

Epidemiological Studies on Guinea-worm Infection

C. R. R. M. REDDY, ¹ I. L. NARASIAH ² & G. PARVATHI ³

Dracontiasis is one of the most easily preventable of the tropical parasitic diseases, yet in India the infection is still present in large numbers of people and causes extreme degrees of morbidity and incapacitation.

The 10 000 inhabitants of 4 villages in South India were interviewed and the prevalence of guinea-worm infection was found to vary from 11 % to 54 %; the prevalence increased with the proportion of the population using step-wells. Questioning revealed that infections with more than one worm at a time had occurred in 707 out of 1759 infected persons, that reinfections were common and that many people had suffered for long periods.

A survey of the water supplies in a district of South India with a population of about 1.87 million showed that more than 0.5 million people were at risk of contracting the disease. The necessity for protected water supplies and for the conversion of step-wells into draw-wells is urgent.

Guinea-worm infection is one of the most easily preventable parasitic infections and yet it is very prevalent in parts of India. The infection causes prolonged suffering, misery, and incapacitation and a few people are permanently crippled. There have been very few epidemiological studies on guinea-worm infection and none in which statistical analyses were made. Sing & Raghavan (1957) reviewed the literature on the epidemiology of the worm and Stoll (1947) estimated the world incidence. In India, surveys have been carried out by Fairley (1925), Moorthy (1932), Rao (1942), Lindberg (1946a, 1946b, 1948), Patnaik & Kapoor (1967), and Datta (1964). Other surveys have been carried out in the Middle East (Lindberg, 1939, 1959), Ghana (Scott, 1960), Pakistan (Ansari, 1963) and Onabamiro (1958) did a survey on schoolchildren in Nigeria.

In a recent study Patnaik & Kapoor (1967) gathered hospital statistics on guinea-worm infections in India but these are unlikely to give a correct picture of prevalence. This paper reports the results of an epidemiological survey carried out in the Kurnool District, in South India.

MATERIALS AND METHOD

The inhabitants of 4 typical villages, with a total population of about 10 000, were interviewed by a

¹ Professor of Pathology, Kurnool Medical College, Kurnool, Andhra Pradesh, India.

² Professor of Social and Preventive Medicine, Kurnool Medical College, Kurnool, Andhra Pradesh, India.

³ Tutor in Pathology, Kurnool Medical College, Kurnool, Andhra Pradesh, India.

medical officer during the summer of 1967 and answers were obtained to the following questions: (a) age; (b) sex; (c) source of drinking-water; (d) whether drinking-water was filtered or boiled; (e) whether infected with guinea-worm or not; (f) if infected, age at first infection; (g) site of infection; (h) number of worms present at one time; (i) number of times infected; (j) number of days or months of suffering each time; (k) number of years of suffering; (l) the season in which the infection occurred; (m) how long was the person aware that he had a worm before the bleb appeared; (n) how long had he stayed in the village?

If one of the villages there was an outbreak of guinea-worm infection in 1967, when 261 people out of a population of 2013 were infected for the first time. The incidence of first infection was analysed statistically by age-group and by sex.

Kurnool District is situated at an altitude of 900 ft–1400 ft (274 m–427 m) between longitudes 76°58' E and 79°34' E and latitudes 14°54' N and 16°18' N. The average maximum temperature is 42.7°C and the average minimum temperature is 13°C. The climate is generally dry and the density of population is 207 per mi² (80 per km²).

Information regarding the number of villages in the district, the population in each village, the type of drinking-water supply and the presence or absence of guinea-worm infection in the village was also obtained so that a rough estimate of the prevalence in the district as a whole could be made from the data from the 4 surveyed villages.

The villages were selected to be representative of the type of village found in the district. Molagavalli had a population of 4569 and had 3 wells of which only one was a step-well: this well was used by about one-third of the population. Hussainapuram had a population of 2535, and had 2 wells, one of which is a step-well used by about half of the people. Tandrapadu is situated on the banks of a river and had a population of 2013 with only one well. The well was a step-well and everybody except a few lower-caste people used this well. The lower-caste people, who were not allowed to use the well, used the river water and were free of infection. The village of Meedivemula had a population of 679 with 2 step-wells and everyone in the village used step-well water. Thus it can be seen that in the first village about one-third of the population, in the second about half of the population, in the third most of the population and in the fourth village the entire population used step-well water for drinking. The data were analysed statistically wherever possible.

