New Methods of Hookworm Disease Investigation and Control *

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THE studies of Keller, Leathers, and their associates [1] clearly show a marked reduction in the recent incidence and, presumably, in the intensity of hookworm infection in the southern states in contrast to the conditions prevailing in 1910–1914 as revealed by the Rockefeller Sanitary Commission. Nevertheless, hookworm disease remains a source of physical disability and economic handicap in certain parts of several states, and considerable amounts of time and money are currently expended by state and local health agencies in its reduction.

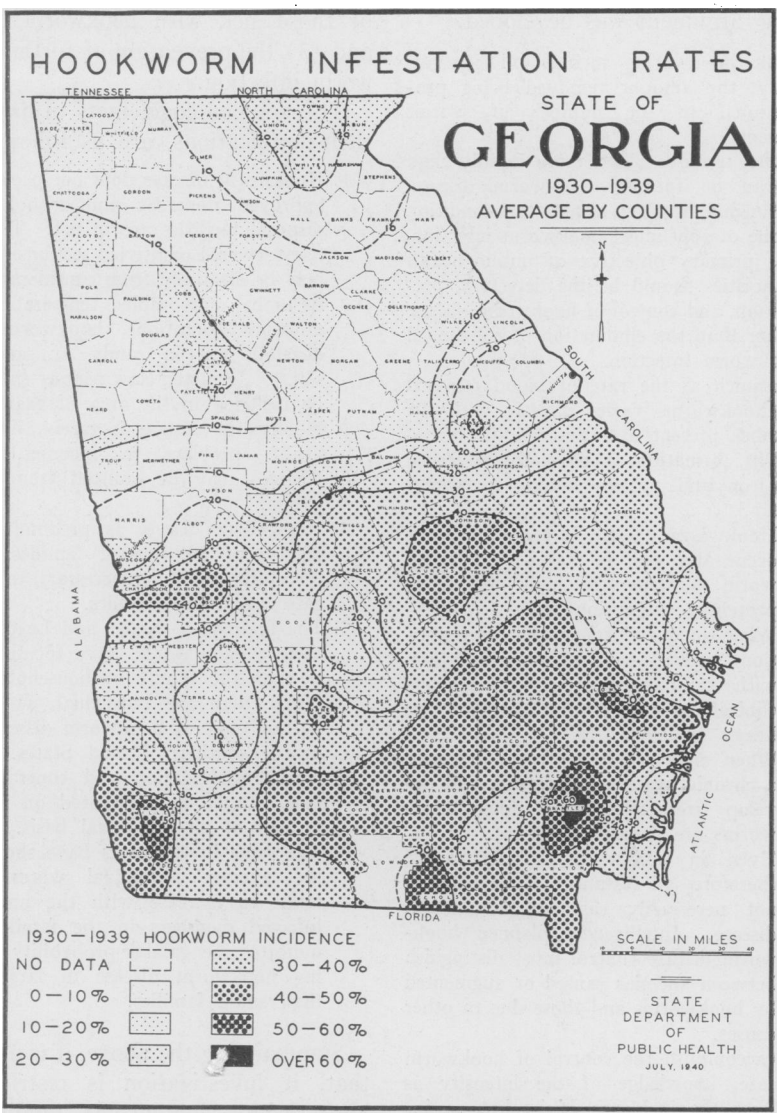
Curiously enough, however, the world-wide researches of the last twenty years on the quantitative aspects of hookworm infection have apparently failed to make an effective impact on state and local health authorities. Indeed, the problem is viewed by them almost without exception as a qualitative one. It is taken for granted that hookworm infection is tantamount to hookworm disease. Egg-positive individuals are discovered by annual flotation surveys of school children. The positives are given, or are urged to take, anthelmintic treatment with little regard to their clinical condition, the relative magnitude of their worm burdens, or the probability of prompt reinfection. The only truly preventive values incidental to these efforts are when the incidence information is used in the promotion of sanitary excreta disposal facilities at homes and in schools. Thus, these anti-hookworm programs involve the special interests and activities of laboratory, epidemiologic, engineering, nursing, and local health administrative services, but these frequently are not coördinated because the program lacks a guiding plan or specific direction. Much of the work, therefore, is repetitious, unnecessary, and wasteful.

