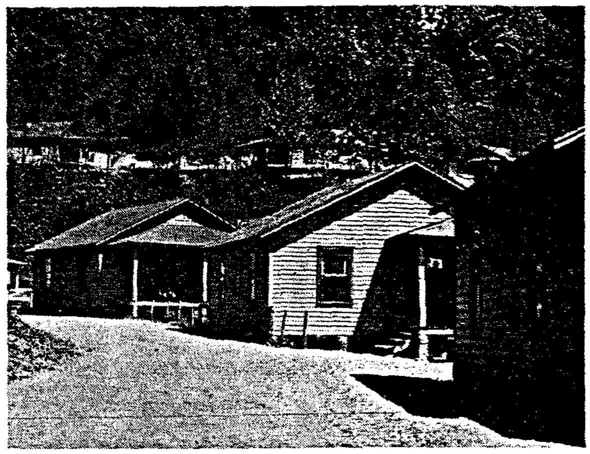
Standard procedures were followed in procurement and examination of water samples (*8*). Initial samples were examined by presumptive and completed tests for members of the coliform group with coliform density estimated by the most-probable-number method. The membrane filter procedure with M-HD Endonmedia (Difco) was employed in the examination of the majority of the samples with direct counts of coliform organisms. Periodic tests for presence and number of coliform bacteria were made of all public and semipublic water supplies and of a representative number of drilled and dug wells used by families in the study areas. Nearly all private water supplies were sampled at least once.

Selection of Study Areas

Of 62 communities evaluated, 13 areas in Floyd, Letcher, and Perry Counties, Ky., were selected for continued observations. Individually, the selected communities represented the greatest homogeneity of housing, sanitary facilities, and economic status obtainable in the region; as a group, they represented the extremes and the various levels of development. Observations were begun in 4 study areas during the fall of 1954 and in 8 additional areas during the spring and summer of 1955 (fig. 1).



Representative housing in group A area.



Representative housing in group B area.

In the spring of 1956, observations were also begun in Leatherwood, a large mining camp in Perry County some 100 miles from station headquarters. Data from Auxier and Leatherwood are not included in the analyses because a full year's observations were not obtained. Four of the remaining 11 areas presented some limitations as study sites because of either small populations or distant locations. Studies in these 4 areas were discontinued after 1 year of observation, since findings were similar to those obtained in the other 7 areas. Therefore, data from 11 study areas are included in the analyses, except in cases necessitating equal representation of data for each season.

Characteristics of Study Areas

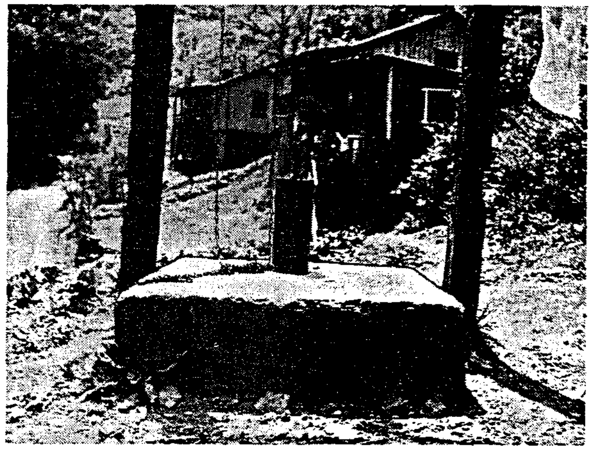
Each of the 11 populations selected for continuous study was placed in one of three groups

Table 1. Population and sanitary facilities of diarrheal disease study areas, eastern Kentucky, 1954–56

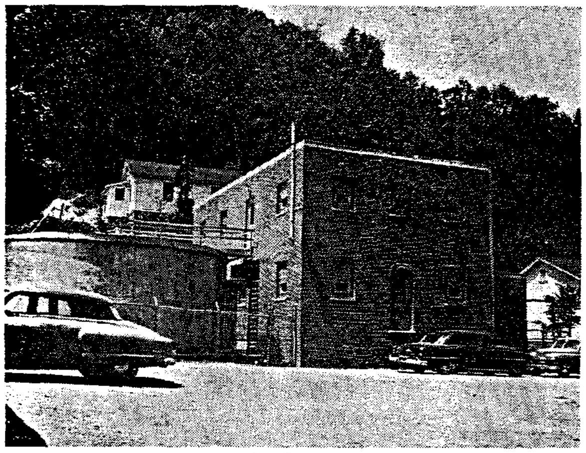
Grouped study areas	Average study population	Average number of households visited monthly	Average number of households cultured monthly	Percentage of dwelling units with—					
				Flush toilet	Privy	Water inside		Water outside	
						Hot and cold	Cold only	Under pressure	No pressure
All areas	3, 928	560	299	46	54	48	19	3	30
Group A:									
Wheelwright[1]	1, 295	194	98	100	0	100	0	0	0
Group B:[2]	1, 624	230	118	20	80	27	39	5	29
Weeksbury	403	57	33	11	89	19	15	7	59
Wayland	545	83	40	29	71	44	52	1	3
Manton	107	15	9	14	86	14	45	9	32
Hemphill	270	36	15	16	84	24	28	6	42
Drift	299	39	21	20	80	18	55	5	22
Group C:[3]	1, 009	136	83	7	93	6	13	4	77
Hollows	211	38	16	17	83	13	20	9	58
Jacks Creek	306	39	26	7	93	7	13	2	78
Slick Rock	100	15	10	0	100	0	12	13	75
Salyers Branch	150	15	10	4	96	4	9	0	87
Mud Creek	242	29	21	0	100	0	5	0	95

[1] Complete community sanitary facilities.
[2] Lacking complete community sanitary facilities.
[3] No community sanitary facilities.

Representative housing in group C area.

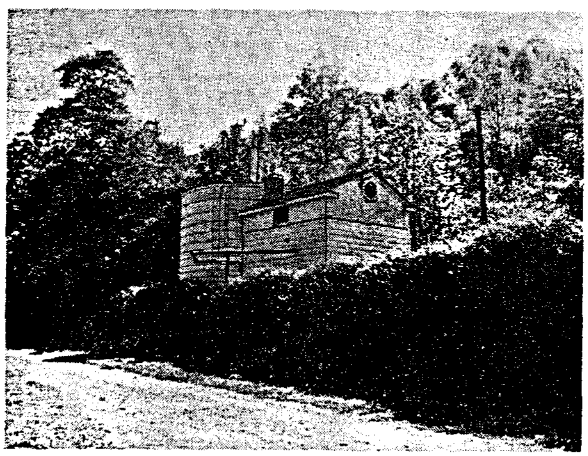


Typical drilled well in group C area.

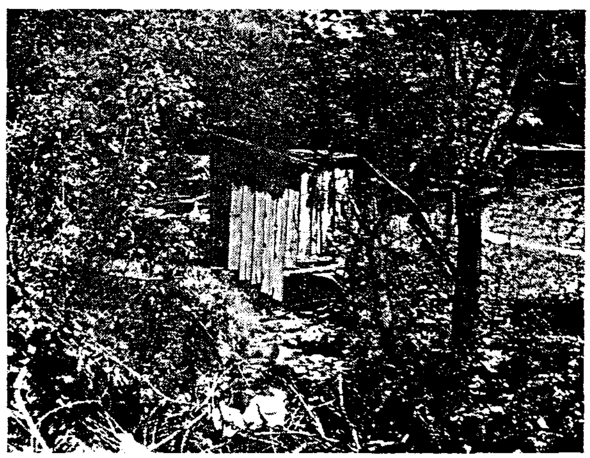


Water treatment plant in group A area.

Typical dug well in group C area.



Water treatment plant in group B area.



A typical insanitary privy in group C area.

on the basis of environmental characteristics (table 1).

Group A, which averaged 1,295 people, included families housed in regularly maintained, uniformly built structures and provided with all necessary community sanitary facilities—flush toilets, hot and cold running water, approved water and sewage treatment plants—and with regular refuse collection services. All of these families were located in Wheelwright, a large, well-organized mining community wholly owned, managed, and maintained by a coal mining company.

Group B averaged 1,624 people and included families at Weeksbury, Wayland, Manton, Hemphill, and Drift, who were incompletely served by public sanitary utilities. In general, the houses and utilities in group B areas had been sold by the mining company, and maintenance was the responsibility of individual owners. Housing structures were generally uniform within each camp, but types of water sources and plumbing and methods of excreta disposal varied.

Group C included an average study population of 1,009 at Hollows, Jacks Creek, Slick Rock, Salyers Branch, and Mud Creek. These areas were rural hamlets with only nominal sanitary facilities; housing varied considerably in facilities and construction. Sources of drinking and wash water at the time of the studies were, for the most part, private, unprotected dug wells. Many homes lacked plumbing of any description, and pit privies were the most commonly employed method of excreta disposal.

As indicated in table 1, 100 percent of the dwellings in group A had water under pressure inside the dwelling units, whereas only 66 and 19 percent of dwelling units in groups B and C, respectively, were so served. All families in group A, 20 percent of group B families, and 7 percent of the families in group C had flush toilets. The average number of rooms per house was approximately the same in all three groups.

Results

Reported Prevalence of Disease

The age-specific incidence of reported diarrheal disease per 1,000 persons per annum is shown in table 2. Since there was little difference in the age distribution of the grouped study populations (table 3), and since extreme variations in morbidity were reported, rates were not adjusted by ages. More than 50 percent of the cases were reported for children 0–4 years old, and the majority of these were in children under 2 years of age. In areas grouped according to sanitary facilities, B and C populations, respectively, showed morbidity rates for all ages that were 1.9 and 2.6 times as high as rates for group A during the entire period of observations.

Incidence reported in the seven camps which were observed throughout the year September 1955–August 1956 was compared with reported incidence for all areas for their full period of observation (table 4). Of the seven study areas, those in groups A and B showed lower morbidity rates, while those in group C showed higher rates, for the 1-year period than for the total period of observation. During the 1-year period, population groups B and C reported diarrheal rates which were 1.6 and 5.1 times as high for children aged 0–4 as the rate reported for that age group in group A. Since the trend and difference between categories was consistent, incidence data collected for the total period of study were used in subsequent comparisons between incidence of disease and sanitation deficiencies.

