Study of Intestinal Helminth Infections in a Coastal South Carolina Area

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BECAUSE of a situation that suggested extraordinarily heavy infection of certain groups with *Ascaris lumbricoides* and *Trichuris trichiura*, an investigation was initiated on the prevalence and possible control of infections in the Bluffton (Beaufort County) area of South Carolina. This is a coastal area, separated from the ocean by the sea islands. No large centers of population were included; the village of Bluffton has a population of approximately 500, and the groups with which we were concerned lived in the surrounding rural areas.

The climate in this area is mild year round with a mean temperature of about 65° F. During the summer months (June through September) the mean temperatures are about 75° to 80° F. The lowest mean temperature of about 50° F. occurs during January. Minimum temperatures were below 32° F. on only 37 days during the winter prior to the survey period, and the lowest temperature recorded was 20° F. The annual rainfall averages around 45 inches and was about 55 inches in 1961. The approximate mean total rainfall for each of the summer months ranges from 4 to 6 inches. The area is mostly cutover timberland, with varying growths of pine, oak, and assorted hardwood. The terrain is flat, with a soil made up mostly of fine coastal sand. The records for Charleston, S.C., some 50 miles to the northeast, show that 4-inch soil temperatures during the summer months of 1960 averaged from 84° to 86° F., with maximum extremes of about 100° to 102° F.; maximum and minimum temperatures of 104° and 33° F. were reported for 1960.

Humidity is generally high. No local records were available, but those for Charleston show the mean summer maximum and minimum to be 94 and 59 percent.

The population was all Negro except for one white family. Housing ranged from the dilapidated, unpainted one- or two-room shack to the painted, multiroomed "shell" house (see photographs), now so common in the southern States. The latter were in the majority. Regardless of the quality of the house, absence of sanitary facilities of any kind was the general rule. Only four of the houses in the study had inside, flush toilets; a few others had outside privies, usually in bad repair, and there was some question as to whether these were used for their designated purpose.

Most of the families were large. The adults were employed in the local seafood industries, as laborers on nearby "plantations," or as domestic help. Their living was mainly on a cash-income basis; practically none of the families

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raised any of their own food. A few were engaged in small-scale cash crop farming.

The health of the people appeared in general to be good. Their diet did not seem to vary from that seen in similar populations in the southern States, except for the inclusion of large amounts of local seafoods—fish, bivalves, and crustaceans—which made the diet extraordinarily high in protein. The area is served by a unit of the Beaufort County Health Department with a resident nurse in charge. A county clinician from nearby makes regular visits to the unit for prenatal and other clinics and is on call for other purposes. One private physician maintains a practice in the area.

The study was designed first to determine the extent of the parasite problem and second to treat persons with significant infections.

Methods

The study was done in two population groups. The first consisted of residents along one particular road for a distance of about 1½ miles. All families in 22 households were included, a total of 128 persons. The second group consisted of 91 persons in 11 households in an area about 2 miles distant from the first. These were the residents along two adjoining roads for a total distance of approximately 2 miles. In this second group there was some selection of households. Several households of elderly adults who were reluctant to cooperate were not included, and a household about a mile away and closer to town was included at the request of the resident county health nurse.

Table 1. Percent infected with intestinal parasites in two population groups, Bluffton, S.C.

Parasite	Group 1 (N=125)	Group 2 (N=87)	Total (N=212)
Protozoa			
One or more species	45. 6	42. 5	44. 3
Entamoeba histolytica	1. 6	1. 1	1. 4
Entamoeba coli	36. 0	26. 4	32. 1
Endolimax nana	9. 6	10. 3	9. 9
Iodamoeba butschlii	0	1. 1	. 5
Trichomonas hominis	0	1. 1	. 5
Chilomastix mesnili	1. 6	1. 1	1. 4
Giardia lamblia	5. 6	10. 3	7. 5
Helminths			
One or more species	65. 6	78. 2	70. 8
Ascaris lumbricoides	58. 4	71. 3	63. 7
Trichuris trichiura	32. 8	43. 7	37. 3
Hookworm	2. 4	5. 7	3. 8

The second group contained a higher proportion of children than the first: this was evident in the higher average number of persons per household (8.3 compared with 5.8). The two groups appeared to be similar in housing, economic conditions, and other characteristics. The procedures were identical in the two groups, and most of the observations on both groups are consolidated in the results.

Half-pint cups were provided and fecal specimens were collected once a week. At least two specimens were desired from each individual, but a few were uncooperative and provided only a single specimen or none at all. Specimens were collected within about 6 hours after passage and examinations initiated about 20 hours later. Specimens were refrigerated during this latter period.

Examinations consisted of direct saline smears and a modified zinc sulfate centrifugal flotation. A Stoll egg count was done on each specimen adequate in quantity and exhibiting helminth ova.