In an attempt to develop a sound anti-hookworm program that could be effectively and conveniently carried on by local health agencies and to assist in its promotion and effectuation in Georgia, the State Department of Public Health established a Hookworm Service unit late in 1939. Personnel includes a nurse and a sanitarian who give their entire time to this project, and a medical epidemiologist and a director (parasitologist) who devote about half their efforts to anti-hookworm activities.

All requests from local lay or health sources for hookworm surveys must be approved by the director before survey materials are supplied. Thus, he is in position to prevent pointless surveys with their wasteful expenditures of time and materials; he frequently can convert the desire to "do something about hookworms" into a more effective procedure than a flotation survey of school children; and, lastly, he can

* Read before the Engineering Section of the American Public Health Association at the Seventieth Annual Meeting in Atlantic City, N. J., October 14, 1941.

FIGURE 1



regulate and equalize the laboratory load of hookworm examinations to a very considerable degree.

The first step toward a refinement of existing knowledge of the hookworm problem in Georgia consisted of tabulating, by year and county, the previous 10 years' incidences of hookworm infection as determined by flotation surveys. The county rates for this period were then used in developing an isoropic map (Figure 1) showing the state-wide distribution of various classes of hookworm incidence. This provided a useful though not statistically or parasitologically ideal basis on which to plan subsequent investigations.

The next step was to substitute, in the minds of local health personnel, quantitative for qualitative concepts regarding hookworm infection. This was done by keynoting the subject at state and regional health meetings and by making it the topic of discussion be-

fore in-service training groups. The following argument was developed.

1. Adult hookworms suck blood continuously, the amount removed being proportional to the number of worms present.
2. If they remove blood more rapidly than it can be formed, hookworm disease, or anemia, results; if not, the condition is one of subclinical hookworm infection.
3. The primary objective of public health authorities should be the detection, prevention, and control of hookworm disease rather than the elimination of subclinical hookworm infection.
4. Inasmuch as the rate of blood removal by hookworms varies directly with the number present and the rate of hemoglobin formation is normally governed by iron and protein intake, it follows that
   a. Hookworm disease is more likely to occur and will be more severe when worm burdens are high and iron-protein consumption low.
   b. When adequate iron-protein consumption prevails, hookworm infection, with rare exceptions, will be subclinical, whether worm burdens are heavy or light.[2]
   c. When diets are iron-protein deficient, a chronic, progressive anemia will develop irrespective of whether hookworms are present or absent.[3]
   d. Even in hookworm infested areas, therefore, all instances of anemia are not necessarily cases of hookworm disease. Intelligently planned hookworm disease control must distinguish between anemias caused or augmented by hookworms and those due to other causes.
5. To accomplish the control of hookworm disease, knowledge of the intensity as well as the incidence of hookworm infection must be available and this must be considered in relation to the apparent anemia and dietary habits of the people concerned.

The third step was the development of a practical program of investigation and control based on this quantitative viewpoint and available epidemiologic knowledge. It was aimed (1) as the destruction of the greatest possible number of hookworms with the least expenditure of time, travel, and materials, (2) the prompt physical rehabilitation of those sick with hookworm disease, and (3) the prevention of further hookworm infection.

The epidemiologic facts utilized, and their implications, are as follows:

1. Hookworm disease does not occur where approved domestic and school excreta disposal facilities are in use. Thus sanitary sewered or privied sections generally may be dismissed from consideration.
2. Assuming favorable temperature and moisture conditions, hookworm larvae develop best in sandy or sandy-loam soil.[4, 5] Strictly clay regions should not be included in the area of examination.
3. Hookworm disease is rarely, if ever, a health problem in Negroes.[1] Thus Negroes may be omitted from investigation.
4. Hookworm disease is predominantly a disease of low-income families. It is, therefore, usually unnecessary to investigate well-to-do families.
5. The findings of Keller and Leathers and their collaborators[1] have focused attention on the family or household group, rather than the individual, as the important unit of hookworm dissemination in the southern United States. Hookworm investigation and control, therefore, should be prosecuted on a family instead of an individual basis.
6. The same investigators have shown that the average individual worm burden tends to increase with the number of infected members in the family. This indicates the greater probability of finding hookworm disease in large rather than small families.

