

INSTITUTIONAL HOOKWORM DISEASE IN A NON-ENDEMIC REGION¹.

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(With 1 Text-figure.)

CONDITIONS in institutions for children or defectives may become peculiarly favourable to the propagation of hookworm disease. The subject of the present study is a long-standing infection with *Ancylostoma duodenale* in the Hospital for the Insane at Goodna, Queensland, the largest of the three hospitals for the insane maintained by the State Government. The investigation was of special interest because the institution is in a region in which the general population is free from hookworm disease, owing to low rainfall, and because the infection was with *A. duodenale*, while the predominating hookworm infection of Queensland is with *Necator americanus*.

HISTORY OF THE INFECTION OF GOODNA HOSPITAL.

It was at the Hospital for the Insane at Goodna, then known as the Woogaroo Lunatic Asylum, that the first authentic case of hookworm disease in Australia was recorded by Hogg in 1889². The diagnosis was made at the autopsy of a male patient who had been in the hospital for ten years and had died of severe anaemia accompanied by general dropsy. Thirty to forty living *A. duodenale* were found adhering to the walls of the duodenum and upper jejunum. The hospital records prior to the death of this patient give little evidence to show whether hookworm disease was present in the institution. One patient died of severe anaemia in 1885, but the record states that no worms were found in the duodenum.

The source of the original hookworm infection cannot at present be determined. The facts that the worms infesting the patients in 1889 were *A. duodenale* and that those now present are of the same species, while the predominant hookworm of Queensland is *N. americanus*, suggest that the infection has been maintained not by repeated introductions, but rather by the perpetuation in the series of inmates of a very early infection. The hookworms

¹ The work on which this paper is based was conducted with the support and under the auspices of the Commonwealth of Australia, the State of Queensland, and the International Health Board of the Rockefeller Foundation.

² Hogg, J. B. (i. 1889). A Case of Death from Anaemia due to *Ankylostomum duodenale*. *Austral. Med. Gaz.* 133-134.

may have been introduced originally by patients who had come from Europe or China, as *A. duodenale* occurs commonly in parts of both places.

Following Dr Hogg's case, diagnoses of ancylostomiasis have been made at various times at the hospital, but the number of cases recorded has been small, as only patients showing recognised symptoms of the disease were investigated prior to 1922. The treatment of only those patients showing obvious anaemia would not tend to control the infection, and therefore it is not surprising that it was carried from the former Woogaroo Asylum buildings on the flats by the Brisbane River to the buildings of the present Hospital for the Insane on the higher land.

In 1922 the examination of all the patients in the hospital was then undertaken by the staff of the Hookworm Campaign at the invitation of the Medical Superintendent, Dr H. Byam Ellerton, and with the cooperation of the hospital staff. The investigation began on May 15 and ended on October 31.

DESCRIPTION OF THE HOSPITAL.

The Hospital for the Insane is situated near the town of Goodna on the south bank of the Brisbane River fifteen miles west of Brisbane, in a region having an average annual rainfall of 36.8 inches. Experience in the hookworm survey of Australia, has shown that hookworm disease is usually absent from the Queensland white population, even from the barefooted children, in sections where the rainfall is below 40 inches.

The grounds of the hospital are spacious and attractive. The buildings are mostly of brick, but a few of the old wooden wards remain. All of the wards are kept scrupulously clean. Every ward or group of wards has its fenced-in yard for the patients. Most of the yards are large and well-grassed, but some are worn almost bare of vegetation. Soil pollution is rare and the number of patients who go barefoot is small except in the wards containing the less teachable insane, such as imbeciles and violent patients. In such wards stools could usually be found by searching, but the general appearance of the yards was always clean.

Some of the wards are provided with modern water-flushed closets while others still have earth closets with pans. Gradually the transition is being made from the pan system to the far more satisfactory disposal by sewerage to septic tanks. The equipment of the newer bath-rooms and wash-rooms includes enamelled baths and basins and tiled floors and walls. About two months before the investigation began the closets of Ward M 4, which showed the highest infection rate, were changed from the system of outdoor pan-closets to water-flushed closets inside the building, but easily accessible from the yard. Ward M 5, the male ward having the next highest rate of infection, was in a transition stage, with a temporary pan-closet in use while a modern water-closet was being installed. The other three wards where infection was high were still using pan-closets.