Rates of reported diarrheal disease per 1,000 per annum, ages 0–4 and all ages for all study areas, are shown in figure 2, by months. Marked seasonal trends were observed, the highest incidence occurring during August and September. The ratio of "summer" diarrhea to "winter" diarrhea for the years 1955 and 1956 was approximately 2 to 1. The increased incidence

Table 2. Age-specific diarrheal disease morbidity rates reported in study populations, eastern Kentucky, 1954–56

Grouped study areas [1]	All ages			0–4			5–9			10–14			15 and older		
	PME [2]	Cases	Rate [3]	PME [2]	Cases	Rate [3]	PME [2]	Cases	Rate [3]	PME [2]	Cases	Rate [3]	PME [2]	Cases	Rate [3]
All areas	70, 826	1, 343	227	11, 210	705	754	13, 754	205	178	12, 143	118	116	33, 719	315	112
Group A:															
Wheelwright	27, 511	310	135	4, 038	139	413	5, 207	53	122	4, 530	29	76	13, 736	89	77
Group B	27, 969	586	251	4, 692	291	744	5, 247	86	196	4, 998	57	136	13, 032	152	139
Weeksbury	9, 165	208	272	1, 660	102	737	1, 876	27	172	1, 546	15	116	4, 083	64	188
Wayland	11, 652	240	247	1, 802	117	779	1, 936	37	229	2, 318	27	139	5, 596	59	126
Manton	894	23	308	184	13	847	188	3	191	109	2	220	413	5	145
Hemphill	2, 169	37	204	300	17	680	476	6	151	359	3	100	1, 034	11	127
Drift	4, 089	78	228	746	42	675	771	13	202	666	10	180	1, 906	13	81
Group C	15, 346	447	349	2, 480	275	1, 330	3, 300	66	240	2, 615	32	146	6, 951	74	127
Hollows	4, 767	126	317	594	58	1, 171	878	21	287	721	14	233	2, 574	33	153
Jacks Creek	4, 963	131	316	808	85	1, 262	1, 200	22	220	860	8	111	2, 095	16	91
Slick Rock	1, 069	34	381	190	16	1, 010	238	9	453	166	2	144	475	7	176
Salyers Branch	1, 311	15	137	252	14	666	280	0	0	258	0	0	521	1	23
Mud Creek	3, 236	141	522	636	102	1, 924	704	14	238	610	8	157	1, 286	17	158

[1] See footnotes to table 1. [2] Person-months experience. [3] Rate per 1,000 per annum.

Table 3. Age distribution of study population, by area, eastern Kentucky, 1954–56

Grouped study areas [1]	Total population	0–4 Number	0–4 Percent of all ages	5–9 Number	5–9 Percent of all ages	10–14 Number	10–14 Percent of all ages	15–19 Number	15–19 Percent of all ages	20 and older Number	20 and older Percent of all ages
All areas	3, 928	646	16	729	19	653	17	371	9	1, 529	39
Group A:											
Wheelwright	1, 295	184	14	219	17	212	16	124	10	556	43
Group B	1, 624	275	17	301	18	273	17	155	10	620	38
Weeksbury	403	76	19	72	18	74	18	35	9	146	36
Wayland	545	82	15	89	16	101	19	65	12	208	38
Manton	107	21	20	21	20	13	12	5	5	47	43
Hemphill	270	41	15	60	22	41	15	26	10	102	38
Drift	299	55	18	59	20	44	15	24	8	117	39
Group C	1, 009	187	19	209	21	168	17	92	9	353	34
Hollows	211	29	14	37	18	30	14	21	10	94	44
Jacks Creek	306	50	16	68	22	54	18	34	11	100	33
Slick Rock	100	20	20	21	21	15	15	7	7	37	37
Salyers Branch	150	31	21	34	23	27	18	12	8	46	30
Mud Creek	242	57	24	49	20	42	17	18	7	76	32

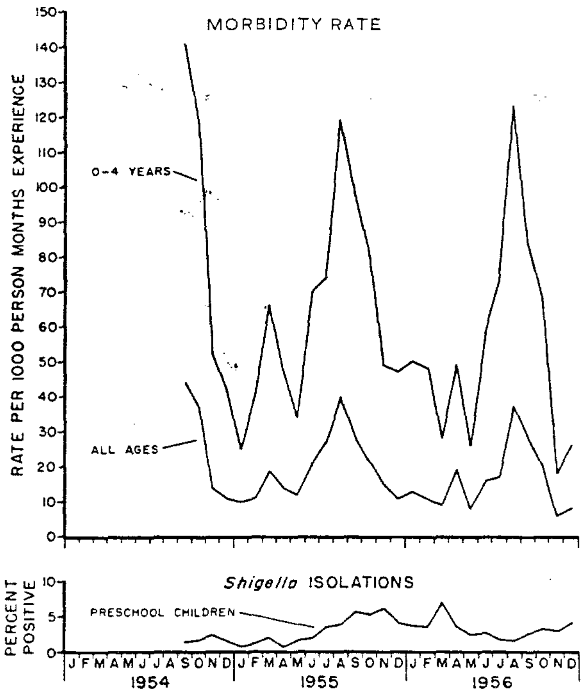
[1] See footnotes to table 1.

Table 4. Reported diarrheal disease morbidity rates of study populations, by age and area, eastern Kentucky, 1954–56

Grouped study areas [1]	Sept. 1954–Dec. 1956, 0–4 years PME [2]	Sept. 1954–Dec. 1956, 0–4 years Rate [3]	Sept. 1954–Dec. 1956, All ages PME [2]	Sept. 1954–Dec. 1956, All ages Rate [3]	Sept. 1955–Aug. 1956, 0–4 years PME [2]	Sept. 1955–Aug. 1956, 0–4 years Rate [3]	Sept. 1955–Aug. 1956, All ages PME [2]	Sept. 1955–Aug. 1956, All ages Rate [3]
All areas	11, 210	754	70, 826	227	4, 449	755	27, 938	213
Group A:								
Wheelwright	4, 038	413	27, 511	135	1, 496	328	10, 446	94
Group B	4, 692	744	27, 969	251	1, 805	525	10, 329	196
Weeksbury	1, 660	737	9, 165	272	700	394	3, 773	165
Wayland	1, 802	779	11, 652	247	684	649	4, 225	215
Manton	184	847	894	308	[4]			
Hemphill	300	680	2, 169	204	[4]			
Drift	746	675	4, 089	228	421	541	2, 331	211
Group C	2, 480	1, 330	15, 346	349	1, 148	1, 672	7, 163	412
Hollows	594	1, 171	4, 767	317	230	1, 304	1, 913	370
Jacks Creek	808	1, 262	4, 963	316	500	1, 512	3, 124	353
Slick Rock	190	1, 010	1, 069	381	[4]			
Salyers Branch	252	666	1, 311	137	[4]			
Mud Creek	636	1, 924	3, 236	522	418	2, 066	2, 126	536

[1] See footnotes to table 1. [2] Person-months experience. [3] Rate per 1,000 per annum. [4] Data for full period not available.

Figure 2. Monthly incidence of reported diarrheal disease morbidity in persons of all ages and *Shigella* prevalence in preschool children, eastern Kentucky, 1954–56.



of diarrheal disease observed February–April 1955, and the plateau observed November 1955–February 1956 in children 0–4 years of age were attributable to diarrheal illness associated with nausea, general malaise, and vomiting. An outbreak of diarrhea limited to a single camp (Drift) was responsible for the increased incidence observed during April 1956.

Monthly data on reported prevalence of diarrheal disease in the three population groups are shown in figure 3. Seasonal peaks were most marked in areas B and C, ranging to only slight seasonal variations in population group A. Data shown in figure 3 also indicate that in the areas with poorer sanitation, incidence of diarrhea increases earlier in the spring and persists longer at a high level in the fall.

A total of 1,343 instances of diarrheal disease morbidity was reported by all families in the study to the enumerators during the period September 1954–December 1956. Abdominal pain, vomiting, fever, and mucus and blood in the stool, in that order of frequency, were the outstanding symptoms reported. The modal number of stools per day was 5, and the median 6. The average duration of illness was 4 days. In approximately 12 percent of the instances of diarrheal disease the individual was confined to bed for 1 day or more; 24 percent received medical attention, including 2 percent who were hospitalized. Less than 1 percent of all cases were of 1-day duration or less, and 15 percent of the individuals reported 3 stools or less in a 24-hour period.

Reported diarrheal disease cases for children 0–4 years old represented 45 percent of all cases in group A, 50 percent in group B, and 62 percent in group C (table 5). Milder diarrhea, indicated by 5 stools or less in a 24-hour period, was reported more frequently in group A than in the B and C groups; this difference was more marked for all ages combined than for the 0–4 age level alone. In group A, 19 percent of all individuals reported 3 or fewer stools per day, compared with 12 percent and 13 percent for B and C groups, respectively. In the category of 10 or more stools per day, representing the most severe diarrhea, data from the 3 population groups were closely com-

Figure 3. Monthly incidence of reported diarrheal disease morbidity in persons of all ages and *Shigella* prevalence in preschool children, eastern Kentucky, by grouped areas, 1954–56.

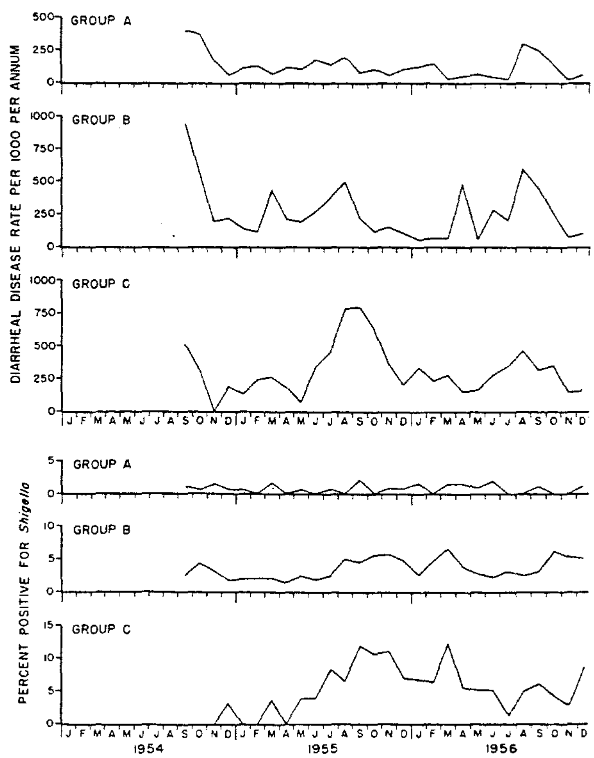


Table 5. Frequency of stools per day in reported diarrheal disease cases, by grouped study areas,[1] eastern Kentucky, 1954–56

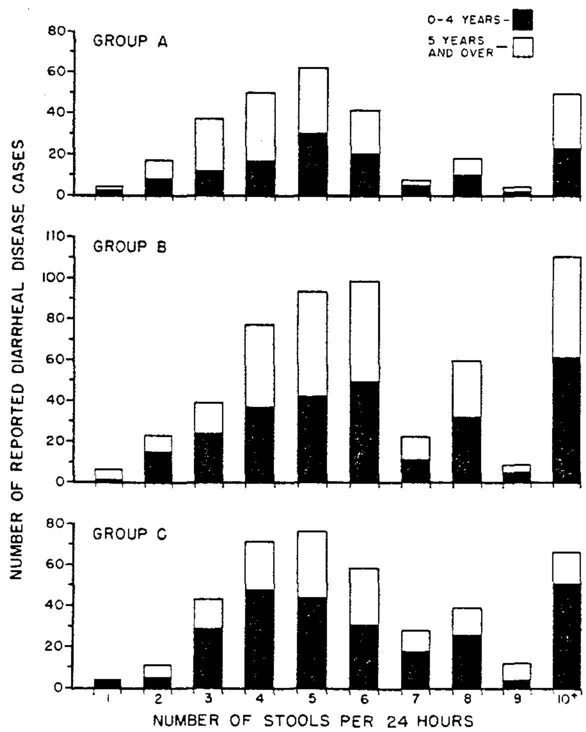
Number of stools in 24 hours	Cases reported					
	Group A		Group B		Group C	
	0–4 years	All ages	0–4 years	All ages	0–4 years	All ages
Total	139	310	291	586	275	447
1–3	23	58	40	68	38	58
4–5	47	112	78	166	92	147
6–9	37	70	96	186	79	137
10 and over	23	49	61	106	51	66
Unknown	9	21	16	60	15	39

[1] See footnotes to table 1.

parable: group A reported 16 percent of all cases; group B, 18 percent; and group C, 15 percent.