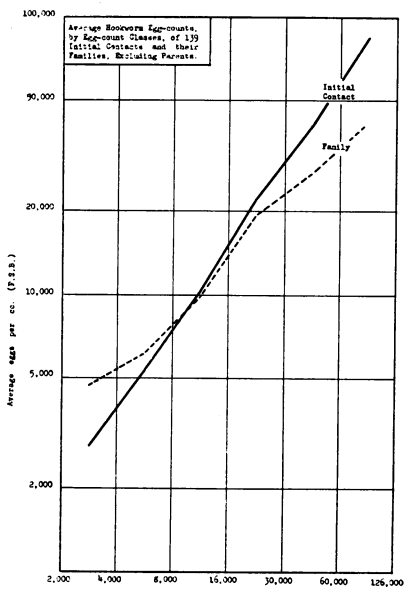
Summarizing the above, it is apparent that, if investigation is restricted to large, white, low-income families living on sandy or sandy-loam soil without sanitary excreta disposal facilities and in which clinical anemia is evident, the majority of the cases of hookworm disease in the area will be encountered.

In apprehending these families, two procedures are in use in Georgia. Where soils, family incomes, races, and domestic sanitation vary widely within a county, direct home visiting without preliminary survey is planned on the basis of soil maps, sanitary survey

maps, and information obtained from welfare agents, county agents, Farm Security representatives, home demonstration agents, physicians, and others whose business takes them into rural homes. Fecal specimens from one or more anemic members of each family, under 20 years of age, are sent to the State Health Department Laboratory and these are examined by brine flotation. Those found positive are egg-counted by the small-drop dilution method of Stoll and Hausheer[7] to obtain some indication of the relative intensity of infection and the corresponding probability that the anemia observed is due to hookworms.

In counties where sandy soils, poverty, and insanitation predominate, home visiting is deferred until the selective school survey has directed attention to families of probable hookworm significance. This is done by distributing fecal containers only to those white school children who show evidence of being anemic. School teachers are invited to assist in the selection because they are able to make their judgments on the basis of activity as well as appearance and because it gives them definite responsibility in connection with this special health program. These specimens are examined in the State Health Department Laboratories first by flotation to eliminate negatives, the positives being egg-counted.

FIGURE 2



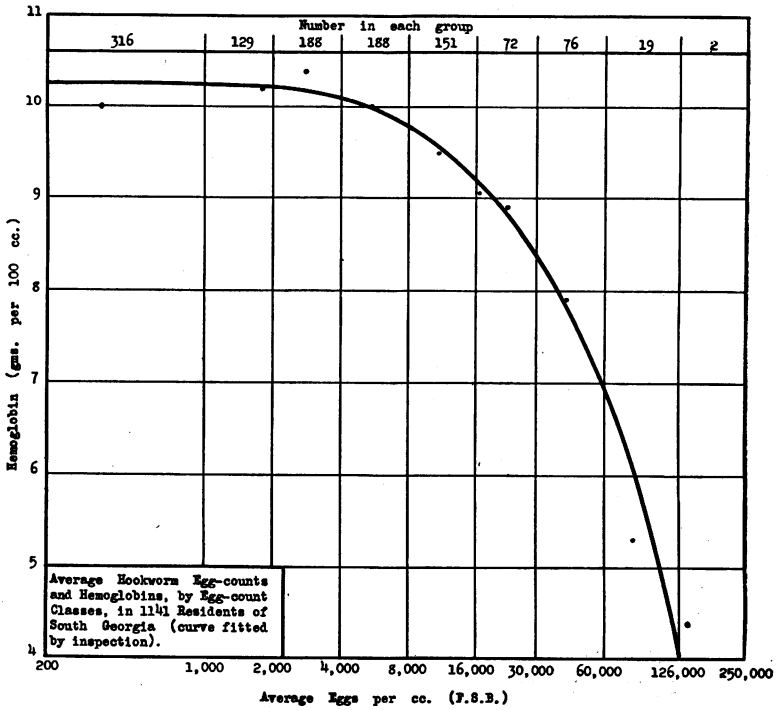
During the development stages of this program, we urged examination of all members of the suspected families. This turned out to be impractical because of non-coöperation, especially of adult males, and the time and travel consumed in repeated visits to the home. This procedure has been abandoned as we presently discovered that in general

TABLE 1

Comparison of Average Egg-counts per ml. of Formed Stool, by Egg-count Classes, of Initial Family Contacts and All Members of Their Families, Excluding Parents