From the information available we were able to calculate the number of people infected prior to 1967, the number reinfected in 1967, the number first infected in 1967 and also the number who had never been infected.

RESULTS

Data for the total number of people of each sex present in each of the 4 villages, the number of people who had active infections in 1967 and the total number of people who either were infected or who reported that they had previously been infected are shown in Table 1. These data show that in each of the 4 villages more males were infected than females, although the differences in Hussainapuram and Meedivemula were not significant by the χ^2 test. For the total population of the 4 villages the difference between males and females was statistically significant. Similarly the prevalence of active infection was greater in males in the total population. Table 1 also shows that the percentage of the population with active infections in 1967 ranged from 2.39% to 44.48% in the 4 villages.

Table 2 summarizes the information obtained on the age of first infection. The Student's *t*-values were calculated between the males and females of each village and between males of one village and males of another village and also between females of one village and that of another village.

There were no significant differences, according to the Student *t*-test at the 1% level, in the mean age

TABLE 1
INCIDENCE OF GUINEA-WORM INFECTION

Sex	Molagavalli			Hussainapuram			Tandrapadu			Meedivemula			Total			
	In- fected	Not in- fected	%	In- fected	Not in- fected	%	In- fected	Not in- fected	%	In- fected	Not in- fected	%	In- fected	Not in- fected	%	
Male	321	2 002	13.82	325	952	25.45	422	615	40.70	210	158	368	1 278	3 727	5 005	25.54
Female	213	2 033	9.48	279	979	22.18	268	708	27.46	155	156	311	915	3 876	4 791	19.10
Total	534	4 035	11.69	604	1 931	23.82	690	1 323	34.28	365	314	679	2 193	7 603	9 796	22.39
χ^2	20.79			3.739			39.09			3.542			58.35			
P	<0.0005			>0.05			<0.0005			>0.05			<0.0005			
Total infection																
Male	55	2 268	2.37	139	1 138	10.88	278	759	26.81	174	194	368	646	4 359	5 005	12.91
Female	54	2 192	2.40	111	1 147	8.82	179	797	18.34	128	183	311	472	4 319	4 791	9.85
Total	109	4 460	2.39	250	2 285	9.86	457	1 556	22.71	302	377	679	1 118	8 678	9 796	11.41
χ^2	0.0066			3.031			20.56			2.559			22.60			
P	>0.9			>0.05			<0.0005			>0.1			<0.0005			
Active infection																

TABLE 2
DISTRIBUTION OF AGE AT FIRST INFECTION
BY SEX IN THE 4 SURVEYED VILLAGES

Age-group (years)	Molagavalli		Hussainapuram		Tandrapadu		Meedivemula	
	M	F	M	F	M	F	M	F
0-5	85	57	79	87	94	67	85	60
6-10	65	54	77	58	107	67	57	38
11-15	57	33	42	44	56	41	27	23
16-20	63	33	62	52	70	35	19	9
21-25	32	19	25	19	30	19	8	5
26-30	12	12	14	9	34	8	4	7
31-35	3	2	10	5	7	10	2	1
36-40	2	1	6	2	11	5	3	5
41-45	—	—	2	1	3	8	2	1
46-50	—	1	3	2	5	3	—	3
51-55	—	—	1	—	—	1	—	—
56-60	1	1	2	—	4	—	2	1
61-65	—	—	1	—	—	2	—	—
66-70	1	—	1	—	1	1	1	2
71-75	—	—	—	—	—	—	—	—
76-80	—	—	—	—	—	1	—	—
81-85	—	—	—	—	—	—	—	—
Total	321	213	325	279	422	268	210	155
Mean	12.53	12.30	14.06	11.84	14.42	14.53	10.24	12.00
SD	8.84	8.96	11.26	8.81	11.25	12.86	10.30	12.80

of first infection either between the sexes or between the different villages. The females and males of Tandrapadu, however, reported a slightly higher age at first infection than females of Hussainapuram and males of Meedivemula.