The distribution of stool frequencies in reported diarrhea experienced by individuals aged 0–4 years and all ages is shown by grouped populations in figure 4. In comparing the 3 groups of data, it should be remembered that numbers, not rates, of cases are given. Irregularity in the distribution curves of all 3 groups is evident in frequency categories beyond 6 stools per day. In these instances the respondents evidently favored even numbers in reporting, although the enumerators were careful not to suggest numbers when eliciting information. The category of 10 or more stools may have served as a convenient repository for many diarrheal disease experiences with which the respondents associated several stools, but could not recall the exact number. In such circumstances a certain amount of unconscious exaggeration is understandable.

Figure 4. Frequency of stools per day in reported diarrheal disease cases, by grouped areas, eastern Kentucky, 1954–56.



Prevalence of Bacterial Pathogens

Shigella was isolated from 354 of the 11,264 rectal swab cultures collected. Of these 354 isolations, 29 were from population A, 165 from B, and 160 from C. Eight biotypes of *Shigella* were represented (table 6): the Manchester biotype of *Shigella flexneri* 6, representing 42 percent of the total isolations, was the most frequently isolated type; *Shigella sonnei* represented 20 percent; and *S. flexneri* 1b, 10 percent. Recovery rates and atypical biochemical reactions of the Manchester variety as compared with other shigellae in the area have been described previously (*9*). Only 4 biotypes were isolated in population A, of which 62 percent were *S. flexneri* 6, Manchester variety.

Rates of *Shigella*-positive cultures obtained by the rectal swab examination of normal preschool children are presented in table 7 by in-

Table 6. Species of *Shigella* isolated from rectal swab cultures taken from preschool children, by grouped study areas,[1] eastern Kentucky, 1954–56

Shigella species	All areas		Group A		Group B		Group C	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total	359	100.0	29	100.0	[2] 167	100.0	[3] 163	100.0
S. dysenteriae	14	3.9			4	2.4	10	6.1
S. flexneri lb	34	9.5			19	11.4	15	9.2
S. flexneri 2a	26	7.2	1	3.4	11	6.6	14	8.6
S. flexneri 3	5	1.4			3	1.8	2	1.2
S. flexneri 4a	46	12.8	4	13.8	19	11.4	23	14.1
S. flexneri 6, Boyd 88 variety	11	3.1			4	2.4	7	4.3
S. flexneri, Manchester variety	152	42.3	18	62.1	64	38.3	70	42.9
S. sonnei	71	19.8	6	20.7	43	25.7	22	13.5

[1] See footnotes to table 1.
[2] One individual had *S. flexneri* lb and 3, and another had *S. flexneri* 4a and *sonnei*.
[3] One individual had *S. flexneri* 2a and Manchester, one had *S. flexneri* 4a and Manchester, and another had *S. sonnei* and Manchester.

dividual and grouped study areas. The lowest rates were observed in group A and the highest rates in group C. Rates by individual study areas ranged from 0.7 percent in Wheelwright to 10.2 percent in Salyers Branch. No *Shigella* isolations were obtained from children under 6 months of age in the study areas represented in the table, although cultures were obtained from an average of 18 children per month in this age group. Most of these children were between 3 and 6 months old. The highest rates observed were in the 4-year age group. When the areas were grouped by level of community sanitary facilities, a shift in the peak *Shigella* prevalence to the younger age groups was observed to accompany progressive increase in number of sanitary deficiencies. Infections occurred in younger children and infection rates were consistently higher in children 0–4 years old in the group C areas than in the B areas. In group C areas, the highest infection rates were observed among 2-year-olds (9.1 percent); in group B and group A areas, highest rates were among 4-year-olds (5.2 percent and 1.6 percent, respectively).

Prevalence rates of shigellae in the seven areas where data were obtained for the year September 1955–August 1956 only were compared with rates of all cultures obtained between September 1954 and December 1956, the entire period of the study (table 8). Rates for the 1-year period were slightly higher than for the total study period, but the overall trends are consistent despite variation between camps.

Salmonellae were recovered from the rectal swab cultures of preschool children on 25 occasions (table 9). *Salmonella tennessee*, isolated 6 times, occurred most frequently; *Salmonella montevideo* was isolated 5 times, *Salmonella derby* and *Salmonella typhimurium* each 3 times, and *Salmonella muenchen* twice. Six other types were each recovered once. Fourteen of the isolates were from area B populations, 5 from area C, and 6 from area A.

A small survey was made to determine the prevalence of four enteropathogenic serotypes of *Escherichia coli* in the normal study population of preschool-age children. A total of 1,000 rectal swab specimens obtained February–August 1955 from preschool children in Wheelwright, Wayland, Weeksbury, and Jacks Creek were streaked upon MacConkey agar plates supplementing the routine field culturing procedure. The cultures were examined for *E. coli* serotypes 026 : B6, 055 : B5, 0111 : B4, and 0127 : B8, as well as for *Shigella* and *Salmonella*. Sixty-nine *Shigella* and 13 enteropathogenic *E. coli* isolations were obtained (*10*). It was concluded from the limited study that the four strains of *E. coli* did not contribute appreciably to prevalence of diarrheal disease during the time of the study.

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Table 7. Rectal swab cultures and *Shigella* isolated from preschool children, by age and area, eastern Kentucky, 1954–56

Grouped study areas [1]	Age groups															
	All ages [2]		0–5 months		6–11 months		1 year		2 years		3 years		4 years		5 years	
	Number of cultures	Percent positive	Number of cultures	Percent positive	Number of cultures	Percent positive	Number of cultures	Percent positive	Number of cultures	Percent positive	Number of cultures	Percent positive	Number of cultures	Percent positive	Number of cultures	Percent positive
All areas	11, 264	3. 1	500	0. 0	798	1. 1	1, 942	2. 4	2, 240	3. 3	2, 062	3. 6	1, 984	4. 5	1, 607	3. 5
Group A:																
Wheelwright	4, 074	0. 7	176	0. 0	307	0. 0	722	0. 3	815	0. 5	694	0. 4	697	1. 6	636	1. 4
Group B	4, 698	3. 5	248	. 0	336	1. 2	698	2. 4	852	2. 2	983	4. 5	885	5. 2	631	5. 1
Weeksbury	1, 735	3. 6	80	. 0	122	. 8	270	. 7	306	2. 0	346	4. 9	341	6. 2	250	5. 6
Wayland	1, 828	3. 4	111	. 0	137	2. 2	275	2. 9	347	3. 2	384	3. 1	312	3. 8	228	6. 6
Manton	162	3. 1	11	. 0	10	. 0	33	. 0	28	3. 6	33	6. 1	26	3. 8	20	5. 0
Hemphill	297	2. 0	18	. 0	28	. 0	27	3. 7	38	. 0	47	2. 1	64	6. 2	65	. 0
Drift	676	4. 3	28	. 0	39	. 0	93	6. 4	133	. 8	173	6. 9	142	5. 6	68	2. 9
Group C	2, 492	6. 4	76	. 0	155	3. 2	522	5. 2	573	9. 1	385	7. 3	402	8. 2	340	4. 4
Hollows	644	2. 6	36	. 0	56	1. 8	104	1. 9	126	5. 6	88	4. 5	101	1. 0	125	1. 6
Jacks Creek	801	8. 1	13	. 0	50	2. 0	199	4. 5	212	13. 2	87	10. 3	122	12. 3	98	3. 1
Slick Rock	230	6. 1	2	. 0	15	6. 7	40	10. 0	41	12. 2	46	4. 3	37	2. 7	41	2. 4
Salyers Branch	236	10. 2	6	. 0	9	. 0	69	4. 3	57	10. 5	50	10. 0	31	25. 8	14	14. 3
Mud Creek	581	6. 9	19	. 0	25	8. 0	110	8. 2	137	4. 4	114	7. 0	111	7. 2	62	11. 3

[1] See footnotes to table 1. [2] Some 6-year-olds included.

Table 8. *Shigella* isolations from rectal swab cultures of preschool children, by area, entire study period and 1-year period September 1955–August 1956

Grouped study areas [1]	September 1954–December 1956		September 1955–August 1956	
	Number of cultures	Percent *Shigella* positive	Number of cultures	Percent *Shigella* positive
All areas	11, 264	3. 1	4, 424	4. 0
Group A:				
Wheelwright	4, 074	0. 7	1, 452	1. 0
Group B	4, 698	3. 5	1, 787	4. 2
Weeksbury	1, 735	3. 6	722	3. 0
Wayland	1, 828	3. 4	686	5. 1
Manton	162	3. 1	(2)	----------
Hemphill	297	2. 0	(2)	----------
Drift	676	4. 3	379	4. 7
Group C	2, 492	6. 4	1, 185	7. 5
Hollows	644	2. 6	241	4. 6
Jacks Creek	801	8. 1	495	9. 3
Slick Rock	230	6. 1	(2)	----------
Salyers Branch	236	10. 2	(2)	----------
Mud Creek	581	6. 9	449	7. 1

[1] See footnotes to table 1. [2] Data not available for full period.