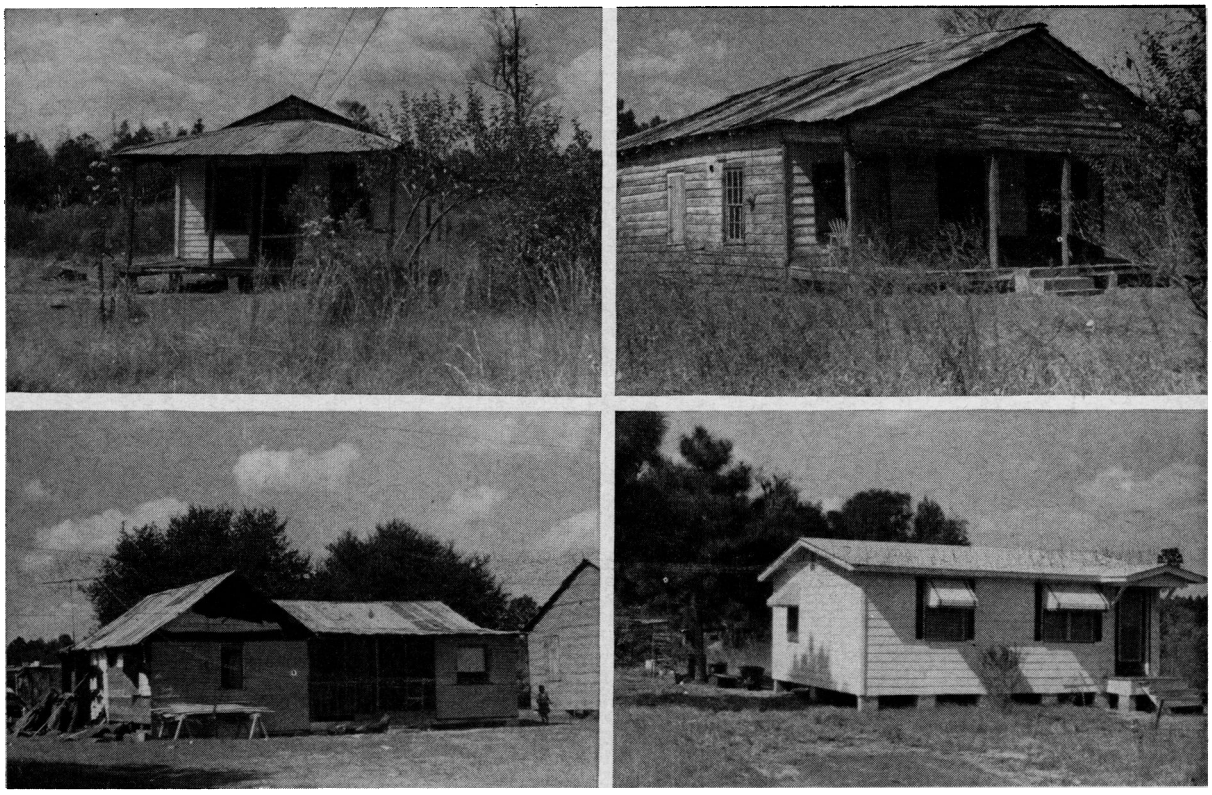
Blood studies were done on as many persons as possible in both groups. The studies consisted of white cell counts, red cell counts, hemoglobin determinations, hematocrit determinations, and differential white counts.

Treatment consisted of single doses of piperazine (*A*), either as liquid or incorporated in chocolate cubes, in gram equivalents of the hexahydrate as follows: 0–5 years of age, 3 grams; 6–15 years, 4 grams; 16 years and over, 5 grams. Post-treatment evaluations were identical to pretreatment evaluations and were done during the period of 1 to 3 weeks after treatment.

Intestinal protozoa were reported when seen on the saline smear or the zinc sulfate flotation.

Results

Prevalence of infection. Table 1 summarizes the results of the examinations for helminth



Typical housing of population under study. *Top left:* Small, two-room house of local construction in poor repair. *Top right:* Larger house, unpainted and in poor repair. *Bottom left:* Larger house, locally constructed and in fairly good repair, with improvements underway. *Bottom right:* Typical smaller "shell" house, fairly new and still in good repair.

parasites in the two population groups. The proportion of persons with *A. lumbricoides* and *T. trichiura* infections in group 2 was somewhat higher than in group 1; there was also a higher proportion of persons in the younger ages in this group. About one-half of group 1 were 18 years of age or older, compared with only one-third in group 2. The overall rate of infection with *A. lumbricoides*, 64 percent, was considerably higher than was expected. The 37 percent infection with *T. trichiura*, although somewhat closer to an expected level, could also be considered a high rate of prevalence for such a population.