PREVALENCE OF HOOKWORMS AND OTHER INTESTINAL WORMS.

All of the patients of the institution were examined. The hookworm infection rate for the hospital as a whole was found to be 23·4 per cent., while the rates for the several wards ranged from 2·0 to 72·3 per cent. Next to the hookworm the most common intestinal worm was *Trichuris trichiura*, for which the infection rate was 13·3 per cent. for the whole institution. The infection rate for this parasite was highest in the wards where hookworm infection was heavy, and lowest where hookworm infection was low, suggesting that the general conditions favouring hookworm transmission also favoured infection with *T. trichiura*.

The infection with *Oxyuris vermicularis* (4·2 per cent.) was a little more extensive in the hospital than among the general white population outside institutions, and varied irregularly between the different wards. The actual number of persons infected with *O. vermicularis* is distinctly higher than the number discovered by the examination of stools for ova, as the ova of this parasite are not evenly distributed through the stool.

The ova of *O. incognita*¹ were found about as frequently as those of *O. vermicularis*, but the distribution between wards was wholly irregular. The only other intestinal worms discovered were *Strongyloides stercoralis* and *Hymenolepis nana*, each of which was found only once. *Ascaris lumbricoides* was not found.

HOOKWORM INFECTION AS RELATED TO THE SOURCE OF THE PATIENTS.

If a considerable part of the infection with hookworms was being brought in by the patients when admitted, a much higher proportion of the infected patients than of the non-infected should come from those areas of Australia in which hookworm disease is endemic.

As a hookworm infection survey of Australia had been completed it was possible to classify the patients according to whether or not they had come from areas of endemic hookworm disease. The results of examinations in four wards are shown in Table I. It will be noticed that the proportions of patients coming from infested and non-infested areas are practically the same

Table I. *Hookworm Infection in Relation to Source of Patients.*

Wards	Infested patients		Non-infested patients	
	From infested areas	From non-infested areas	From infested areas	From non-infested areas
M 4	31	68	12	26
M 5	12	18	12	22
F 1	12	16	5	14
F 2	12	28	15	38
Total	67	130	44	100

¹ Kofoid, C. A., and White, A. W. (22. ii. 1919). A New Nematode Infection of Man. *Journ. Amer. Med. Assoc.* 72, 567-569.

for the infected and non-infected groups in the two male wards included in the table and differ only moderately in the two female wards. These observations strengthen the evidence that the infections were nearly all contracted within the institution.

HOOKWORM INFECTION AS RELATED TO LENGTH OF STAY IN THE INSTITUTION.

If most of the hookworm infection was contracted within the institution, the infected patients should have had the longest average length of stay. On the other hand, if the infection was chiefly contracted before admission, many infections should have disappeared gradually as the worms died out, and the non-infected patients should have been in the institution longest. In Table II is shown the average length of stay for the patients in the five wards where infection was highest and in one ward where there was little infection (M 9). Except in one of these wards (M 5) the average length of stay for the infected patients was longer than for the non-infected.

Table II. *Hookworm Infection as Related to Average Length of Stay in Hospital.*

Ward	Infected patients Stay in months	Non-infected patients Stay in months
M 4	133	72
M 5	89	94
M 6	101	88
M 9*	226	125
F 1	77	74
F 2	96	49

* Slight infection with hookworm.

DISTRIBUTION OF HOOKWORM INFECTION ACCORDING TO WARDS.

The amount of hookworm infection was very irregularly distributed between wards. Five wards had over 20 per cent. of infected patients, while several had about 3 per cent.

Starting with the assumption that most of the hookworm infection took place in the five highly infested wards, the records were studied to find how many of the infected patients in the other wards had been in one of the highly infested wards within the past six years and might have contracted the infection there. After deducting from the total number of infected patients in the more lightly infected wards, the number of these who had been in the five highly infested wards, the remaining number gave infection rates represented by the black columns in Fig. 1.

It will be noticed that these modified rates for five wards, excluding the hospital ward, were as low as 2 per cent. The infection rates of the two admission wards, M 2 and F 7, were 1.6 and 2.0 per cent., which may be taken as approximately the amount of hookworm infection brought into the hospital by new patients.