Prevalence of Intestinal Parasites

Single fecal specimens were collected from 2,798 individuals in the study areas during the period September 1954–December 1956. In the early phases of the study, 843 specimens were examined for both intestinal protozoa and helminths. Results of the examinations for intestinal protozoa have been reported previously by Atchley and co-workers (*11*). The highest infection rates were in the group aged 10–14 years. Of the 843 stool specimens obtained from individuals of all ages, 3.3 percent were positive for *Entamoeba histolytica*, 21 percent for *E. coli*, 5.9 percent for *Endolimax nana*, 0.6 percent for *Iodameoba bütschlii*, 9.5 percent for *Giardia lamblia*, and 0.5 percent for *Chilomastix mesnili.*

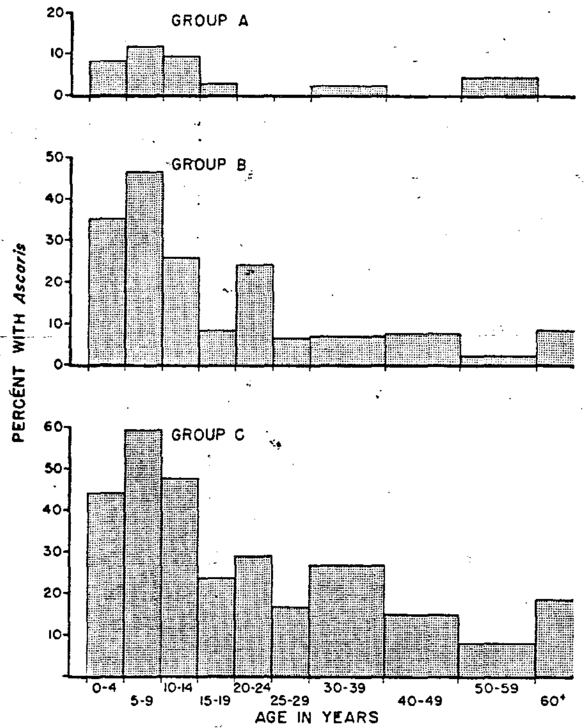
Table 9. Species of *Salmonella* isolated from rectal swab cultures taken from preschool children, eastern Kentucky, 1954–56

Salmonella species	Isolations	
	Number	Percent
Total	25	100
S. derby	3	12
S. paratyphi B	1	4
S. typhimurium	3	12
S. thompson	1	4
S. montevideo	5	20
S. infantis	1	4
S. bareilly	1	4
S. tennessee	6	24
S. meunchen	2	8
S. meleagridis	1	4
S. anatum	1	4

The percentage of stools positive for any helminth and the percentage of all stools positive for *Ascaris*, *Trichuris*, *hookworm*, *Strongyloides*, or *Hymenolepis* infections are presented by age and by grouped study areas in table 10. Inasmuch as stool examination procedures are inadequate for the detection of *Enterobius*, reliable rates were not obtained for this species, but other incidental observations implied a very high prevalence. Occurrences of all helminth species were lowest in group A and highest in group C. Rates of *Trichuris* infection approximated that of roundworm, although the whipworm infections were almost invariably much lighter as judged by egg counts.

The number and percentage of stool specimens positive for *Ascaris lumbricoides* are shown by age and study area in table 11. In the group 2–12 years old, rates ranged from

Figure 5. Percentage of individuals infected with *Ascaris*, by age, in study areas grouped according to sanitary facilities, eastern Kentucky, 1954–56.



approximately 12 percent in Wheelwright to 70 percent in Mud Creek. Nearly the same numbers of individuals of other ages were examined in the 11 study areas. Closely similar variations in infections were observed, but at lower rates. One-fourth of the 2,798 individuals examined were positive for *Ascaris*. Omitting group A, 33 percent of the specimens from all ages combined were positive.

Figure 5 shows the distribution of *Ascaris* infections by age group in the three population areas. The greatest proportion of positive specimens came from children 5–9 years old, with 12, 47, and 59 percent infected in areas A, B, and C, respectively. In general, the age distributions were similar in the three groups, except where only small numbers of cooperating individuals were available in certain age groups.

Fly Abundance

Sarcophagids, *Phaenicia* spp., and *Musca domestica* were the most common flies observed in the study areas. Scattered garbage and waste water were the most common attractants. Because of the demonstrated role of *M. domestica* as a vector of *Shigella* (*5*) and the close association between this species and humans, grill counts of houseflies only were measured (table 12). Houseflies were seen first in the study areas about the middle of April each year; a few *Cynomyopsis*, *Calliphora*, *Phaenicia*, and sarcophagids were seen about a month earlier. Houseflies increased slowly in May and June and more rapidly thereafter to a peak in September of 1954 and 1955. During the summer months, *M. domestica* comprised one-half to three-fourths of the total fly population. Generally windy conditions during August 1956 seriously interfered with fly measurements; counts for the month probably would have been much higher if winds had not been so strong. Although no grill counts were made in the fall months of 1956, on the basis of occasional field observations housefly abundance appeared to reach a peak during the first 2 weeks of October.

Consistently smaller fly populations, both of *Musca* and of total flies, were observed at premises of group A than at premises of group B

Table 12. Average grill count of houseflies by study area group, eastern Kentucky, August 1954–August 1956

Study area group [1]	1954			1955						1956		
	August	September	October	May	June	July	August	September	October	June	July	August
Group A	2.8	2.8	(2)	0.4	0.1	0.6	1.5	2.2	1.2	0.1	1.8	1.1
Group B	13.5	20.6	12.6	.8	1.3	4.0	7.9	11.8	7.4	.6	4.8	3.3
Group C	5.5	13.1	(2)	1.0	.6	4.1	10.1	13.9	(2)	.5	2.5	(2)

[1] See footnotes to table 1. [2] No grill counts made.

or C. This finding was anticipated, since Wheelwright was the only study area where general use was made of covered garbage containers and refuse collection service. There were no consistent differences in fly abundance between group B and group C areas. Group B had higher *Musca* counts than group C in 5 of the 9 months for which comparable data are available (table 12). It was noticed that, although about the same number of flies per attractant were obtained at premises in the two groups, on the whole there appeared to be more attractants in the yards of group C homes. Typically, houses in both groups were screened inadequately or not at all; during the summer months numbers of *Musca* and *Phaenicia* were commonly observed indoors.

Examinations of Water

Bacteriological examination of water samples was conducted from January 28, 1955, through December 1956. The number of water sources examined included 7 piped public supplies, 7 semipublic supplies, 62 private drilled wells, 142 private dug wells, and 15 springs (table 13). Frequency of sampling was generally related to the number of individuals served by the water supply. Most wells used by a single family were tested only once or twice, but the larger public systems were sampled as often as 3 or 4 times a week. During the late summer and early fall, many of the dug wells and springs were dry, and a number of families obtained water temporarily from creeks or from supplies outside the study area. With the exception of these emergency sources and a few infrequently used dug wells, all water supplies available to the populations under study were tested for bacteriological quality at least once.

Only in Wheelwright were all houses provided with piped water. An abandoned mine was used as a water source and reservoir. The water was regularly treated by coagulation, filtration, storage, and chlorination. Houses at Wayland were served by a common supply, with a few exceptions. The Wayland service included two systems, which were connected during most of the period of investigations. Abandoned mines, a creek, and a deep well were used separately and in combination as water sources. Treatment included filtration, storage, and occasional chlorination. In Manton and Hemphill, water was obtained from mines and piped to homes without treatment other than storage. Deep wells were used by Weeksbury and Drift; treatment consisted of storage and intermittent chlorination in Weeksbury and storage only in Drift.

Coliform contamination was lowest in the piped public supplies and highest in the individual dug wells (table 14). Dug wells in eastern Kentucky were usually lined with flat rocks laid without mortar. The wells rarely were covered or otherwise sheltered. In most instances, the water probably was contaminated

Table 13. Water sources examined for bacteriological quality, by area and type, eastern Kentucky, 1954–56

Grouped study areas [1]	Public water systems	Semipublic drilled wells	Individual drilled wells	Individual dug wells	Springs
Group A:					
Wheelwright	1	-----	-----	-----	-----
Group B	6	1	30	46	7
Weeksbury	1	-----	14	26	6
Wayland	2	-----	3	6	-----
Manton	1	1	3	2	-----
Hemphill	1	-----	-----	5	-----
Drift	1	-----	10	7	1
Group C	0	6	32	96	8
Hollows	-----	4	-----	24	2
Jacks Creek	-----	2	14	37	2
Slick Rock	-----	-----	3	13	2
Salyers Branch	-----	-----	14	5	-----
Mud Creek	-----	-----	1	17	2

[1] See footnotes to table 1.

Table 14. Distribution of coliform contamination in water samples, by source and degree of contamination, eastern Kentucky, 1954–56

Water source	Number coliforms per 100-ml. sample			
	0–1	2–19	20–99	100 and over
	Percent			
Public water systems	89. 4	7. 0	1. 8	1. 8
Semipublic drilled wells	64. 3	7. 1	9. 6	19. 0
Individual drilled wells	51. 9	8. 9	13. 9	25. 3
Springs	18. 5	25. 9	26. 0	29. 6
Individual dug wells	12. 1	9. 9	28. 0	50. 0

both during drawing operations and by surface drainage.

The Wheelwright water system was the only public supply in the study area which consistently produced water of good quality during the period of observation. No coliforms were recovered from any of 183 samples collected over a period of 62 weeks. With one exception, the samples were free of turbidity, sediment, and color; the pH usually ranged between 7.2 and 7.4. Chlorine residuals taken at a point distant from the treatment plant usually ranged between 0.2 and 0.4 p.p.m.; chlorine residual was present in all but 4 of the 183 samples.

The record of 572 examinations of the Wayland system over a period of 61 weeks shows erratic and frequently inadequate settling, filtration, and chlorination. Sixty-eight (12 percent) of the samples, representing 27 weeks' observation, revealed varying degrees of contamination by coliform bacteria; in 14 of the 68 instances, however, the count was only 1 coliform per 100 ml. of sample. In general, sources in group B study areas usually provided water subject to frequent bacterial contamination.

Heavy pollution was most consistently present in group C water sources which consisted of open dug wells for the most part.

Socioeconomic Factors

Studies of the relationship between sanitary facilities and enteric disease are complicated by the difficulty, or improbability, of securing population groups in which the desired variables are represented, but which are otherwise similar. Such closely comparable groups can be approximated only in highly artificial populations, such as military camps. Even with the most careful selection of available alternatives, population groups exhibiting measurable social and economic differences had to be included in the present study.

Table 15 summarizes information concerning a number of these factors, which were analyzed to determine their possible influence upon correlations of sanitary facilities and diarrheal disease incidence. One factor which influenced selection of the eastern coalfield region for these studies was the heavily unionized single industry, which served to minimize differences in the nature of employment and family income and, partly as a consequence, to effect some uniformity in the study population. A large proportion of the inhabitants of the area, even of the rural hamlets in group C, were dependent upon mining for a livelihood. The majority of the unemployed were miners by trade. The lowest rate of persons engaged in coal mining, 30 percent in Mud Creek, coincided with the highest unemployment rate of 35 percent. Employment information was obtained during the initial visits to the camps; during this time period, mining employment was coincidentally at a low level. The opening of numbers of small truck mines in 1955 and 1956 unquestionably reduced greatly the percentage of unemployed and raised the percentage of individuals engaged in coal mining, particularly in the Mud Creek area. With these acknowledged statistical limitations, for all areas, coal mining employment averaged 67 percent, full-time agriculture 1 percent, all other employment 22 percent; about 10 percent were unemployed.

Information on annual income of the study families was not obtained directly since the question was considered sufficiently personal to encourage misleading answers and perhaps arouse resentment as well. Instead, coal operators and union officials were consulted for estimates of average income of miners in the study populations. These estimates, supplemented by information from a limited number of individuals in each study area, indicated an approximate 1956 average family income in group A of $4,800 and in groups B and C of $3,600 and $3,000, respectively. House rentals in group A averaged $25 per month and in groups B and C, $10.

The median school grades completed were 9, 8, and 7 in groups A, B, and C, respectively; medians ranged from 6 to 9 in the individual areas.