	Initial Contacts		*Families, Including Initial Contacts, Excluding Parents*				
			Number of Members				
Hookworm Egg-Count Class	*Number Examined*	*Average Egg-Count*	*Total*	*Average*	*Positive*	*5,000 or More Eggs per Ml.*	*Average Egg-Count of Positives*
2,000– 4,000	25	2,868	110	4.4	76%	18%	4,692
4,000– 8,000	36	5,419	150	4.2	79%	39%	6,225
8,000– 16,000	28	10,696	104	3.7	92%	60%	9,715
16,000– 30,000	21	22,400	91	4.3	96%	74%	18,607
30,000– 60,000	21	41,181	77	3.7	94%	83%	27,468
60,000–126,000	8	84,550	29	3.6	97%	97%	41,646
Totals	139	18,030	561	4.0	86%	53%	14,080

FIGURE 3



the egg-count of the initial contact, *i.e.*, the first anemic member of the family seen, under 20 years of age, was roughly representative of the average intensity of infection of all positive members of the family under 20 years of age, in which age group most cases of hookworm disease occur in this state. A comparison of average egg-counts of initial contacts and all members of the families is shown for 139 families in Table 1 and Figure 2. Accordingly, we have discontinued routine examination of other members of the family at great saving for both laboratory and local health services.

Similarly, we at first recommended control follow-up of families of anemic individuals with counts of 2,000 or more eggs per ml. of formed stool. This level was selected, more or less arbitrarily, before the results of our own county-wide surveys became available. It allowed a reasonable margin of safety below the egg-count level (2,600 eggs per ml.) at which Smillie and Augustine [9] noted minimal symptoms of hookworm disease in Alabama. Our own observations,[10] shown in Figure 3, on the relation between egg-counts and hemoglobin determinations (Sahli) convinced us that it was pointless in Georgia to attempt control in families where the average egg-count was much below 6,000 eggs per ml. This corresponds in Figure 2 to an average egg-count of 5,000 eggs per ml. in initial contacts. Accordingly, local health personnel are now advised to select for control follow-up families of anemic individuals under 20 years of age whose egg-counts are 5,000 or more eggs per ml.

The families selected by either of these methods do not, of course, include *all* the cases of hookworm disease in the area. If faithfully carried out, however, these procedures, with a minimum expenditure of time, travel, and materials, will direct attention to the

bulk of the true hookworm morbidity, excluding that much larger group with hookworms but no hookworm disease. Attempts to eliminate hookworm from the latter group serve no useful health purpose, with the possible exception of promotion, a purpose which should be served better by an actual rather than a fictitious health problem. Nevertheless, knowledge of these families, members of which are suffering from anemia not due to hookworms, is of health significance as it is generally found that these persons are undernourished with respect to iron. Dietary anemia in Georgia, and apparently in Florida as well,[3] is more prevalent than hookworm disease with which it frequently and perhaps always occurs. This health problem can be economically attacked along with hookworm disease control; indeed, the two health activities effectively complement each other.

What is to be done for these hookworm diseased families once they are identified? First of all, their sick members must be made well. This requires medical service and, as far as possible, is handled by private physicians in Georgia. Indigency is high, however, among hookworm sufferers and it is usually the expressed desire of local medical groups or practitioners that health doctors assume treatment responsibilities for such patients. Anthelminic drugs are supplied gratis to medical men by the state.

The therapeutic problem is a dual one consisting of worm removal and treatment of the anemia. As Payne and Payne [11] have recently shown, hemoglobin recovery following worm expulsion without iron therapy is a long drawn out process. This is especially true when dietaries are iron deficient.[10] On the other hand, while iron administration alone produces rapid improvement in the blood picture, the gains are not sustained unless the worms are removed. So we do both, giving iron, usually as Blaud's pills, *before* deworming if the anemia is exceptionally severe, *i.e.*, 5 gm. or less; *after* worm removal if the anemia is moderate. Educational efforts are made, thereafter, to improve the dietary so that greater iron intake in food is provided, especially for growing children in which the concurrence of hookworm anemia and nutritional anemia is most marked.

The prevention of hookworm disease is, first of all, a matter of sanitation, *i.e.*, the provision of approved excreta disposal facilities, second, education concerning their use and the physical benefits that will result therefrom and, probably, of improved dietary as well if the immunity hypothesis of Cort and Otto [2] based on observations of experimental dog hookworm infection is verified in man.