From the evidence presented it would seem safe to conclude that most of the infections in the institution took place in five of the twenty wards, M 4, 5, and 6, and F 1 and 2.

RELATION OF MENTAL CONDITION TO HOOKWORM INFECTION.

The outstanding factor determining the infection rates in the various wards was found to be the type of mental impairment of the patients. The wards containing a considerable proportion of imbeciles, idiots, and epileptics, and those in which there were violent insane patients, had been spreading hookworm disease, while the others had been relatively free. The ward where infection was greatest, M 4, contained among its 137 inmates, about forty-seven imbeciles and idiots and about sixteen epileptics. In these groups were a number of children. Ward F 2 contained congenital imbeciles and idiots and also

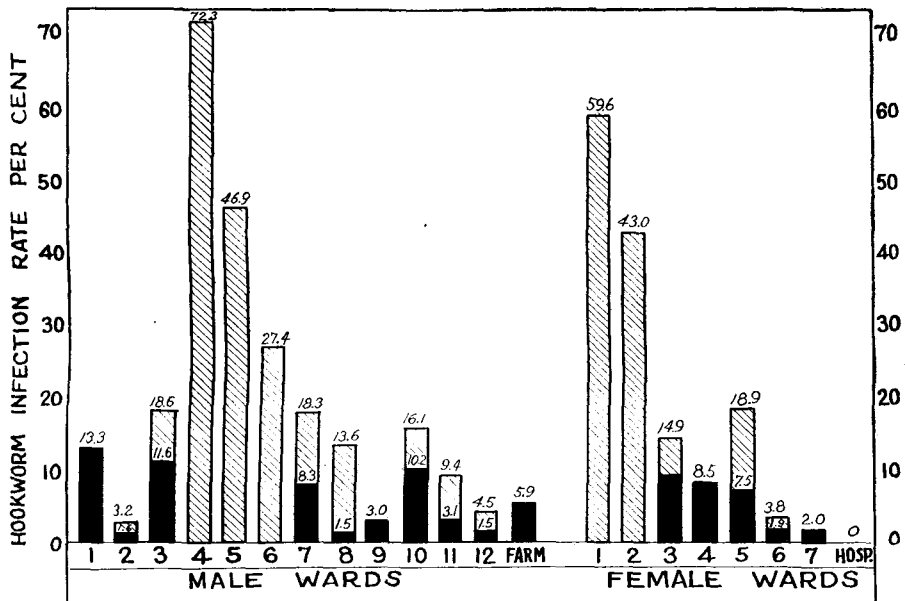


Fig. 1. Hookworm infestation rates by wards (total height of columns), and rates after excluding patients who had been in the five heavily infested wards within six years (dark columns).

noisy and troublesome female patients, including some of the epileptics. In this ward there were about thirteen idiots and imbeciles and five additional epileptics. There were a few children in the ward. Wards M 5 and F 1 contained the most violent adult insane, and Ward M 6 contained males having mental conditions similar to those of the patients in M 5 but much less violent. It will be noted that the infection rate in M 6 is the least of those of the five highly infested wards. Thus it appears that the wards containing the most unmanageable or unteachable insane were the ones in which hookworm disease had been spread most actively.

No evidence was obtained suggesting that the mental condition for which any of the patients were originally admitted was related to hookworm infection. The patients in the hospital were nearly all of the white race. Nine

persons were noticed who were of other races; and three of these were found to be infected.

INFECTION IN RELATION TO SHOE-WEARING.

According to nurses and attendants who had been long in the wards, 105 of the infected patients of the highly infested wards frequently went barefoot, while 121 usually wore boots. Of the non-infected patients of these wards only 29 had been habitually going barefoot, while 192 wore boots almost constantly. Many of the patients recorded as wearing boots took them off occasionally in the yards and may have been infected through the skin of their feet.

ANAEMIA DUE TO HOOKWORM INFECTION.

As the degree of anaemia accompanying hookworm infection is probably our best index of the damage being done by the disease, particularly where malaria is absent, as at Goodna, the percentage of the normal amount of haemoglobin in the blood was measured by the Tallquist scale for all infected patients and for the non-infected patients in the five heavily infested wards (M 4, 5, 6, and F 1, 2) and also in one of the least infested (M 9).