Hookworm infection was confined to 3 of the 33 households. Two members, aged 13 and 16 years, of a relatively small family of five had fairly intense hookworm infection. This family had moved to the area not many years previously, and it is possible that the hookworm infection may have been acquired elsewhere. In another household, a 19-year-old male was slightly infected with hookworm. None of the other 17 members of the household had hookworm infection, but nearly all were heavily infected with *T. trichiura* and *A. lumbricoides*. The house had no sanitary facilities. The third household with hookworm infection had 11 members, 4 of whom (aged 6, 7, 13, and 15 years) were infected with very low numbers of worms. There was a privy near this house, but it did not seem to be frequently used. The family had resided at this same location for many years, and it seemed certain that the hookworm transmission had occurred there.

No infections with *Strongyloides stercoralis*, *Enterobius vermicularis*, or tapeworms were found during the study.

From the distribution of *T. trichiura* and *A. lumbricoides* infections according to age (table 2), it is immediately apparent that the higher prevalence is associated with the younger age

groups, although the youngest age group contained at least seven under 1 year of age. The youngest infant showing these worm infections was 6 months old. The age differences are even more apparent in considering the intensity of infection (below) than in the prevalence rates.

The prevalence of intestinal protozoa, as determined by the methods used, is summarized in table 1. Had more efficient methods been used, the apparent infection rates undoubtedly would have been higher. For instance, of the 22 persons examined only once, protozoa were found in 23 percent, compared with 44 percent in the whole group.

Infection intensity. The intensity of infection was measured by the Stoll egg-counting method. For *A. lumbricoides* the egg counts ranged from 100 to 366,200 per gram, with a mean of 45,074. For *T. trichiura* the range was from 100 to 29,400 eggs per gram, with a mean density of 3,627.

The mean egg counts by age followed in general the same pattern visible in the proportion of persons infected (table 2). The overall mean *A. lumbricoides* egg counts reached a peak in the 6–11 age group, but there was little difference between this group and the adjacent age groups. A similar trend could be noted in the *T. trichiura* infections, with a general tendency for the mean egg counts to be higher in the lower age groups.

Blood studies. The results of blood studies in 132 individuals from both groups are summarized in table 3. Of the total, 103 were known to be infected with at least one helminth. In addition to the high eosinophile levels, the mean differential blood counts showed a somewhat higher proportion of lymphocytes (46.1 percent) and lower proportion of neutrophiles (40.5 percent) than would be normally expected. About one-fourth of the persons studied had white cell counts in excess of 10,000 per cubic millimeter, but most of these were in a range that could be considered only a mild leucocytosis. The mean hematocrit value and the mean hemoglobin level were somewhat below normal, and the ranges were fairly wide. An attempt was made to correlate the various blood levels with parasitism in the group studied, but only in regard to the eosinophile levels was any significant correlation possible. Of the 132 samples checked, 61 (46 percent) showed eosinophile counts of over 10 percent. Of these 61, a

Table 3. Blood values for 132 persons, Bluffton, S.C.

Test item	Range	Mean	Median
Red cells/cmm. ($\times 10^6$) [1]	2. 65–5. 25	3. 90	3. 90
Hematocrit (percent) [2]	23. 5–53. 0	38. 0	38. 0
Hemoglobin (gm./100 ml.)	6. 5–15. 2	11. 0	11. 0
White cells/cmm	4, 000–20, 050	8, 909	8, 300
Eosinophiles (percent of white blood count)	0–35	11. 0	9. 0

[1] For 73 persons.
[2] For 127 persons.

Table 2. Prevalence and intensity of helminth infection in a rural population, by age group, Bluffton, S.C.

Infection	0–5 yrs. (N=61)	6–11 yrs. (N=53)	12–17 yrs. (N=21)	18–23 yrs. (N=19)	24 yrs. and over (N=58)	Total (N=212)
Ascaris						
Number infected	50	44	16	11	14	135
Percent infected	82. 0	83. 0	76. 2	57. 9	24. 1	63. 7
Mean eggs [1]	[2] 459	623	506	93	96	[2] 450
Trichuris						
Number infected	26	28	10	7	8	79
Percent infected	42. 6	52. 8	47. 6	36. 8	13. 8	37. 3
Mean eggs [1]	41	49	22	14	14	36

[1] In hundreds per gram of feces.
[2] Determined from one less than total number of persons infected.

total of 7 (11 percent) were found in persons not infected with *A. lumbricoides*, while 54 (89 percent) were found in the infected persons.

Because of the small number of persons in each age group, it is difficult to show any significant eosinophile-age correlations. However, some information can be gained by considering two larger groups, those 10 years of age and younger and those over 10 years of age. Table 4 summarizes to this extent the relationship of age to the effect of *A. lumbricoides* infection on eosinophilia. The mean eosinophile level in the total of 33 uninfected persons was about 5.8 percent. Only 4 of the 33 were known to be infected with *T. trichiura*, and their eosinophile levels ranged only from 5 to 7 percent with a mean of 6.5 percent. A number of others had protozoan infections; the number carrying *Enterobius vermicularis* is unknown. The eosinophile levels in the two age groups were approximately the same when no detectable *A. lumbricoides* infection was present. In the younger age group the difference between the mean eosinophile densities of 14.7 percent in the infected and 6.8 percent in the uninfected persons was significant ($p<0.01$).