We, therefore, vigorously promote the sale and use of sanitary sewage disposal structures in homes and schools, but in these days of progressively restricted WPA participation in community sanitation projects, of increasing cost and decreasing availability of materials and of labor, the prospects of seriously interfering with the transmission of hookworms by the use of standard sanitary units are comparatively remote. Families that cannot afford minimal medical service cannot afford pit privies.

In those numerous instances, therefore, in which home sanitation cannot be provided, we are trying to develop definitely preventive values from anthelminic treatment. As indicated above, individuals suffering from hookworm anemia are treated as fast as they are discovered, irrespective of whether or not the premises are to be sanitated. The deworming of other members of the family at that time is not encouraged. If a pit privy is provided and used, there will be no material increase in the intensity of infection and so family treatment is not necessary.

If, however, the household must get along without sanitary facilities, at least one and desirably two worm-removal treatments are urged for all members of the family during the cold months of the year. The object here is to reduce—and, if possible, to eliminate—the family worm burden at a time when immediate reinfection of its members from each other is less likely than it is during the summer months. The unfavorable effect on non-parasitic stages of hookworms of temperatures below 50° F. has been noted by various observers. Augustine,[6] working in southern Alabama, was unable to find larvae in polluted soil from the latter part of December into March. Our own findings in south Georgia, incomplete and inconclusive, confirm this observation. Thus it appears that the soil in this area tends to become free from infective larvae during the winter months and the likelihood of reinfection following treatment at this season is correspondingly remote. This seasonal prophylactic effect is enhanced by the fact that it is during the cold months of the year that rural residents wear shoes if they ever wear them at all.

Two treatments with tetrachlorethylene completely remove worms from about 90 per cent of the patients and reduce the group egg output by 99 per cent.[12] If these are given during the winter to all members of families in which hookworm disease has occurred, it seems improbable that hookworm infection could build itself up to clinical intensities in those families within several years.

This program has not yet experienced the test of time. It is subject to improvement as further field investigations suggest. Nevertheless, we feel that through it we are accomplishing better hookworm control at a lower cost than we did before its development.

REFERENCES

1. Keller, Alvin E., Leathers, W. S., and Densen, Paul M. The Results of Recent Studies of Hookworm in Eight Southern States. *Am. J. Trop. Med.*, 20, 4:493–509 (July), 1940.

2. Cort, W. W., and Otto, G. F. Immunity in Hookworm Disease. *Rev. Gastroenterol.*, 7, 1:2–11 (Jan.–Feb.), 1940.

3. Abbott, O. D., and Ahmann, C. F. Nutritional Anemia and Its Prevention. *Agri. Exper. Sta. Bull. 328* (Nov.), 1938. (Gainesville, Fla.)

4. Augustine, D. L., and Smillie, W. G. The Relation of the Type of Soils of Alabama to the Distribution of Hookworm Disease. *Am. J. Hyg.*, 6:36–62 (Mar. Suppl.), 1926.

5. Rickard, E. R., and Kerr, J. A. The Incidence and Intensity of Hookworm Infestation in the Various Soil Provinces of Tennessee. *J. Prev. Med.*, 1, 2:185–203, 1926.

6. Augustine, D. L. Studies and Observations on Soil Infestation with Hookworm in Southern Alabama from October, 1923, to September, 1924. *Am. J. Hyg.*, 6:63–79 (Mar. Suppl.), 1926.

7. Stoll, N. R., and Hausheer, W. C. Concerning Two Options in Dilution Egg-counting: Small Drop and Displacement. *Am. J. Hyg.*, 6:134–145 (Mar. Suppl.), 1926.

8. Chandler, Asa C. *Hookworm Disease.* XII+494 pp. 1929. New York.

9. Smillie, W. G., and Augustine, D. L. Hookworm Infestation. The Effect of Varying Intensities on the Physical Condition of School Children. *Am. J. Dis. Child.*, 31:151–168, 1926.

10. Hill, A. W., and Andrews, Justin. The Relation of Hookworm Burden to Physical Status in Georgia. *In press.*

11. Payne, G. C., and Payne, Florence K. Relative Effectiveness of Iron and Anthelminthics in the Treatment of Hookworm Anemia. *Am. J. Hyg.*, 32, 3, D:125–132 (Nov.), 1940.

12. Andrews, Justin. Hookworm Disease and Plans for Its Control in Georgia. *Georgia Malaria Bulletin* (Hookworm Suppl.), 3, 2:64–78 (June), 1940.