Mobility as a characteristic of study populations was found to vary greatly between areas (table 15). The greatest movement occurred in Drift, where only 62 percent of the households remained in the same house for a year or more. The least mobility was observed in Salyers Branch, where only 5 percent moved before they had stayed a year at a residence, and all of these remained in the study area. Little differences were observed in percentages of households changing residence within each population group, although variations between individual camps ranged from 5 to 29 percent. The percentage of households moving into groups A and B was greater than the percentage entering group C. Almost all people moving into the study areas during the investigations came from similar environments in eastern Kentucky. Therefore, since people moving into group A could only come from equal or poorer environments, the net effect of these shifts was a possible increase of disease rates in group A and a lowering of rates in group C.

Median family size in all study areas was 5 (table 15). The number of families with 5 or more members averaged 61 percent for all camps. As a rule, families in the rural hamlets tended to be larger than those in the mining communities. The median family size was somewhat larger in group C populations; therefore, the average number of persons per room and the level of crowding was greatest in group C, since the average size of houses did not differ greatly among the three grouped areas.

The fertility index (number of children under 5 years old for every 1,000 women aged 15–44 years) ranged from 547 in Hollows to 1,390 in Mud Creek. For group A, it was 655; for group B, 879; and for group C, 979. The fertility index for the entire study population was 772, compared with a Kentucky average of 544 (1950 United States census). The proportion of individuals under 5 years of age was 14, 17, and 19 percent in groups A, B, and C, respectively (table 3). In the A, B, and C areas 33 percent, 35 percent, and 38 percent of the population, respectively, were in the group aged 5–14 years.

The highest percentage of households with mechanical refrigerator, television set, and washing machine was in group A, and the lowest in group C (table 15).

The possible effect of racial factors upon the results of the investigations appeared to be minimal. Only 7 percent of the study populations was Negro and these lived in three camps: Wheelwright (18 percent), Hollows (5 percent), and Weeksbury (7 percent). The sex ratio for both whites and Negroes was reasonably well balanced in all camps, averaging 51 percent female.

Implications of the information presented above were that variations among the groups in such factors as family size, education, and crowding were sufficiently randomly distributed as to have no more than a moderate correlative influence upon the enteric disease indexes. Analysis of the separate factors tended to confirm this hypothesis since the individual effect of each, when considered in terms of environmental facilities, indicated a moderate degree of positive correlation with *Ascaris* and *Shigella* data, but inverse relationship with reported morbidity.

The results of this analysis prompted a three-way comparison of enteric disease indexes with family size and crowding (table 16); family size and education of the housewife (table 17); and crowding and education of the housewife (table 18).[1] Separation of the data into so many cells naturally resulted in limited numbers for many categories; thus in many instances significant comparisons between the various factors were not obtainable. Interpretation of results is complex because the factors are not mutually exclusive; however, several conclusions are possible.

[1] Numbers in tables 16–18 and 20 do not agree with numbers in tables 2, 4–8, 10, 11, and 19 due to some instances of incomplete data on environment.

Table 15. Characteristics of study populations, eastern Kentucky, 1954–56

Grouped study areas [1]	Percent employment of head of household			Median school grades completed by housewife	Percentage of households changing residence during 1 year		Median family size	Fertility index [2]	Percentage of households with—		
	Coal mining	Other	Unemployed		Within camp	From outside			Mechanical refrigerator	Television set	Washing machine
Group A:											
Wheelwright	88	12	0. 4	9	17	10	5	655	100	95	98
Group B	56	30	14	8	16	11	5	879	92	[3] 74	92
Weeksbury	73	15	12	7	20	16	5	1, 056	88	95	87
Wayland	40	44	16	8	14	12	5	837	96	90	97
Manton	68	27	5	8	5	10	4	954	100	([4])	96
Hemphill	58	26	16	7	6	6	5	745	92	([4])	95
Drift	57	29	14	8	29	9	5	833	88	45	85
Group C	51	33	16	7	15	6	6	979	75	[3] 59	86
Hollows	32	61	7	6	24	9	4	547	83	54	88
Jacks Creek	65	22	13	8	13	7	7	909	78	88	87
Slick Rock	44	31	25	8	6	0	7	1, 111	56	([4])	78
Salyers Branch	82	18	0	6	5	0	6	1, 291	86	([4])	88
Mud Creek	30	35	35	6	16	8	6	1, 390	62	32	85

[1] See footnotes to table 1.
[2] Number of children under 5 years for every 1,000 women aged 15–44 years.
[3] For camps for which information was available.
[4] Information not available.

Table 16. Comparison of enteric disease indexes, by selected sanitary facilities, family size, and crowding, eastern Kentucky, 1954–56

Sanitary facilities available	Family size	Reported diarrheal disease incidence in all ages				Prevalence of *Shigella* in preschool children				Prevalence of *Ascaris* infections in in all ages			
		Persons per room				Persons per room				Persons per room			
		Under 1.5		1.5 and over		Under 1.5		1.5 and over		Under 1.5		1.5 and over	
		PME [1]	Rate [2]	PME [1]	Rate [2]	Number of cultures	Percent positive	Number of cultures	Percent positive	Number of specimens	Percent positive	Number of specimens	Percent positive
Total		*22, 012*	*155*	*11, 949*	*109*	*2, 835*	*0. 6*	*2, 182*	*1. 7*	*660*	*4*	*300*	*15*
Flush toilet and water inside dwelling.	2–5	16, 826	175	262	137	2, 354	. 3	21	4. 8	511	3	5	0
	6–9	4, 690	99	8, 744	119	416	1. 0	1, 520	1. 1	130	8	231	12
	10 and over	496	24	2, 943	77	65	7. 7	641	3. 0	19	16	64	27
Total		*10, 769*	*225*	*4, 052*	*275*	*1, 423*	*1. 5*	*772*	*3. 9*	*462*	*22*	*203*	*32*
Privy and water inside dwelling.	2–5	5, 586	223	504	119	678	1. 3	92	3. 3	266	15	20	50
	6–9	3, 976	193	2, 898	318	449	2. 0	556	3. 8	155	28	140	26
	10 and over	1, 207	338	650	203	296	1. 4	124	4. 8	41	46	43	42
Total		*4, 578*	*249*	*6, 305*	*350*	*722*	*3. 5*	*1, 266*	*7. 1*	*220*	*34*	*313*	*45*
Privy and water outside dwelling on premises.	2–5	2, 298	250	313	460	371	2. 2	66	10. 6	114	24	27	33
	6–9	2, 090	246	4, 820	348	302	4. 3	1, 003	7. 1	96	47	228	46
	10 and over	190	252	1, 172	327	49	8. 2	197	6. 1	10	30	58	47
Total		*4, 691*	*337*	*6, 028*	*471*	*762*	*3. 8*	*1, 244*	*7. 3*	*185*	*29*	*320*	*51*
Privy and water outside dwelling off premises.	2–5	2, 711	336	673	410	389	5. 1	206	9. 2	109	29	47	38
	6–9	1, 777	378	4, 147	489	334	2. 7	823	7. 8	76	28	215	55
	10 and over	203	0	1, 208	447	39	. 0	215	3. 7	0	-------	58	48

[1] Person-months experience. [2] Rate per 1,000 per annum.

Table 17. Comparison of enteric disease indexes, by selected sanitary facilities, family size, and education of housewife, eastern Kentucky, 1954–56

Sanitary facilities available	School grades completed by housewife	Reported diarrheal disease incidence in all ages (number in family)						Prevalence of *Shigella* in preschool children (number in family)						Prevalence of *Ascaris* infections in all ages (number in family)					
		2–5		6–9		10 and over		2–5		6–9		10 and over		2–5		6–9		10 and over	
		PME [1]	Rate [2]	PME [1]	Rate [2]	PME [1]	Rate [2]	Number of cultures	Percent positive	Number of cultures	Percent positive	Number of cultures	Percent positive	Number of specimens	Percent positive	Number of specimens	Percent positive	Number of specimens	Percent positive
Total		*17,088*	*174*	*13,434*	*112*	*3,439*	*69*	*2,375*	*0.4*	*1,936*	*1.1*	*706*	*3.4*	*516*	*3*	*361*	*11*	*83*	*24*
Flush toilet and water inside dwelling.	0–6	2,694	151	3,308	116	1,120	96	284	2.5	452	2.0	271	4.4	70	4	96	22	27	44
	7–8	4,184	126	4,065	100	1,357	44	572	.0	527	1.1	217	5.1	126	6	99	10	44	18
	9 and over	9,726	206	5,932	117	962	74	1,454	.1	957	.6	218	.5	313	1	162	4	12	
	Unknown	484	99	129	186	0	-----	65	1.5	0	-----	0	-----	7	0	4	0	0	-----
Total		*6,090*	*214*	*6,874*	*246*	*1,857*	*290*	*770*	*1.6*	*1,005*	*3.0*	*420*	*2.4*	*286*	*17*	*295*	*27*	*84*	*44*
Privy and water inside dwelling.	0–6	2,156	128	3,466	228	487	468	185	4.9	476	2.3	121	2.5	100	12	149	32	18	44
	7–8	2,357	249	3,036	276	1,157	207	251	.8	480	4.0	238	2.1	119	19	126	21	54	39
	9 and over	1,544	287	343	174	213	338	328	.3	41	.0	61	3.3	67	21	20	20	12	67
	Unknown	33	0	29	0	0	-----	6	.0	8	.0	0	-----	0	-----	0	-----	0	-----
Total		*2,611*	*275*	*6,910*	*317*	*1,362*	*317*	*437*	*3.4*	*1,305*	*6.4*	*246*	*6.5*	*141*	*26*	*324*	*46*	*68*	*44*
Privy and water outside dwelling on premises.	0–6	1,587	340	4,068	330	993	410	208	4.3	721	7.8	196	5.1	93	31	160	52	54	43
	7–8	620	135	2,317	300	219	0	158	3.2	507	4.9	13	15.4	38	16	129	40	4	100
	9 and over	326	294	214	560	150	160	57	1.8	45	.0	37	10.8	7	14	18	22	10	30
	Unknown	78	0	311	115	0	-----	14	.0	32	9.4	0	-----	3	0	17	71	0	-----
Total		*3,384*	*351*	*5,924*	*455*	*1,411*	*382*	*595*	*6.6*	*1,157*	*6.3*	*254*	*3.1*	*156*	*32*	*291*	*48*	*58*	*48*
Privy and water outside dwelling off premises.	0–6	2,088	333	4,129	465	755	445	394	7.6	754	6.0	123	4.1	105	31	195	49	44	43
	7–8	907	423	1,417	465	568	338	118	5.9	311	8.7	106	2.8	23	43	85	51	14	64
	9 and over	371	258	378	317	0	-----	78	2.6	92	1.1	0	-----	23	26	11	9	0	-----
	Unknown	18	666	0	-----	88	136	5	.0	0	-----	25	.0	5	20	0	-----	0	-----

[1] Person-months experience. [2] Rate per 1,000 per annum.