The results indicated that the average infection at the Hospital for the Insane was light, for the average loss of haemoglobin was only 2·2 per cent. of the normal in the five wards where the rate of infection was high. On the other hand, a small number of the patients were severely affected. All but one of the 22 patients having a haemoglobin percentage below 70 were infected with hookworms and were regarded as definite cases of hookworm disease. Seven patients, all of them infected, had severe anaemia; their haemoglobin percentages ranged from 40 to 55 per cent. of the normal. The average haemoglobin percentages for all infected patients was 78·4 in the male wards and 73·9 in the female wards.

The blood of ten of the more heavily infected patients showed a marked eosinophilia: 11 to 34 per cent. (average was 18·8 per cent.).

TREATMENT FOR HOOKWORM INFECTION.

The infected patients were treated either with oil of chenopodium or with carbon tetrachloride. Many persons received both drugs in the course of the series of treatments which proved necessary before a cure could be attained. The administration of treatments began in the male wards. At first the dosage for adults was either 1·5 c.c. of oil of chenopodium in a single dose followed in one hour by a purge of magnesium sulphate, and repeated in seven days; or a single dose of 3 c.c. of carbon tetrachloride followed usually, but not always, in four hours by a purge of magnesium sulphate. For those under seventeen years of age the dosage of chenopodium was 0·06 c.c. for each year, and the dosage of carbon tetrachloride was 0·06 c.c. for each cubic centimetre of the adult dose. In no case was there preliminary fasting or purging. The treatments were administered at 6.30 a.m. The patients treated were given no

breakfast, but all had their midday meal. Re-examinations were made not less than three weeks after the end of the treatment.

The reports from other countries regarding the effectiveness and safety of carbon tetrachloride, when used experimentally in animals or in thousands of patients infected with *Necator americanus*¹ led us to hope that a single dose of 3 c.c. would remove most of the hookworms present, even those of the species *Ancylostoma duodenale*, and would cure a large proportion of the patients. We were sadly disappointed, however, for only 23·1 per cent. of the patients who received carbon tetrachloride in this amount were cured, while 46·7 per cent., or twice as many, of those receiving the standard course of two treatments with 1·5 c.c. of oil of chenopodium were freed from infection. The counting of worms passed after treatment confirmed the relative failure of carbon tetrachloride in doses of 3 c.c. In subsequent treatments the dosage was gradually raised to 5, 6, 8, or 10 c.c. for the healthy adult. With 5 c.c. and 6 c.c. dosages the results were still slightly inferior to those obtained with the standard chenopodium treatment, but the efficiency of the 8 c.c. and 10 c.c. doses definitely exceeded that of two 1·5 c.c. treatments of chenopodium and was a little greater than that of a single undivided dose of 2 c.c. of chenopodium.

On account of the change in the method of treatment from time to time, the detailed results cannot all be brought together in a simple table. In Table III, however, are shown all the first treatments given and the percentage of resultant cures, and in Table IV are shown all subsequent treatments grouped together

Table III. *Results of First Treatments.*

Drug	Dose	Male wards		Female wards		All wards		%
		Treated	Cured	Treated	Cured	Treated	Cured	
Carbon tetrachloride	3 c.c.	91	21	10	1	101	22	21·8
	5 c.c.	0	—	20	6	20	6	30·0
	6 c.c.	0	—	20	5	20	5	25·0
	8 c.c.	0	—	21	14	21	14	66·7
Oil of chenopodium	1·5 c.c.	150	70	0	—	150	70	46·7
	repeated in 7 days							
	2·0 c.c.	0	—	15	11	15	11	73·3
Total		241	91	86	37	327*	128	39·2

* Excluding 15 first treatments which were of selected cases or otherwise irregular.

¹ Lambert, S. M. (1. vi. 1922). *Ankylostomiasis: Observations on Twenty Thousand Treatments with Carbon Tetrachloride*; Government Printer, Suva, Fiji.

Nicholls, L. and Hampton, G. G. (1. vii. 1922). Treatment of Human Hookworm Infection with Carbon Tetrachloride. *Brit. Med. Journ.* II. 8-11.

Hall, M. C. (19. xi. 1921). The Use of Carbon Tetrachlorid for the Removal of Hookworms. *Journ. Amer. Med. Assoc.* 77, 1641-1643.