The mean eosinophile level in the *Ascaris*-infected group was 12.7 percent. In this group there was a considerable and significant difference between the younger and older age groups, with a 14.7 percent level in the former and 5.6 percent in the latter ($p<0.01$).

The presence of concurrent diseases or infections in the subjects for the blood studies was not exhaustively investigated and could not be entirely ruled out as a factor in producing the abnormal findings. All those studied were ambulatory and appeared not to be suffering from any concurrent disease.

Clinical studies. There appears to be evidence of clinical disease from helminth infections in the group under study. In addition to the typical gastroenteric complaints heard from many in the area, bronchial and pulmonary involvement is also found. Continual bronchial coughing, increased bronchial markings on X-ray, and bronchial pneumonia are seen. While the specific etiology of this pulmonary syndrome cannot be stated with certainty, its failure to respond to antibiotic therapy and its association with heavy intestinal parasitism suggest that migrating *Ascaris* larvae may be the etiologic agent. Another possible cause of respiratory and nervous symptoms observed is generalized allergic response to the presence of adult or larval worms in various stages of development.

It is probable that deaths have occurred with helminth infection as the primary or secondary cause. A single autopsy report is available on a sibling of several of the more heavily infected children in our group. The provisional pathological diagnosis included trichuriasis, ascariasis, enterobiasis, ulceration and hemorrhages, mucosa, large bowel, paralytic ileus, bilateral pneumonia, tracheitis and bronchitis, peptic esophagitis, and generalized edema.

A primary clinical problem in this area is the almost universal complication of other illnesses in Negro children by the presence of heavy

Table. 4. Relation of age and Ascaris lumbricoides infection to eosinophile levels in 132 persons, Bluffton, S.C.

Age group	Total number	Uninfected				Infected				p value [1]	
		Number	Eosinophiles/100 WBC			Number	Eosinophiles/100 WBC			Uninfected vs. infected	Younger vs. older infected groups
			Range	Median	Mean		Range	Median	Mean		
10 years and under	86	12	0–24	6	6.8	74	0–35	14	14.7	$p<0.01$	$p<0.01$
11 years and over	46	21	0–12	5	5.2	25	1–30	4	5.6	--------	
Total	132	33	0–24	5	5.8	99	0–35	12	12.7	$p<0.01$	

[1] Using mean values.

worm burdens. Apparently about three-fourths of the illnesses of children under 15 years of age which come to the attention of a clinician are primarily worm-associated, and most of the others may have these helminthiases as a secondary and perhaps a complicating problem. All of these cases present the dilemma of whether to treat first the helminth infection, or to use other specific therapy in the face of an almost certain coexisting worm infection. Frequently an apparently unassociated medical complaint will disappear on reduction of worm burden.

Treatment of helminth infections. A total of 135 persons were treated with piperazine for helminth infections, and of these, 114 were evaluated for anthelmintic effect. The results of the treatment are summarized in table 5.

For *A. lumbricoides* there appeared to be little difference in percentage reduction of egg counts among the three dosages given (3, 4, or 5 grams according to age group). There seemed to be a progressively higher cure rate in the older age groups, which received 4 or 5 grams, but the difference lacked significance (in all comparisons $p>0.1$). The 92.3 percent reduction and the 59 percent cure rate for the whole group was about as expected from the single-dose treatment.

Piperazine appeared to have little effect on *T. trichiura* infections, with a reduction of only 1.7 percent in the entire group and only 2 of 62 infections disappearing. It is doubtful if even these changes represent activity of the drug. Neither of two cases of hookworm treated with 4.0 grams of the drug was significantly affected.

Analysis of the data to determine possible differences in effect between the liquid preparation and the chocolate cubes is summarized in table 6. While the differences in reduction of egg count in the individual dosage groups (3, 4, or 5 grams) did not appear to be significant, the overall difference between the 89.1 percent

Table 5. Treatment of intestinal helminth infection with single doses of piperazine in 135 persons, Bluffton, S.C.

Dosage [1] (grams)	Number treated	Number evaluated	*Trichuris*		*Ascaris*	
			Percent egg reduction [2]	Cured/ treated	Percent egg reduction [2]	Cured/ treated
3	47	39	9. 7	0/21	90. 2	18/38
4	60	54	Increased	1/33	93. 6	34/53
5	28	21	. 7	1/8	93. 2	13/19
Total	135	114	1. 7	2/62	92. 3	65/110

[1] In hexahydrate equivalent.
[2] In mean eggs per gram of feces.

Table 6. Effect of single doses of two forms of piperazine in Ascaris lumbricoides infections, Bluffton, S.C.