The sex and age of the people of Tandrapadu who were infected for the first time during the 1967 outbreak is shown in Table 3. In both males and females the χ^2 values show that the greater incidence of first infection in the lower age-groups was statistically significant. The rate of first infection increased in males up to the 11-15-year age-group and then decreased, and in females the peak age of first infection was in the 6-10-year age-group.

Table 4 gives the percentage of the infected persons who reported having been infected more than once. The data show that as people became older they were more likely to be reinfected: there was no

significant difference between the sexes. The percentages of people who were newly infected, previously infected, not infected in the year of study or who were never infected at any time, were also calculated but they did not give any significant information.

A survey of the water supplies in all the villages of the area was carried out and the numbers of villages with suspect supplies and the numbers of people at risk are shown in Table 5. From this table it is seen that in this district alone there were more than half a million people at risk of developing the infection. Although the proportions of infected persons in our 4 surveyed villages were very variable, ranging from 11.69% in Molagavalli to 53.75% in Meedivemula, we have used them to estimate the total number of people in this district who might have had infection at one time or another. On this basis it is estimated that a minimum of 59 695 or a maximum of 274 400 people could have been affected.

The interviews revealed that almost all the infected people had drunk step-well water without boiling or filtering it. Even those who boil or filter the water in their own houses may contract the infection by drinking untreated water in neighbouring houses. The number of families with some infection was as follows: 342 out of 933 families in Molagavalli, 311 out of 513 families in Hussainapuram, 306 out of 435 families in Tandrapadu and 140 out of 160 families in Meedivemula: in each family, not all the members were infected.

One further aspect of the problem has to be borne in mind, and that is the calcification of the worm. In our studies (Reddy et al., 1968) on the calcification of the worm we failed to find any history of guinea-worm infection in 19% of the people who had calcified worms even though they were from endemic areas. As a rule calcified worms are asymptomatic, and so acute guinea-worm infection need not occur in all those who have drunk step-well water. Some of these people may have a calcified worm and others may have no infection at all. Thus it is clear that the actual prevalence of infection is probably greater than that shown in the tables.

Most of the worms presented themselves in the leg but no part of the body was exempt from the infection.

Table 6 gives a summary of the number of days, prior to the actual formation of bleb, that people became aware that they had a worm, either by palpation or because of movement of the worm or because of allergic manifestations. From the table it is seen that only 37.03% (812 out of the 2193

TABLE 3
DISTRIBUTION OF AGE AT FIRST INFECTION IN TANDRAPADU IN 1967

Age-group (years)	Males				Females			
	Infected	Not infected	Total	%	Infected	Not infected	Total	%
0-5	18	164	182	9.89	24	143	167	14.37
6-10	27	147	174	15.52	36	126	162	22.22
11-15	24	72	96	25.00	13	70	83	15.66
16-20	22	88	110	20.00	9	86	95	9.47
21-25	10	79	89	11.24	7	75	82	8.54
26-30	13	92	105	12.38	6	100	106	5.66
31-35	5	36	41	12.20	7	36	43	16.28
36-40	10	101	111	9.01	3	82	85	3.53
41-45	2	9	11	18.18	5	26	31	16.13
46-50	4	55	59	6.78	2	45	47	4.26
51-55	—	8	8	—	1	10	11	9.09
56-60	4	32	36	11.11	—	41	41	—
61-65	—	6	6	—	2	3	5	40.00
66-70	1	5	6	16.67	—	10	10	—
71-75	—	1	1	—	—	1	1	—
76-80	—	2	2	—	1	5	6	16.67
81-85	—	—	—	—	—	1	1	—
Total	140	897	1 037	—	116	860	976	—
	$\chi^2 = 25.3377$ P = <0.01				$\chi^2 = 41.8329$ P = <0.0005			

infected people) knew that they had a worm before the bleb was formed and most of these who did know were aware of the fact only 8–10 days prior to the formation of bleb.