Lake, G. C. (12. v. 1922). Carbon Tetrachloride. A Drug Proposed for the Removal of Hookworms, with Special Reference to its Toxicity for Monkeys when Given by Stomach Tube in Repeated Doses. *U.S. Pub. Health Reports*, 37, 1123-1126.

Leach, C. M. (10. vi. 1922). Carbon Tetrachlorid in the Treatment of Hookworm Disease. *Journ. Amer. Med. Assoc.* 78, 1789-1790.

according to drug and dose regardless of the number of kinds of previous treatments. The percentages of cures are also shown for purposes of comparison.

Table IV. *Results of All Treatments after the First.*

Drug	Dose	Male wards		Female wards		All wards		%
		Treated	Cured	Treated	Cured	Treated	Cured	
Carbon tetrachloride	3 c.c.	8	0	1	1	9	1	11.1
	5 c.c.	2	1	0	—	2	1	—
	6 c.c.	19	9	0	—	19	9	47.4
	8 c.c.	14	11	8	7	22	18	81.8
	10 c.c.	121	93	45	33	166	126	75.9
Oil of chenopodium	1.5 c.c.	4	2	0	—	4	2	—
	2 c.c.	44	28	12	4	56	32	57.1
	2.5 c.c.	3	1	1	0	4	1	—
Total		215	145	67	45	282*	190	67.4

* Excluding 150 second chenopodium treatments in courses of two chenopodium treatments, shown in Table V, and 11 treatments not adaptable to this table.

SYMPTOMS AFTER TREATMENT.

Watch was kept for any symptoms which would suggest that the limit of tolerance of the vermifuge was being reached. On account of the mental condition of the patients minor symptoms were doubtless overlooked. The outstanding symptoms were vomiting and drowsiness. Vomiting occurred occasionally with both of the vermifuges, the frequency tending to rise gradually as the dose increased. The amount of vomiting was about the same after oil of chenopodium as after carbon tetrachloride, comparing separately the smaller and the larger doses of each and this symptom occurred most frequently immediately after the purge was administered.

Only one patient showed the persistent vomiting which occurs occasionally after the administration of carbon tetrachloride. A woman who had received 10 c.c. of the drug vomited two hours later, before the purge was administered, and vomited occasionally until the evening of the third day. She had had no previous treatment with carbon tetrachloride or oil of chenopodium.

Drowsiness was noted in a few cases after treatment with oil of chenopodium, but it occurred most frequently in the patients who had received 10 c.c. of carbon tetrachloride. It was observed twenty-eight times in the group of 169 treatments with this dosage, and usually came on soon after treatment, but disappeared a few hours later.

Six patients, three of whom had received 1.5 c.c. of oil of chenopodium and three 10 c.c. of carbon tetrachloride, were noticed to be cold and perspiring from one to three hours after treatment. One of those receiving carbon tetrachloride had also a rapid and feeble pulse. His earlier treatments had been with chenopodium only. These symptoms disappeared during the day.

The symptoms following the larger doses of carbon tetrachloride seemed to occur about as often in those who had not had previous doses of the same drug as in those who had.

HOOKWORM LARVAE IN THE SOIL.

The source from which the patients received hookworm larvae was of great interest, as the institution lies outside the hookworm belt. Soil sampling was accordingly undertaken in the hospital yards in the autumn on May 22, 1922, and was continued until the spring, ending on September 26, 1922. The wards receiving most attention were those most highly infested, Wards M 4, 5, and 6 and F 1 and 2. In all, 66 soil specimens were examined. The chances of finding large numbers of hookworm larvae in the earth of the yards were diminished by two factors: the cool weather of the autumn, winter, and spring, during which the investigation was carried on, and the fact that patients had been treated until their faeces were free from hookworm ova.

Soil samples of about 500 c.c. each were collected in glass bottles and conveyed to the Central Office of the Hookworm Campaign in Brisbane. There they were examined by the Baermann method as modified by Cort and his associates¹.