Dosage (grams)	Liquid				Chocolate cubes				p value (percent reduction)
	Number of patients	Percent egg reduction	Standard deviation	Percent cured	Number of patients	Percent egg reduction	Standard deviation	Percent cured	
3	15	80. 7	39. 2	40	23	91. 8	21. 5	52	$p>0.05$
4	29	90. 5	18. 4	52	24	97. 4	20. 6	79	$p>0.05$
5	12	89. 5	40. 2	67	7	98. 4	5. 7	71	$p>0.05$
Total	56	89. 1	30. 4	52	54	94. 5	19. 7	67	$p=0.01$

reduction when the liquid was used and the 94.5 percent reduction when the cubes were used appeared to be significant at the 1 percent level.

In comparing the cure rates of the various regimens, the chocolate cubes did not appear to have any significant advantage over the liquid form in the total number treated ($p>0.1$) or when the individual dose was 3 ($p>0.4$) or 5 grams ($p>0.8$). However, with a dose of 4 grams the cure rate with cubes (19 of 24 treated) appeared to be significantly greater than with the liquid (15 of 29); the chi-square test yielded a p value between 0.02 and 0.05.

No side effects of consequence were encountered with the regimens of drug employed. One case of nausea and vomiting occurred shortly after drug administration but was not severe. The preparations were accepted without resistance by all but a very few children, who nevertheless took the drug after some encouragement.

Discussion

Little precise information is available on the prevalence of intestinal parasites in the coastal areas of South Carolina. In a summary of the status of parasitism in the southeastern United States, Wright (*1*) gave the prevalence of *A. lumbricoides* in South Carolina as 3.8 percent. This was determined by about 25,000 examinations by the South Carolina State Health Department during 1951–54, but no information was given as to the areas included, race, method of examination, or other qualifying data.

Leathers and Keller (*2*) in 1937 reported *A. lumbricoides* infection in 4.0 percent of 28,875 white persons from 44 of the 46 counties of South Carolina. Of 595 Negroes from six counties, 15.1 percent were infected; four of the six counties were coastal. The 10 coastal or subcoastal counties provided a larger than average percentage of infected white persons, with an overall 7.1 percent infected.

The *T. trichiura* infection rate has been reported to be considerably lower than that for *A. lumbricoides*. Leathers and Keller found only 0.04 percent of 28,875 specimens infected.

While these reports may reflect accurately the prevalence in the State as a whole, it appears certain that in particular areas the helminth problem may be considerably more severe. Our study groups, with 64 percent infected with *A. lumbricoides* and 37 percent with *T. trichiura*, were without question groups from a selected area, but large areas of coastal South Carolina, and undoubtedly of other States, have similar populations, climate, terrain, and other factors which would tend to produce similar rates of infection.

Efforts to find reports of similar rates of infection in other areas of the United States seem to support the general opinion that the highest infection rates are found in the mountainous areas of the southeastern States, with a very much lower incidence in the coastal plains. Atchley and associates (*3*) in 1956 reported prevalences of *A. lumbricoides* of 21 and 27 percent and *T. trichiura* of 15 and 24 percent in two groups studied in two counties in Kentucky. When only children under 10 were considered, about one in three was infected with *A. lumbricoides*. Earlier studies in this same area noted prevalence rates of 8.5 to as high as 46 percent; *T. trichiura* had been estimated as present in 10 to 40 percent of the population. Jones and associates (*4*) reported about 10 percent of 322 Tennesseans infected with *A. lumbricoides*; an earlier survey by Milam and Meleney (*5*) in the same community had found about 33 percent of 357 individuals infected. For *T. trichiura* the infection rate had dropped from 11 percent to about 1 percent.

The monumental study by Keller and associates (*6*) on the helminth parasites of North Carolina showed an enormously higher prevalence of *A. lumbricoides* in white persons in the western, mountainous part of the State as compared with the coastal area. The two counties with the highest rates showed about 58 and 59 percent infected among more than 1,000 persons examined. The area they classified as "mountainous region" had a rate of about 31 percent, while the "coastal plain" registered about 7 percent infected. However, in the Negro population, the highest rates occurred in five coastal counties, with rates of 42 to 56 percent. In the 37 counties where both Negroes and whites were examined the infection rate of 23 percent for Negroes was more than three times as high as the rate for whites, and the intensity of infection in Negroes was about twice

that in whites. It is interesting that although the infection rate in whites was much higher in the "mountain region" as compared with that in the "coastal plain," the individual infection intensity in the coastal plain was somewhat greater. The overall prevalence of *T. trichiura* in North Carolina was only 0.5 percent in whites and 3.0 percent in Negroes. In five coastal counties, however, the *T. trichiura* prevalence ranged from 11 to 25 percent.

Otto and Cort (*7*) also noted a relatively low *Ascaris* incidence outside the mountainous areas of southeastern United States, but they did find evidence of a few centers of *Ascaris* infections in "generally *Ascaris*-free regions," particularly near the coast of Virginia, North Carolina, and South Carolina. In one isolated community in Columbus County, N.C., fairly intense infection with *Ascaris* was found. While only 17 percent of the 567 persons examined were infected, the infection that occurred tended to be of high intensity and was a serious problem in some of the families.