The seasonal awareness of infection in each village is shown in Table 7. Most people were aware of their infection in the summer and fewest people were aware of their infection in the October-January period. A few had the infection right through the year.

The answers given to the questions concerning the occurrence of multiple infections, the frequency of reinfection and the period of suffering are analysed in Table 8. To ascertain the number of worms that had been involved at any one time people were asked to report the maximum number of worms they had seen at one time emerging from different parts of their body. The duration of suffering shown in this table is the length of time that people reported

having been bedridden or absent from their work. Since there was not much difference in the findings from each village, only the totals for the 4 villages are given. The table shows that 707 out of 1759 people (40%) had had more than one worm at a time, 1126 out of 1884 people (60%) had been infected more than once and that some had been infected up to a 100 times. It is also seen that 1090 out of 1769 (62%) of the people from whom the information was available reported having suffered for more than one year. Thus it is clear that more than half of the people had suffered from recurrent infection and that some had suffered from recurrent infection for more than 50 years.

The length of the period of suffering from each infection is shown in Table 9. It is seen that 1265 out of 1709 people (74%) had suffered for a month or more from each infection, and quite a number of

TABLE 4
PERCENTAGE OF THE NUMBER OF INFECTED PERSONS IN EACH VILLAGE WHO WERE REINFECTED

Age-group (years)	Molagavalli		Hussainapuram		Tandrapadu		Meedivemula	
	M	F	M	F	M	F	M	F
0-5	—	—	100.00	50.00	42.85	50.00	80.00	100.00
6-10	30.77	—	66.67	55.56	80.77	52.00	96.67	90.48
11-15	40.00	50.42	65.00	93.34	80.00	44.44	90.91	88.24
16-20	51.72	64.00	36.85	67.85	85.71	76.47	84.62	88.24
21-25	50.00	58.33	73.08	68.75	70.83	62.50	84.62	84.62
26-30	75.00	71.43	84.44	75.00	82.61	90.00	88.46	100.00
31-35	78.57	66.67	91.84	53.85	83.33	60.00	77.78	57.15
36-40	75.00	65.00	88.24	90.00	84.00	84.62	80.00	88.89
41-45	87.50	85.69	81.82	100.00	100.00	100.00	75.00	100.00
46-50	84.21	85.69	68.75	66.67	84.62	90.91	85.71	85.71
51-55	71.43	100.00	100.00	100.00	50.00	50.00	100.00	100.00
56-60	100.00	55.56	60.00	50.00	90.91	100.00	100.00	80.00
61-65	100.00	100.00	100.00	—	100.00	—	100.00	100.00
66-70	100.00	66.67	100.00	66.67	—	—	83.34	—
71-75	100.00	—	50.00	—	—	—	—	—
76-80	100.00	—	—	100.00	—	100.00	100.00	—
81-85	—	—	100.00	—	—	—	—	—
86-100	—	—	100.00	—	—	—	—	—

TABLE 5
**NUMBER OF VILLAGES WITH A SUSPECT WATER SUPPLY
AND THE POPULATION AT RISK IN THESE VILLAGES**

District	Total No. of villages	No. of villages having suspect water supply	Total population	Population at risk
Adoni	177	14	260 942	21 933
Alur	98	47	125 817	67 453
Allagadda	19	52	110 656	38 181
Atmakur	61	6	78 850	8 380
Banaganapalli	66	47	60 657	38 250
Dronachalam	190	141	149 690	100 775
Giddalur	239	19	169 557	13 970
Koilkuntla	120	28	154 860	39 883
Kurnool (excluding Kurnool city)	95	32	161 521	38 470
Markapuram	87	Nil	152 931	—
Nandikotkur	73	20	89 208	30 373
Nandyal	91	34	159 800	46 400
Pattikonda	70	60	177 408	66 248
Total	1 486	500	1 871 897	510 316