Each sample was put in a cylindrical sieve lined with cloth and placed in a large glass funnel closed at the outlet by a piece of rubber tubing and a pinch-cock. Water at a temperature of 46° C. was added until it rose above the bottom of the soil. The apparatus was then allowed to stand over night. The following morning the fluid at the bottom of the funnel was drawn off and examined under the low power of the microscope. Hookworm larvae and free-living nematodes were noted, and the former were counted. The sheathed and unshathed hookworm larvae were recorded separately. Fluid was drawn from the apparatus and examined on three successive days, but most of the larvae were found in the first specimen.

In the examination of samples taken during the early part of the winter it was found that hookworm larvae were present in moderate numbers in a few samples, but only in the superficial layers of soil directly under recent stools. Many specimens taken at various depths where pollution was less recent showed no hookworm larvae, or exceedingly few. The evidence seems to indicate that in the season which is less favourable to hookworm larvae on account of lowered temperature and lessened rainfall, larvae may still hatch and develop, but will do so in considerable numbers only in the immediate vicinity of very recent stools. There had been rains shortly before the more heavily infected specimens were taken, and this doubtless favoured the development of the larvae. Although the number of observations were few, they seem to justify the conclusion that most of the infections of patients at Goodna took place outside the winter months, and that the larvae largely disappeared from the soil when conditions of temperature and moisture became unfavourable.

In Ward M 4, with the high infection rate of 72.3 per cent., only one place

¹ Cort, W. W., Ackert, J. E., Augustine, D. L., Payne, F. K. (i. 1922). The Description of an Apparatus for Isolating Infective Hookworm Larvae from Soil. *Amer. Journ. Hyg.* II, 1-16.

in the yard (Spot 7) was found at which the number of larvae was sufficient to indicate a possible source of infection. At the time of first and second examinations there were remnants of stools near this spot. In the first half of Table V the results of the examinations of specimens at and near the spot are shown. There was no shade in this place and the grass was thin and short from wear. The ground sloped gently. The surface soil was a dark garden earth, varying from dry to moist according to the rainfall of the previous fortnight. Six to twelve inches below the surface the soil was mostly yellow sand; at greater depths we encountered a compact mixture of sand and clay. In the north-west corner of the yard, where the ground was moister, the grass deeper, and pollution more common than elsewhere, no larvae were found in repeated samplings. From a hole in the asphalt walk in the yard some faeces and rubbish were taken which were swarming with free-living forms of *Strongyloides stercoralis*.

Results of examinations at Spot 42 in Ward F 2 which were also of special interest are shown in the latter half of Table V. The place at which the samples were taken was on a steep slope devoid of shade and covered by long grass; it was of made ground and consisted of garden earth, stones, and sand. At a depth of about 20 inches clay was reached. On the day the first specimen was secured an old stool was scraped away from the place. This may account for the large number of larvae found in the first sample.

In the north-east corner of the yard of Ward F 2 eleven specimens were taken at various depths on June 13 and 16 and September 26. Here the grass was thin and worn, and there was no shade except from buildings during a small part of the day. Pollution of the ground was frequent, and at one time there was an old stool on the surface at the place of sampling. Ova of the appearance of those of the hookworm were found in the sample from under this stool, but no hookworm larvae. The earth consisted of loam and stones, with clay 20 inches from the surface, and was moist or dry according to the previous rainfall. No hookworm larvae were found in any specimen from this locality.

In the yard of Ward M 5 one unsheathed hookworm larva was found at Spot 11 and one sheathed and one unsheathed larva at Spot 14. Both specimens were from the top six inches of soil. In the centre of the yard was a temporary latrine; the ground beneath it was wet from washings from above. Only one hookworm larva was found under the structure or near it. Possibly the use of disinfectants may have been an inhibiting factor.

Ward F 1, containing the violent insane women, ranked second in rate of hookworm infection. The yard is relatively small. It slopes rather steeply, and is absolutely devoid of vegetation. There is no shade except from fences and buildings. The slope is of hard, packed clay furrowed by rain, but toward the bottom of the incline a layer of loose sand has accumulated, and at this point stools were seen. A soil sample from the clay slope showed no larvae, and several samples taken at different depths at the bottom of the slope,

where the sand and pollution were noted, were devoid of larvae. The soil in the sandy spot consists of sandy earth, sand, and clay. At a depth of 18 inches or more the clay became very compact and was mixed with coarse sand and friable stone.