It would appear that a high incidence of *A. lumbricoides* in specific groups may not depend so much on the climate or topography, although certain favorable conditions are necessary, as on the particular habits and sanitation of the population involved. Compared with the mountainous regions of southeastern United States, the coastal and subcoastal areas have a mucher higher proportion of Negroes in the population, and in these areas there is considerable contrast between the Negro and white populations in economic development, housing, sanitation, and other factors which might contribute to the spread of these helminth infections.

High rates of infection with the two species are not difficult to find in other parts of the world, particularly in tropical and economically underdeveloped areas where unsanitary conditions prevail. In this hemisphere, in a limited survey Guerrero and associates (*8*) found 57 percent of 362 Colombians infected with *A. lumbricoides* and 59 percent with *T. trichiura.* In Mexico, Tay Zabala and Navarrete (*9*) found in 651 persons prevalence rates of 90 percent for *A. lumbricoides* and 85 percent for *T. trichiura.* Dobbin and Vasconcellos Coelho (*10*) found *A. lumbricoides* in 75 percent of 690 persons on a small island off the coast of Brazil. In particularly interesting studies in Chile, Silva and associates (*11*) and Neghme and associates (*12*) compared the prevalence of *A. lumbricoides* in two areas. In an area of high humidity and moderate temperature, a prevalence of about 57 percent was noted, while in an area with less favorable climate the prevalence was only 1 to 7 percent. Silva and associates described the higher prevalence rate as "one of the highest reported in the literature all over the world." A superficial survey of the literature supports this estimate for studies of such magnitude (more than 2,000 individuals), but comparable rates are more frequent in smaller studies.

Several examples might be cited. Kuntz (*13*), studying 295 school children in Dacca, Pakistan, found 67 percent infected with *A. lumbricoides* and 77 percent with *T. trichiura.* In Egypt, Nagaty and Khalil (*14*) found 46 percent of 389 outpatients infected with *A. lumbricoides* and 14 percent with *T. trichiura.* In a slum area in Durban, South Africa, Elsdon-Dew (*15*) noted prevalence rates of 50 percent for *A. lumbricoides* and 60 percent for *T. trichiura,* but in an adjacent, new, subeconomic housing area the rates were significantly lower, being 26 and 40 percent respectively. In a review of parasite prevalence in the Near and Middle East, Mumford (*16*) lists a number of reports of prevalence ranging from 20 to 90 percent for *A. lumbricoides* and as high as 78 percent for *T. trichiura.* A series of four small studies (120 to 202 individuals) summarized or cited by Fink (*17*) gave *A. lumbricoides* infection rates ranging from 26 to 50 percent among natives of Okinawa. A series of 664 autopsies in Djakarta, Indonesia (*18*), yielded rates of infection of 61 percent for *A. lumbricoides* and 85 percent for *T. trichiura.* Surveys in the Cook Islands (*19*) revealed a prevalence of 69 percent for *A. lumbricoides* and 41 percent for *T. trichiura.*

It is apparent, without further exploration of the literature, that the infection rates found in Bluffton are comparable to the highly elevated rates found in a number of localized situations around the world, and may represent one

of the areas of highest endemicity for the continental United States.

The low incidence of hookworm infection in the communities studied was not too surprising. Previous surveys of Beaufort County (*20*) found a prevalence of 14 percent in 322 whites and 6 percent in 177 Negroes. Soil conditions appear to be favorable, but there are few shade trees in the vicinity of most of the houses. Most of the soil pollution is of the dooryard type, which appears to be responsible for the high incidence of *A. lumbricoides* and *T. trichiura* but which, under the circumstances, is not ideally suited for hookworm transmission. The one family in which hookworm seemed to have gained a foothold probably used a dense area of high weeds for defecation, a practice which may have encouraged the completion of the larval cycle of the hookworm. A good portion of this area was also shaded by an evergreen oak, and the sandy soil probably remained quite moist.

The distribution and intensity of *Ascaris* infection in relation to age did not vary from information on this aspect in previous reports (*2,6,21*). In all these reports the highest mean rates of infection were found during the first 10 years of life, and usually during the first 4 or 5 years. The highest average intensity of infection, however, usually appeared after the first 4 or 5 years and through age 14 or 15.

The blood studies were of considerable interest. In view of the heavy parasitism in the group the mean hemoglobin and hematocrit levels might have been expected to be somewhat lower. There did not appear to be any correlation between the total white cell count or the depressed neutrophile counts and the higher than usual proportion of eosinophiles.