TABLE 6
NUMBER OF DAYS BEFORE THE APPEARANCE OF THE BLEB THAT PEOPLE
WERE AWARE THEY HAD A WORM

No. of days	Molagavalli	Hussainapuram	Tandrapadu	Meedivemula	Total
1	36	3	—	15	54
2	16	27	1	34	78
3	29	24	19	60	132
4	11	44	21	27	103
5	6	11	6	37	60
6	6	5	9	7	27
7	16	11	—	9	36
8	22	32	3	21	78
9	—	—	—	2	2
10	22	24	6	19	71
11-15	13	18	25	34	90
16-20	1	4	7	4	16
21-25	1	1	—	—	2
26-30	2	23	30	8	63
Movement	3	26	—	—	(29)
Total					812

them had suffered for anything up to 3 months. Only a few people had had a short period of suffering and the maximum period was 1 year. This information, coupled with the number of recurrent infections, gives an idea of the enormity of the suffering and of the consequent economic loss.

DISCUSSION

Our figures show that in a village (Molagavalli) where one-third of the people used step-well water

the infection was present in 11.69% of the people; in Hussainapuram, where half of the people used the step-well water, 23.82% had the infection; in Tandrapadu, where most of them used step-well water, 34.28% had the infection; and in Meedivemula, where everyone used step-well water 53.75% had the infection. Thus not all people who drink step-well water become infected.

Scott (1960) gave a fractional test meal to 7 men and showed that the level of acid in the stomach was higher 2 hours after the meal in the men without

TABLE 7
NUMBER OF PERSONS AWARE OF THEIR ILLNESS AT DIFFERENT SEASONS

Season	Molagavalli	Hussaina- puram	Tandrapadu	Meedivemula	Total
Summer (Feb.-May)	393	263	429	204	1 289
Rainy (June-Sept.)	3	106	8	10	127
Winter (Oct.-Jan.)	5	17	15	7	44
All through the year	7	109	46	107	269

TABLE 8
HISTORY OF INFECTION

No. of worms at one time	No. of people	No. of times infected	No. of people	Duration of infection (years)	No. of people
1	1 052	1	758	1	679
2	234	2	215	2	128
3	183	3	111	3	86
4	91	4	96	4	80
5	59	5	59	5	55
6	40	6	76	6	45
7	11	7	25	7	38
8	16	8	40	8	41
9	9	9	13	9	27
10	20	10	113	10	77
11-15	27	11-15	96	11-15	122
16-20	10	16-20	105	16-20	130
21-25	2	21-25	6	21-25	65
26-30	4	26-30	58	26-30	61
31-35	—	31-35	18	31-35	41
36-40	1	36-40	44	36-40	36
41-45	—	41-45	10	41-45	19
46-50	—	46-50	22	46-50	17
51-90	—	51-90	12	51-90	22
91-100	—	91-100	7	91-100	—
Total ^a	1 759		1 884		1 769

^a Totals represent the total number of people from whom the requisite information could be obtained.

TABLE 9
PERIOD OF SUFFERING FROM EACH INFECTION

Days of suffering	Molagavalli	Hussainapuram	Tandrapadu	Meedivemula	Total
1-5	3	11	3	7	24
6-10	30	64	22	19	135
11-14	99	48	23	46	216
15-21	14	22	11	22	69
one month	128	173	251	151	703
31-60	56	62	110	48	276
61-90	53	65	79	17	214
91-120	6	20	14	6	46
121-180	8	8	2	2	20
181-360	4	1	1	—	6
Total	401	474	516	318	1 709

infection than in the infected men. He did not take X-rays of the non-infected persons to rule out the presence of calcified worms. We are at present conducting a large-scale study of the role of acid in the stomach with respect to guinea-worm infection.

There have been very few previous surveys of guinea-worm infection. Our survey does not show any differences from the figures presented by Rao (1942) and Lindberg (1946a, 1946b, 1948) that young children (0-5 years of age) have less infection than those in the 6-10-year and the 10-15-year age-groups: in children less than 1 year old infection is uncommon. Our data agree with those of Lindberg (1946a, 1946b, 1948) which show that first infection can occur at any age, in our investigations the oldest person to report a first infection was a woman of 80 years of age in the village of Tandrapadu.