The conditions in this yard showed that vegetation and shade are not necessary for the development of hookworm larvae in considerable numbers. The absence of shade and vegetation may possibly have been offset by the increase of the moisture at the sandy foot of the slope occasioned by the run-off from the impervious clay surface above. Samples were taken in this ward to a depth of two feet, at which depth an impervious layer of clay and soft stone was reached, but no larvae were found. It seemed more probable that the larvae had died out than that they had descended to escape drying and cold.

Table V. *Hookworm Larvae Recovered from the Soil at Spot 7 in Ward M 4 and Spot 42 in Ward F 2.*

Locality	Date 1922	All depths		0-6 in.		6-12 in.		12-18 in.		18-24 in.	
		Sheathed	Un-sheathed	Sheathed	Un-sheathed	Sheathed	Un-sheathed	Sheathed	Un-sheathed	Sheathed	Un-sheathed
Ward M 4	May 22	27	2	27	2						
Spot 7	May 26	214	110	214*	110						
	June 2	43	1	0	1	43	0				
	June 20	8	3	7	3	1	0	0	0	0	0
	Sept. 26	0	0	0	0	0	0	0	0	0	0
Total at Spot 7		292	116	248	116	44	0	0	0	0	0
Ward F 2	June 13	412	6	412†	6						
Spot 42	June 16	11	0	11	0	0	0	0	0	0	0
	Sept. 26	0	0	0‡	0	—	—	0§	0	0	0
Total at Spot 42		423	6	423	6	0	0	0	0	0	0

* In top 3 inches, 23 sheathed and 55 unsheathed.

† In top 3 inches.

‡ Top 12 inches in one specimen.

§ 12-24 inches in one specimen.

CONTROL MEASURES RECOMMENDED.

At the conclusion of the investigation at the Goodna hospital the following measures for the control of hookworm disease were recommended to the Superintendent of the hospital:

1. That the patients in the five wards where infection was high be examined for hookworm disease annually and treated with oil of chenopodium if infected. That all anaemic patients in the institution should be examined as soon as the condition is noticed, and given treatment if infected.
2. That patients be examined on admission and before discharge or transfer from the five wards of present high infection, and that those infected be treated, as far as practicable, to a cure.
3. That the yard of Ward F 1 be paved as soon as possible with asphalt

to prevent the development of hookworm larvæ, and that the similar paving of Ward M 4 be considered after the results of the re-examination of the patients in 1923 are available.

4. That all patients be compelled to wear boots continuously while in the yards, locked boots being used when necessary.

5. That constant efforts be made to train the patients not to defecate on the ground, and to have stools removed from the yards as quickly as possible.

CONCLUSIONS.

1. An institutional infection with *Ancylostoma duodenale* has existed for over thirty-seven years in the State Hospital for the Insane at Goodna, Queensland.

2. The average severity of the infection is low, but a moderate number of heavy infections were present at the time of investigation, and deaths from hookworm disease have occurred.

3. The infection is essentially institutional; the hospital lies outside the hookworm belt, the residents in the vicinity are free from hookworms, and the predominating species of hookworms in Queensland is *Necator americanus*.

4. Most of the infection found in the twenty wards was contracted in the five which contained the highest proportion of unteachable and violent insane, and infection varied with the amount of soil pollution and the number of patients going barefoot.

5. Carbon tetrachloride given in doses of three cubic centimetres was found to be relatively inefficient in removing *Ancylostoma duodenale* and decidedly inferior to chenopodium in ordinary dosage.

6. Carbon tetrachloride in doses of eight to ten cubic centimetres had a distinct laxative effect. Few important symptoms were encountered after the administration of these large doses, but they are not recommended for general use.

7. In a subtropical region outside the belt in which there is sufficient rainfall to permit hookworm disease to spread in the normal white population, and in winter, when temperature and rainfall are lowest, hookworm larvæ may hatch and develop in considerable numbers in the vicinity of recent stools moistened by showers, but the infestation tends to diminish rapidly and almost to disappear from the soil in a short time.

8. Hookworm infestation may be transmitted freely in the complete absence of vegetation if there is a high degree of soil pollution and sufficient moisture.

9. The effect of influences moderately unfavourable to hookworm larvæ is to reduce the proportion of ova in the soil and thus limit the production of larvæ developing to the infective stage.

MS. received for publication 4. vii. 1923.—ED.