Table 18. Comparison of enteric disease indexes, by selected sanitary facilities, crowding, and education of housewife, eastern Kentucky, 1954–56

Sanitary facilities available	School grades completed by housewife	Reported diarrheal disease incidence in all ages				Prevalence of *Shigella* in preschool children				Prevalence of *Ascaris* infections in all ages			
		Persons per room				Persons per room				Persons per room			
		Under 1.5		1.5 and over		Under 1.5		1.5 and over		Under 1.5		1.5 and over	
		PME [1]	Rate [2]	PME [1]	Rate [2]	Number of cultures	Percent positive	Number of cultures	Percent positive	Number of specimens	Percent positive	Number of specimens	Percent positive
Total		*22,012*	*155*	*11,949*	*109*	*2,835*	*0.6*	*2,182*	*1.7*	*660*	*4*	*300*	*15*
Flush toilet and water inside dwelling.	0–6	4,187	143	2,935	102	503	2.0	504	3.6	124	7	69	39
	7–8	5,999	100	3,607	109	721	.8	595	1.8	170	7	99	13
	9 and over	11,334	192	5,286	111	1,548	.1	1,081	.6	359	1	128	4
	Unknown	492	97	121	198	63	.0	2	50.0	7	0	4	0
Total		*10,769*	*225*	*4,052*	*275*	*1,423*	*1.5*	*772*	*3.9*	*462*	*22*	*203*	*32*
Privy and water inside dwelling.	0–6	4,017	218	2,092	200	437	3.4	345	2.3	169	20	98	36
	7–8	4,724	213	1,826	361	573	.7	396	5.6	200	22	99	28
	9 and over	1,999	270	101	356	405	.7	25	.0	93	27	6	17
	Unknown	29	0	33	0	8	.0	6	.0	0	--------	0	--------
Total		*4,578*	*249*	*6,305*	*350*	*722*	*3.5*	*1,266*	*7.1*	*220*	*34*	*313*	*45*
Privy and water outside dwelling on premises.	0–6	2,397	285	4,251	378	297	2.7	828	8.1	108	41	199	46
	7–8	1,286	233	1,870	256	279	3.2	399	5.8	70	19	101	48
	9 and over	506	237	184	652	100	5.0	39	.0	22	27	13	15
	Unknown	389	92	0	--------	46	6.5	0	--------	20	60	0	--------
Total		*4,691*	*337*	*6,028*	*471*	*762*	*3.8*	*1,244*	*7.3*	*185*	*29*	*320*	*51*
Privy and water outside dwelling off premises.	0–6	2,908	309	4,064	504	443	3.6	828	7.7	113	28	231	50
	7–8	1,034	452	1,858	413	149	6.7	386	7.0	37	38	85	56
	9 and over	734	277	15	800	165	1.8	5	.0	33	21	1	0
	Unknown	15	800	91	131	5	.0	25	.0	2	0	3	33

[1] Person-months experience. [2] Rate per 1,000 per annum.

Approximately one-third of the people providing enteric disease data resided under optimum conditions of environment; that is, they had water and flush toilets inside the house, minimum crowding, and higher levels of education as contrasted with occupants of premises having water outside the house. More than 55 percent of the inhabitants of the more poorly sanitated areas had water outside the dwelling unit, had larger families, were more crowded, and were less well educated.

Data in table 16 show that, for occupants of dwellings having person-per-room ratios greater than 1.5, *Shigella* and *Ascaris* rates were about two or more times as high as those rates for individuals living under less crowded conditions. These differences in infection rates were almost as great as rates according to types of sanitary facilities compared under identical conditions of crowding. Inverse relationships between crowding and reported diarrheal experience were observed in the well-sanitated areas. The effect of family size was not apparent except insofar as it resulted in greater crowding.

The effects of family size and educational differences are shown in table 17. Prevalence of *Shigella* and *Ascaris* infections in general varied inversely with educational level. Although the data are limited, there was some indication that larger family size increased the infection rates observed. It is apparent from the data that persons in higher educational levels tended to report more diarrhea than those in lower educational levels.

Data in table 18, comparing indexes of disease by differences in education and crowding, reflect generally higher rates of diarrheal disease and *Shigella* and *Ascaris* prevalence wherever conditions of crowding are greater, and also where the educational level is low. Again, the incidence of enteric disease was primarily affected by availability of water and sanitary facilities.

It was concluded from the comparisons in tables 16, 17, and 18 that the combination of increased crowding, large families, and low educational levels tend to increase the prevalence of diarrheal disease. It was concluded further, however, that in the perpetuation of enteric disease the combined effects of these factors are not as significant as the effects of inadequate sanitary facilities.

Discussion

Efforts have been made previously to estimate the effect of a single or of a limited number of environmental factors on the occurrence of diarrheal diseases. Investigations by Watt and Lindsay (*12*) in Texas and by Lindsay and associates (*7*) in Georgia demonstrated that effective fly control in communities with high to moderate fly populations reduced the prevalence of diarrheal disease and *Shigella* infections. Investigations among prisoners of war in Korea during the fall of 1951 by Schliessmann showed that prevalence of diarrheal diseases decreased with increased quantity of water available to prisoners for bathing. Watt and associates, in studies of migratory workers in California, suggested that use of water as a diluent might reduce the prevalence of shigellosis (*13*). Subsequent investigations of similar situations by Hollister and coworkers indicated that *Shigella* prevalence was associated with availability of water for personal hygiene (*14*). Similar observations were made in southern Georgia by Stewart and others, who indicated that not only the potability of water but also its availability for personal hygiene must be considered in any diarrheal disease control program (*2*). The studies reported in this monograph were an extension of these investigations and were designed to provide statistically reliable information on a number of measurable environmental factors which might affect the incidence of diarrheal disease.

Sanitary Facilities

The lowest rates of reported diarreal disease, *Shigella*-positive cultures, and *Ascaris*-positive stools were from the area in group A where all residents were provided with complete community sanitary facilities. Group B areas were served by some but not all public sanitary services, and rates of all three enteric diseases indexes were higher. Highest rates were observed in group C study populations, where community sanitary facilities were entirely lacking (table 19). Reported diarrheal disease rates in group B populations were about twice as great, and in group C populations, about three times as great, as those in group A. *Shigella*-positive culture rates were approximately 5 and 9 times as large in groups B and C, respectively, as in group A. *Ascaris*-positive stool rates in group B were 4 times as great, and in group C, for ages 2–12 and all ages, 5 and 6 times as great, respectively, as in group A.

The effect of several specific sanitary facilities upon occurrence of enteric disease, as measured by rates of reported disease and *Shigella* and *Ascaris* prevalence, was both marked and consistent. People provided with water piped inside the house and with privy excreta disposal reported approximately twice the incidence of disease, had twice the prevalence of *Shigella* infections, and over three times the *Ascaris* infection rate of individuals who not only had access to water inside the dwelling unit but also had flush toilets (table 20 and fig. 6). Reported incidence of diarrhea and *Shigella* and *Ascaris* infection rates for individuals who used privies but who had water piped inside their dwellings were compared with the same rates for persons who used privies but whose source of water was outside the house. Rates of reported morbidity and *Ascaris* infection were approximately one-third lower among persons having access to water inside their dwellings than among persons whose source of water was outside the house. In addition, the *Shigella* infection rate in preschool children having access to water inside their dwellings was approximately 50 percent less than rates among children whose source of

Table 19. Reported diarrheal disease morbidity rates, *Shigella* infections in preschool children, and percentage of population infected with *Ascaris*, by area, eastern Kentucky, 1954–56

Grouped study areas [1]	Morbidity rate				*Shigella* prevalence		*Ascaris* prevalence			
	0–4 years		All ages				2–12 years		All ages	
	PME [2]	Rate [3]	PME [2]	Rate [3]	Number of cultures	Percent positive	Number of specimens	Percent positive	Number of specimens	Percent positive
All areas	11, 210	754	70, 826	227	11, 264	3. 1	1, 413	40	2, 798	26
Group A:										
Wheelwright	4, 038	413	27, 511	135	4, 074	0. 7	377	12	765	7
Group B	4, 692	744	27, 969	251	4, 698	3. 5	606	43	1, 197	26
Weeksbury	1, 660	737	9, 165	272	1, 735	3. 6	173	44	310	31
Wayland	1, 802	779	11, 652	247	1, 828	3. 4	199	45	433	26
Manton	184	847	894	308	162	3. 1	35	40	57	26
Hemphill	300	680	2, 169	204	297	2. 0	90	43	195	23
Drift	746	675	4, 089	228	676	4. 3	109	35	202	24
Group C	2, 480	1, 330	15, 346	349	2, 492	6. 4	430	60	836	42
Hollows	594	1, 171	4, 767	317	644	2. 6	71	52	150	29
Jacks Creek	808	1, 262	4, 963	316	801	8. 1	129	60	255	44
Slick Rock	190	1, 010	1, 069	381	230	6. 1	45	60	100	37
Salyers Branch	252	666	1, 311	137	236	10. 2	50	46	82	35
Mud Creek	636	1, 924	3, 236	522	581	6. 9	135	70	249	50

[1] See footnotes to table 1. [2] Person-months experience. [3] Rate per 1,000 per annum.

Table 20. **Reported diarrheal disease morbidity rates, *Shigella* infections in preschool children, and *Ascaris* infections according to selected sanitary facilities, eastern Kentucky, 1954–56**

Sanitary facilities	Morbidity rate				*Shigella* prevalence		*Ascaris* prevalence			
	0–4 years		All ages		Number of cultures	Percent positive	2–12 years		All ages	
	PME[1]	Rate[2]	PME[1]	Rate[2]			Number of specimens	Percent positive	Number of specimens	Percent positive
Total	11, 121	756	70, 384	228	11, 206	3. 0	1, 334	39	2, 663	25
Water inside dwelling:										
Flush toilet	5, 040	428	33, 961	139	5, 017	1. 1	458	12	960	7
Privy	2, 200	829	14, 821	238	2, 195	2. 4	313	42	665	25
Water outside dwelling:										
On premise	1, 900	953	10, 883	307	1, 988	5. 8	290	58	533	41
Off premise	1, 981	1, 320	10, 719	413	2, 006	6. 0	273	62	505	43

[1] Person-months experience. [2] Rate per 1,000 per annum.

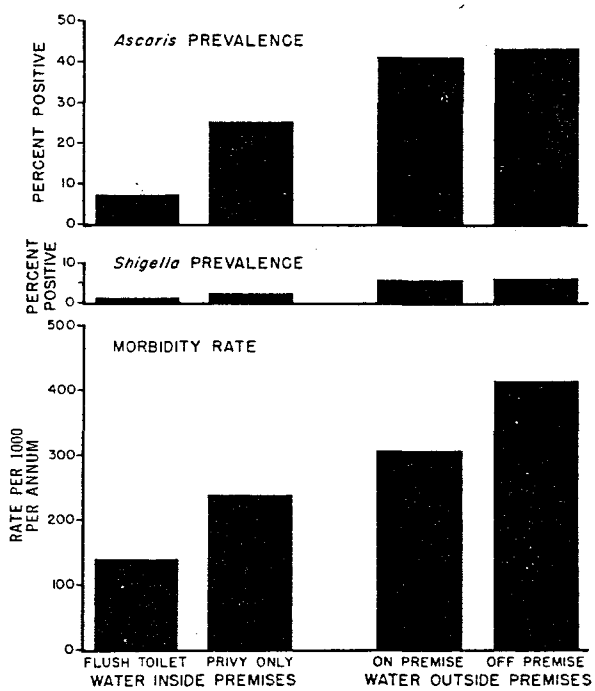
water was outside their dwellings. Where water was not piped inside the house, reported morbidity rates among individuals who had water available on the premises were approximately 30 percent lower than for those who had to obtain water from a distant source; rates of *Shigella* prevalence and *Ascaris* infection evidently were not affected by this variable.