Our finding that the infection is more common in summer agrees with the results of other surveys (Rao, 1942; Lindberg, 1946a, 1946b, 1948). The people studied by Fairley (1925) each had on average about 1.9 worms. Our figures show about 2.2 worms per individual at a time. Our figures also bring out the fact that repeated infections are very common and thus are in accord with the conclusions of Rao (1942), Fairley (1925) and Scott (1960) that one infection does not give rise to any immunity.

The prevalence of the infection was much higher in our survey than in previous studies. Fairley (1925) mentioned that the general incidence in Madras

State was 29.64/1000 and 28.1/1000 in Deccan. Rao (1942) reported a maximum annual incidence of infection of 155.7/1000 in one village and a minimum of 11.8/1000 in another. Our survey in 1967 shows that we had a maximum of 444.7/1000 active infections in one village and a minimum of 23.85/1000 active infections in another. Lindberg (1946a, 1946b, 1948) reported the general prevalence to be 26.4% in parts of Andhra Pradesh and 45.6% in Rajasthan. Our highest rate of prevalence was 53.75% in one village.

Singh & Raghavan (1957) estimated the population at risk of developing guinea-worm infection in the state of Andhra Pradesh, as 0.9 million, and in the whole of India as about 5 million. The same figures are quoted by Patnaik & Kapoor (1967). From our detailed survey in 4 villages and our knowledge of number of villages having guinea-worm infection and also step-wells or other water supplies potentially capable of spreading the infection, we feel that more than 500 000 people are at risk of developing the infection in the Kurnool district alone. Patnaik & Kapoor (1967) showed that only 89 of the 329 districts in India had no infection and we think that the estimates of the numbers of people at risk in India quoted by Singh & Raghavan (1957) and Stoll (1947) of 5 million and 25 million, respectively, considerably underestimate the problem. When the amount of suffering of each infected individual is taken into consideration, the morbidity and the economic loss for the country becomes evident.

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RÉSUMÉ

ENQUÊTE ÉPIDÉMIOLOGIQUE SUR L'INFECTION PAR LE VER DE GUINÉE

Lors d'une enquête épidémiologique menée en 1967 dans quatre villages de l'Inde méridionale, tous les habitants, au nombre de 10 000 environ, ont été invités à répondre à une série de questions en vue de préciser la prévalence et les modalités de l'infection par le ver de Guinée (*Dracunculus medinensis*).

Cet interrogatoire a révélé une variation considérable de l'incidence globale de la dracunculose (cas anciens ou en évolution) suivant les villages, avec des taux respectifs de 11,69%, 23,82%, 34,28% et 53,76%. En 1967, au moment de l'enquête, le nombre des cas évolutifs

atteignait 2,39%, 9,86%, 22,71% et 44,48%. Le sexe masculin est plus souvent atteint que le sexe féminin, mais on ne note aucune différence notable sous ce rapport en ce qui regarde l'âge de la première infection. Dans le sexe masculin, le taux de morbidité est maximal dans le groupe d'âge 11-15 ans; dans le sexe féminin, dans le groupe d'âge 6-10 ans. Les jeunes enfants (0-5 ans) sont moins fréquemment infectés et la maladie est rare au-dessous d'un an. Sur 1759 sujets, 707 (40%) avaient été porteurs de plus d'un ver de Guinée à un moment donné de leur existence; sur 1884 sujets, 1126

(60%) avaient été infectés à plusieurs reprises, certains une centaine de fois. Enfin, chez 1090 personnes sur 1769, soit 62%, l'affection avait persisté pendant plus d'un an.

La principale mesure de prévention de la dracunculose consiste dans l'amélioration des installations d'approvisionnement en eau. L'infection est en effet contractée dans certains puits, où l'on accède au moyen de marches

(*step-wells*), qui offrent des conditions favorables à la transmission. Dans l'ensemble du district, 500 villages disposent d'installations de ce genre. Les auteurs estiment que sur une population totale d'environ 1 800 000 habitants, plus de 500 000 personnes sont exposées aux risques d'infection et que 59 695 personnes au minimum et 274 400 personnes au maximum ont pu contracter la maladie.

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