It would appear that the higher eosinophile levels were related to the heavier *A. lumbricoides* infections, recalling that the infections in the lower age groups were generally more intense than in the older. The presence of *T. trichiura*, at least in the intensity seen in this group, did not appear to exert any considerable effect on the eosinophile levels. Persons with combined *A. lumbricoides* and *T. trichiura* infections had a mean eosinophile level of 15.3 percent, compared with 9.4 percent in those with *A. lumbricoides* alone. A further check showed, however, that persons with both infections had a mean *A. lumbricoides* egg density of 56,400 eggs per gram compared with 33,900 eggs per gram when *A. lumbricoides* alone was present. Thus it would appear that the higher eosinophile level could be a result of a heavier *A. lumbricoides* infection rather than a result of the multiple species present. Otto (*7*) found no differences in eosinophile levels in children heavily infected with *T. trichiura* and those not infected, and Swartzwelder (*22*) found the mean eosinophile level to be fairly low (4.2 percent) in young persons with *T. trichiura* infections.

According to the accepted idea of the course of events following *Ascaris* infection (*23*), the hypereosinophilia associated with this parasite appears very early in the course of the infection, presumably during and shortly after the larval stages in the lung, and subsides to near normal levels after about the second month, when the worms have reached maturity. This may account for the eosinophilia which we found, since our blood samples were acquired in the late summer, presumably at the close of the most active transmission season. This may also explain why some of the heavier worm burdens were sometimes not associated with hypereosinophilia; apparently in long-standing infections the eosinophilia is reduced to fairly normal levels.

Results of the single-dose treatment of *Ascaris* compared favorably with the previously reported studies. Brown (*24*), using total doses of 2.0, 3.0, and 3.5 grams of piperazine hexahydrate (as the citrate syrup) in three weight classes, reported a cure rate of 74 percent and an overall egg reduction of 92 percent. Atchley and associates (*25*), using graduated doses of 1 to 4 grams of the hexahydrate (as citrate syrup) according to the weight of the recipient, obtained cures in about 78 percent of the 102 individuals treated. The overall egg reduction appeared to be about 55 percent.

In our treatments somewhat larger quantities of drug were given to comparable individuals, which should have resulted in better cure rates as well as better overall egg reduction. A

possible explanation of our poorer results in achieving cures might lie in the probably heavier worm burdens in our group or in the more thorough post-treatment evaluation done in the study.

The advantage we noted in the use of the chocolate cubes as compared with the liquid preparation is difficult to explain. One difference noted was a somewhat heavier average worm load in the group treated with cubes, but one would not expect this to increase the cure rate, although it might result in a larger egg reduction.

The absence of side effects of any consequence in our groups is in accordance with the findings of others who have used similar regimens of this drug. Of particular interest was the willing acceptance of the drug, regardless of form, by a population unaccustomed to such procedures and perhaps even inclined to regard with some suspicion other public health practices. It appears that with proper preparation and approach such mass treatment measures would not only be effective but also very welcome by those in similar situations where heavy worm infections exist.

Such populations as those included in these studies have been and continue to be reluctant to make any of the radical changes in sanitation procedures and personal habits that would be required for the control of these infections. The heavy parasitism in the group studied is an example of a situation which exists despite efficient State and county health departments and many years of effort toward improving sanitary conditions. Resistance to improvement in sanitation continues apparently in the face of knowledge, at least in the adults, of the parasite problem and available means of alleviating it. This impasse seems to demand a new approach in coping with the parasite problem. One answer to this need for a simple, inexpensive, and acceptable method to reduce the worm loads, especially in the younger members of the community, may lie in repeated mass treatment of exposed groups, both as a therapeutic and prophylactic measure. It is felt that single-dose therapy similar to that used here with considerable success, with periodic repetition when necessary, would be a means to immediate reduction of worms and possibly even to eventual control or elimination of parasites in population groups.

Summary

In a study of two similar population groups, totaling 212 persons, in a coastal area of South Carolina, *Ascaris lumbricoides* infection was found in 64 percent and *Trichuris trichiura* infection in 37 percent. Only 4 percent of those examined were found to have hookworm. The *A. lumbricoides* infections had an average intensity of 45,074 eggs per gram of feces; *T. trichiura* infections averaged 3,627 eggs per gram. The prevalence of the common intestinal protozoa was also determined.

The highest prevalence and intensity of worm infection were found in the younger age groups, with considerable reduction after 15 or 16 years of age.

Blood studies for 132 persons showed a mild leucocytosis, slightly depressed neutrophile and elevated lymphocyte proportions, and a mean eosinophile density of 11 percent. Hemoglobin and hematocrit levels were depressed only slightly below normal. The increased eosinophile proportion showed a significant correlation with the presence of *A. lumbricoides* infection in the younger age groups and in the total group but not in the older age group. There was also significantly greater eosinophilia in younger persons infected with *A. lumbricoides* compared with infected older persons.

A total of 135 persons were treated with single doses of piperazine, either liquid or in chocolate cubes. Doses equivalent to 3, 4, and 5 grams of the hexahydrate were used in respective age groups of 0–5 years, 6–15 years, and 16 years and older. Evaluation of 114 such treatments found a cure rate for *Ascaris* infections of 59 percent and an overall egg reduction of 92.3 percent. The piperazine in chocolate cubes appeared to give somewhat better reduction of worms than did the drug in liquid form. The drug appeared to have no effect on the *T. trichiura* or hookworm infections.