Limited data indicated *Shigella* and *Ascaris* prevalence rates to be about 2 and 3 times lower, respectively, among occupants of dwellings with installed bath fixtures, than the same rates for individuals not having access to installed tub or shower but otherwise provided with similar facilities. There were also indications that where hot water was available to families, *Shigella* and *Ascaris* rates were lower than where there was access to cold water only, all other factors remaining constant.

Flies

Comparison of seasonal housefly abundance (table 12) with seasonal incidence of reported diarrheal disease morbidity (fig. 2) reveals a superficial correlation between the two sets of data. Discrepancies are evident, in that the highest morbidity rates were obtained in August 1955 and August 1956 while periods of highest *Musca* prevalence were September 1955 and early October 1956. Moderate peaks of diarrhea prevalence in March 1955 and April

Figure 6. Diarrheal disease morbidity rates: *Shigella* infections in preschool children and percentage of study population infected with *Ascaris*, according to selected sanitary facilities, eastern Kentucky, 1954–56.



1956 occurred during periods when adult houseflies were absent, or nearly so. There is even less agreement between seasonal housefly abundance and the *Shigella*-positive culture rates shown in figure 2. The fall of 1954, which was a period of comparatively high fly populations, was evidently a period of low *Shigella* prevalence; the September *Shigella* rate, in particular, failed to correspond with the peak of housefly abundance. In 1955 and 1956, *Shigella* rates remained at a comparatively high level throughout the winter, whereas fly populations definitely did not.

Studies in Texas (*12*) and Georgia (*7*) showed that reduction in incidence of diarrheal disease was accomplished by fly control. The standard measure of effective fly control was a Scudder grill count average of 10 houseflies or less. This standard has been employed in evaluating effectiveness of chemical insecticides for the control of flies. Housefly populations in the present study, in general, were below the level established as a standard of fly control in the earlier studies mentioned. It appears that these vectors did not contribute appreciably to the transmission of diarrheal disease in eastern Kentucky during the period of observations.

Water

The Wheelwright water system (group A) was the only public supply in the study areas which consistently produced water of good drinking quality during the period of observation. It does not appear likely that the Wheelwright public water supply was involved in the transmission of *Shigella* or of other enteric bacteria during the period of observation.

Examinations of the Wayland city water system revealed frequently inadequate purification, and other water sources in group B study areas generally provided water subject to frequent bacterial contamination, in contrast to the heavily chlorinated water in group A. Group C water sources, open dug wells for the most part, were the most consistently and heavily polluted of all. Transmission of enteric pathogens by water in the B and C study populations could have occurred easily. There was, however, nothing in the results of the water examinations which we could relate to any outbreak of disease, to *Shigella* prevalence, or to the morbidity rates reported within the study areas. Therefore, the apparent correlations between water quality and *Shigella*, *Ascaris*, and reported morbidity rates were not considered to be an expression of causal relationship.

Socioeconomic Factors

Despite efforts to minimize inclusion of socioeconomic variables by a careful selection of study areas, quantitative social and economic differences were shown to exist between the observed population groups. During the course of the study, employment in mining operations and wages were comparatively high. The minimum wage of miners established in September 1956 was $21.16 per day. While monetary incomes by groups varied directly with level of sanitation, incomes of the more poorly sanitated groups were supplemented frequently by agricultural activities and were compensated further by low rental costs. The high percentage of households having television sets (group A, 95 percent; B, 74 percent; and C, 59 percent) which, in this fringe reception area necessitates extensive aerial installations and boosters and cables from the mountains, attests to the fact that the population groups had sufficient income over and above the minimum required for survival. These data strongly suggest that economic factors did not account for the diversity in incidence of enteric disease in the different study groups.

The effect of low level of education of the housewife, as well as the interrelated effects of large families and increased crowding, all were shown to accompany increased prevalence of *Shigella* and *Ascaris* infections. Similar relationships with reported illness were not as apparent. The housewife customarily assumes the responsibility for household cleanliness and the personal hygiene habits of the children, and the level of her educational background was considered to be a measure of the adequacy of hygiene practices in the home. Families in which the housewife had a higher educational level, however, tended to create bias in reporting. These families were smaller on the average, so that complaints of individual family members might be expected to receive more attention. Also, the housewives with a higher educational level apparently were more concerned about illness within the family than were those with less education. These factors may have contributed to the remembering and reporting of more diarrheal episodes of milder character.

Etiological Agents

Since it was not possible to obtain clinical appraisals or multiple fecal specimens from acute diarrheal cases reported to the public health nurses during their monthly visits, definitive information on etiology was not obtained. However, data gathered from monthly culturing of preschool children and from periodic stool examinations permit the drawing of presumptive conclusions. The low *Salmonella* infection rates in the study populations suggest that this genus did not contribute appreciably to the morbidity experienced in any of the areas. Likewise, data obtained during a 6-month survey of 4 enteropathogenic *Escherichia coli* serotypes (026:B6; 055:B5; 0111:B4; and 0127:B8) revealed a low prevalence of all types and suggested their comparative unimportance as a cause of morbidity in the study populations.

Age-specific prevalences of *Shigella* infection in group B and C populations were comparable to those reported in Texas in 1946 and in New Mexico in 1938 and 1948 (*13*). In the Texas and New Mexico studies, it was shown that prevalence of *Shigella* infection was related directly to diarrheal disease morbidity and mortality, and that bacillary dysentery caused the majority of illnesses and deaths due to diarrheal disease. Therefore, as in studies in migratory labor camps in California (*13*), it was concluded that shigellae were the primary cause of acute diarrheal disease in groups B and C of the present study.

The low *Shigella* isolation rate observed in the well-sanitated group A area indicated that bacillary dysentery was not a primary cause of acute diarrheal disease in that area, in contrast with findings in group B and C populations. In the absence of clinical appraisal of diarrheal illnesses in group A, it was not possible to determine whether the primary cause of the cases reported was an infectious agent, a dietary manifestation, an allergic response of some nature, or a combination of these. It is apparent, however, that factors which contribute to a low rate of *Shigella* in well-sanitated areas result in a reduction of other enteric infections and diarrheal disease morbidity in such areas.

Infection rates of *E. histolytica* were low in the entire study area, and no frank cases of amebiasis were known to have occurred during the period of investigation. High prevalences of certain helminth species were noted and a number of observations of relationships between helminths and disease were made. Local physicians expressed concern over infections of *Ascaris* and *Strongyloides*, as well as over the presence of large numbers of *Trichuris*, particularly among persons less than 3 years of age. Also, heavy ascarid and similar infections in young adult females and mothers of small children were considered to constitute an important hazard for family health and especially for the well-being of younger members of the family. However, appreciable evidence was obtained which indicated that the majority of helminthic infections did not cause manifest disease.

To study rates at which reinfections with *Ascaris* took place, a semiannual program of treatment for ascariasis was instituted. A single dose of piperazine citrate alone was found to be effective in almost 3 of every 4 cases treated. A major portion of the study on treatment has been reported by Atchley and associates (*15*). Instances in which the single dosage was not completely effective, according to post-treatment fecal examinations, were observed to occur with greatest frequency in heavily infected individuals. Study areas with highest ascarid prevalences showed the greatest rates of reinfection when examinations were conducted some 6 months later. Tendencies to become reinfected were least among adults, but 80 percent of those children who had been cured were positive again when examined during the following year. Of the nearly 500 persons of all ages participating throughout the entire investigation of treatment and reinfection over a period of a year and a half, approximately 80 percent of the adults and 40 percent of the children were never observed to harbor *Ascaris*. A majority of these negative individuals resided in the well-sanitated area. While the promotional and temporary therapeutic values of single-dose treatments were well established, this measure requires implementation by additional public health procedures to give lasting improvement within a limited time.

Applicability of Enteric Disease Indexes

The validity of morbidity rates obtained from data of reported diarrheal disease episodes unsupported by bacteriological examinations as a measurement for elucidating differences in prevalence of diarrheal disease between population groups has been questioned frequently. In this investigation, reported diarrheal disease morbidity rates, *Shigella* or *Ascaris* infection rates, and the results of an environmental survey all were found to be satisfactory indexes for describing the relative differences in the enteric disease problem between study populations.

Although variations in reporting were observed between study groups, results of the investigation indicate that reported diarrheal disease morbidity may serve in many situations as a single index of enteric disease prevalence. Reliability of this index in differentiating differences in the diarrheal disease problem between population groups will be dependent upon several factors. Therefore, consistency in the routine of questioning respondents is essential, and questions should be explicit, easily understood, and free of bias. In addition to information on age of patient, date of onset, and data on duration of illness, number of stools per day, and whether the individual was compelled to defecate at night will aid in establishing the degree of severity of the episode. The significance of reported diarrheal episodes of 1-day duration, or of three or less stools, or both is not known. Accuracy of reporting frequency of stools beyond 6 stools a day was poor in this study; probably the highest category used for recording frequency should be 6 or more stools. Analysis of the data to establish a definition of diarrhea based on criteria of significant severity will assist in comparing morbidity rates between population groups by eliminating many mild diarrheal episodes reported by individuals in higher socioeconomic levels.

Reliability of the *Shigella* infection rate as an index of enteric disease prevalence and of environmental hygiene has been well established. In the region selected for the present study, helminthic parasite rates were high, and *Ascaris* infection rates were shown to be at least as suitable an index as *Shigella*. Ascarid infections usually persist for about 1 year, and transmission of infection is directly dependent upon improper methods of excreta disposal as well as on deficiencies of personal hygiene. Other intestinal helminth species showed rate trends paralleling that for *Ascaris*, but were less satisfactory indexes either because of their mode of transmission or because of a tendency to persist in the host for relatively long periods. The latter characteristic would necessarily complicate evaluations of the effectiveness of a particular sanitary improvement because of the need for prolonged observations.

The relative opportunities for dissemination of enteric organisms and the subsequent risk of a population exposed to diarrheal disease can be predicted on the basis of an environmental survey. The extensiveness of the survey to designate portions of a community where enteric diseases are probably most prevalent will depend on the purposes for which the information will be utilized. The populations subject to the greatest risk of contracting diarrheal disease can be determined in a few days by a rapid reconnaissance of water sources, excreta disposal practices, and general esthetic conditions of housing, yards, and neighborhood. Such economically and rapidly obtained information would be of aid in planning work and scheduling activities of local public health nurses and sanitarians. If more extensive programs are planned, or if it should prove desirable to evaluate effectiveness of the local health department program, a more detailed survey would be required.