The study indicates a prevalence of *A. lumbricoides* and *T. trichiura* infections which is comparable to that found in many areas of high prevalence throughout the world and which is probably one of the highest in the continental

United States. Control of these infections, in the absence of probable improvement in sanitation and living conditions, might be possible through mass, single-dose treatment campaigns.

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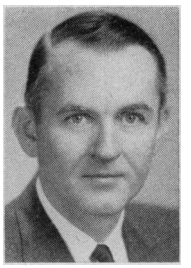
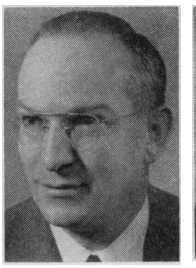
SUPPLY REFERENCE

(*A*) Piperazine compounds, Burroughs Wellcome and Co. (U.S.A.) and Endo Products, Inc.

New Members of the PHR Board of Editors


Dr. Gehrig


Dr. Hundley


Dr. Kandle


Dr. Watt

The Board of Editors of *Public Health Reports* has four new members, who will serve for 3 years. Retiring from the board are Dr. A. L. Chapman, Dr. Roger W. Howell, and Dr. Helen M. Wallace.

Leo J. Gehrig, M.D., is deputy chief of the Bureau of Medical Services, Public Health Service. He joined the commissioned corps of the Service soon after graduating from the University of Minnesota School of Medicine in 1945.

Dr. Gehrig has served as acting director of tuberculosis control in Alaska, chief of thoracic surgery in the Public Health Service Hospital at Staten Island, N.Y., and as deputy chief of surgery in the Service's hospital at Seattle, Wash. In 1959 he was appointed deputy chief of the Division of Hospitals. In 1961 he was assigned as medical director of the United States Peace Corps. He came to his present position in July 1962.

Dr. Gehrig is a diplomate of the American Board of Surgery and the American Board of Thoracic Surgery. He is a fellow of the American College of Surgeons and a member of Alpha Omega Alpha Honor Medical Society.

James M. Hundley, M.D., is Assistant Surgeon General for Plans, Office of the Surgeon General, Public Health Service.

Dr. Hundley joined the Public Health Service after graduating from the Indiana University School of Medicine in 1940. In 1943, he was assigned to nutrition research at the National Institutes of Health.

His principal research interests have included the metabolism of vitamins and amino acids, nutritional aspects of peptic ulcer and heart disease, human growth, and methods of assessing nutritional status. He has written several chapters in textbooks on biochemistry and medicine and contributed numerous articles to scientific journals.

In addition to his work at the Institutes, he has served as nutrition consultant in developing plans for civil defense. In 1956 he served for 2 years with the Food and Agricultural Organization and UNICEF of the United Nations. On his return to NIH in 1958, he organized studies of naturally occurring diseases in population groups in various parts of the world and acted as special assistant for international affairs to the NIH director.

In January 1960, Dr. Hundley was appointed chairman of the Surgeon General's Study Group on Mission and Organization of the Public Health Service.

Roscoe P. Kandle, M.D., M.P.H., has been New Jersey State Commissioner of Health since July 1, 1959. During the previous 5 years, he was first deputy commissioner of the New York City Department of Health.

As field director of the American Public Health Association, he studied the public health organization of Colorado, Georgia, Missouri, Pennsylvania, and Wyoming and a number of county and city jurisdictions.

Dr. Kandle was graduated from Johns Hopkins University in 1930, received his M.D. degree from Jefferson Medical College in 1934, and his M.P.H. from the School of Hygiene and Public Health, Johns Hopkins University, in 1938.

He is a member of the Interstate Sanitation Commission (New Jersey, New York, and Connecticut), and serves on several Public Health Service committees: the Advisory Committee to the Heart Disease Control Program; the Surgeon General's Advisory Committe on Influenza; Health Services Research Study Section, National Institutes of Health; and the Surgeon General's Advisory Group on Community Health Services.

Dr. Kandle is a lecturer at the School of Public Health and Administrative Medicine, Columbia University.

James Watt, M.D., Dr.P.H., is Assistant Surgeon General for International Health, Public Health Service.

Dr. Watt received his doctoral degrees from Johns Hopkins University. He was commissioned in the Public Health Service in 1938. Until 1952, he was in epidemiologic research in the diarrheal diseases at the National Institutes of Health. From 1952 to 1961 he was director of the National Heart Institute.

In addition to his research, Dr. Watt held appointments at the University of Puerto Rico, Louisiana State University, and Johns Hopkins University.

He is a member of the founders group of the American Board of Preventive Medicine and was director of the Commission on Enteric Infections, Armed Forces Epidemiology Board. He served as a member of the UNRRA commission to China in 1945.

Dr. Watt has been awarded the Bailey E. Ashford Award for research in tropical medicine, the Bronfman Prize for Public Health Achievement, and the Award of Merit of the American Heart Association.