Application of Findings

The importance of such socioeconomic factors as income, family size, education, and crowding has been recognized, but in this study their effect on the incidence of disease was secondary to the effect of the presence or absence of sanitary facilities. Diarrheal diseases are not a specific entity and may result from a number of causes, not all of which are fecally transmitted. However, the observed close correlation of reported diarrhea and such parameters as *Shigella* and *Ascaris* infections with various levels of environmental sanitation provides presumptive evidence that the majority of infectious diarrheal diseases have similar routes of transmission. It is axiomatic, therefore, that since sanitary facilities tend to improve personal hygiene, provision of such facilities will result in decreased incidence of infectious enteric disease.

The results of this study strongly support the premise that incidence of acute infectious diarrheal disease may be reduced significantly through selective modification of specific environmental factors within communities without regard to etiological or sociologic differences. Variation in the degree to which reductions in disease incidence can be attained through these modifications may well vary between population groups because of regional differences in living habits, etiological agents, and fly abundance, and in milk and food control sanitation practices. However, preventive measures may be formulated with confidence that specific environmental improvements, based on a knowledge of local deficiencies, will invariably effect significant reductions in enteric disease.

Summary

Studies of the relation of environmental factors to the occurrence of enteric diseases were conducted in 11 mining camps in the eastern coalfield region of Kentucky from June 1954 through June 1957 by the Cumberland Field Station, a field unit of the Communicable Disease Center, Public Health Service. The objective of the investigations was to provide basic information for development of specific control measures by: (*a*) determining seasonal and annual incidence of diarrheal disease among human populations of areas differing from one another in one or more measurable characteristics of environmental sanitation; (*b*) identifying causative agents of diarrheal disease in the different areas; and (*c*) evaluating levels of sanitation in the households and communities studied.

Reported diarrheal disease morbidity rates for all ages in 7 study populations for which a full year of comparative data was available ranged from 94 to 536 per 1,000 persons per annum. The average rate for the 7 study populations was 213. More than half the total cases were reported from the group aged 0–4 years, and within this group the majority of illnesses were reported from children under 2 years of age. Marked seasonal trends were observed, the highest incidence occurring during August and September. The ratio of "summer" diarrhea to "winter" diarrhea for the years 1955 and 1956 was approximately 2 to 1. Diarrheal disease incidence increased earlier in the spring and persisted at a high level later in the fall in the areas with poorer sanitation. The modal frequency of reported stools per 24-hour period was 5, and the median 6. Average duration of illness was 4 days. Severe diarrhea was reported more frequently from the poorly sanitated areas.

Shigella isolation rates obtained by rectal swabbing of preschool children ranged between 0.7 percent and 10 percent by individual study areas. The highest rates for all study populations combined occurred in the 4-year age group; in the most poorly sanitated areas, children were found to be infected at an early age, and the highest prevalence was in the 2-year age group. *Shigella* was isolated from 354 rectal swab cultures of the 11,264 collected.

Eight biotypes were found, with *Shigella dysenteriae* making up 4 percent; *S. sonnei*, 20 percent; and 6 biotypes of *Shigella flexneri*, 76 percent. Of the *flexneri* group, the most common isolate was the Manchester variety, which made up 42 percent of all positive cultures. Bacillary dysentery (shigellosis) probably was responsible for the majority of acute diarrheal disease experiences observed in poorly sanitated areas, but was not a primary cause in the most well-sanitated area.

There were only 25 *Salmonella* isolations from all 11,264 rectal swab cultures collected. Thirteen isolations of enteropathogenic *Escherichia coli* were obtained from a series of 1,000 rectal swab specimens collected from preschool children and examined for 026:B6, 055:B5, 0111:B4, and 0127:B8 serotypes. Salmonellae and the enteropathogenic *E. coli* evidently did not contribute substantially to enteric disease morbidity reported in the study areas.

Of 2,798 individuals of all ages examined, 1 of every 4 had stools positive for *Ascaris lumbricoides*. In the 1,413 of these individuals aged 2–12 years, *Ascaris*-positive rates ranged from 12 to 70 percent. Rates of *Trichuris trichiura* approximated those of roundworm, although the whipworm infections, as judged by egg counts, were almost invariably much lighter. *Strongyloides* and *Hymenolepis* infections were recorded occasionally. Hookworm infections were rare. Among 843 stool specimens examined for intestinal protozoa, *Entamoeba histolytica* was found in 3.3 percent and *Giardia lamblia* in 9.5 percent.

In previous investigations, when a reduction of diarrheal disease was obtained by control of flies, an average grill count of 10 or less was considered effective fly control. In this study, average grill counts were generally well under 10. Also, housefly abundance was not significantly correlated with morbidity or *Shigella* prevalence in the present investigation.

Transmission of enteric pathogens by polluted water could have occurred easily. Many water sources in use by the study populations were subject to possible fecal contamination and may have been responsible for some cases of diarrheal disease. There were, however, no instances in which water quality could be implicated in disease outbreaks or correlated with seasonal differences in morbidity rates or *Shigella* prevalence.

Lowest rates of reported diarrheal disease, *Shigella*-positive cultures, and *Ascaris*-positive stools were recorded among study families served by complete community sanitary facilities. Markedly higher rates of these enteric disease indexes were experienced by households served by some but not all public sanitary services, and the highest levels of the three indexes were reported from populations living where community sanitary facilities were entirely lacking. Individuals living in homes provided with inside piped water and privy excreta disposal reported approximately twice the diarrhea, had twice the *Shigella* prevalence, and over three times the *Ascaris* infection rate experienced by individuals using inside piped water and flush toilets.

For the population groups using privies, *Ascaris* infection rates and reported morbidity rates were one-third lower, and *Shigella* infections were 50 percent fewer, among those who had water inside the house than among those whose water source was outside. Where water was not piped inside the house, persons having access to water on the premises reported a third less diarrhea than individuals obtaining water away from the premises. Where the water source was outside the dwelling unit, *Shigella* and *Ascaris* infection rates were comparable regardless of water source location in relation to the premises.

Limited data were available concerning the influence of bathing facilities; there were trends, however, to indicate that lower rates of *Shigella* and *Ascaris* infection accompanied the existence of installed bathing fixtures. Desirability of installed hot water systems was also indicated.

Of the many socioeconomic factors analyzed for their possible influence upon enteric disease rates, only crowding, family size, and education of the housewife appeared to affect the enteric disease indexes studied. The combined effect of these factors on diarrheal disease was not, however, as great as the effect of adequate sanitary facilities.

The results of this study strongly support the premise that incidence of acute infectious diarrheal disease may be reduced significantly through selective modification of specific environmental factors within communities without regard to etiological or sociologic differences. It is concluded that specific environmental improvements, based on a knowledge of local deficiencies, will invariably effect significant reduction in enteric disease.

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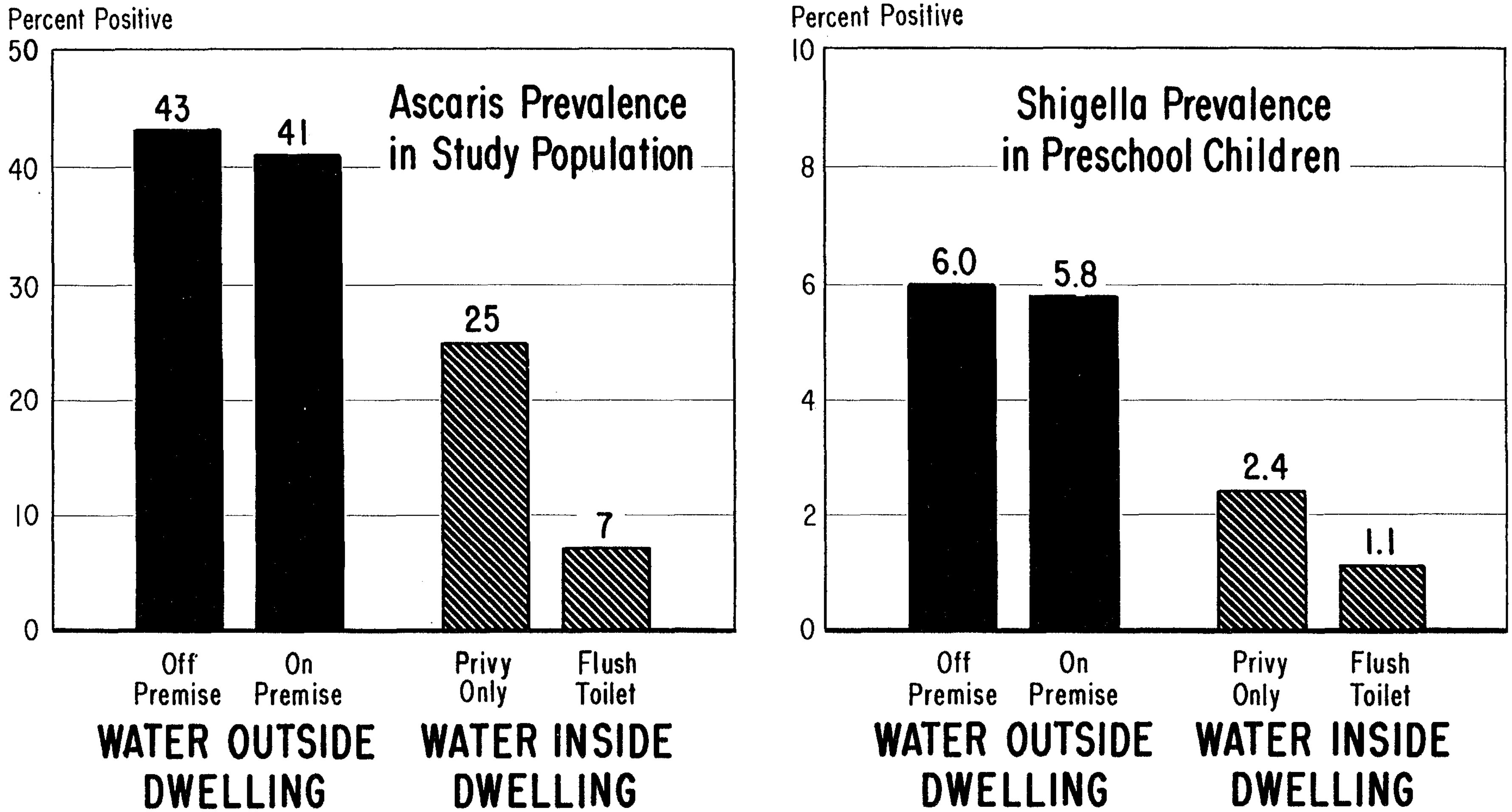
RELATIONSHIP OF ENVIRONMENTAL FACTORS TO ENTERIC DISEASE

ASCARIS AND SHIGELLA INFECTIONS ACCORDING TO SELECTED SANITARY FACILITIES

Eastern Kentucky, 1954-1956



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