Guinea Worm and Water Supply in Kordofan, Sudan

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SYNOPSIS

A study of a guinea worm epidemiology in South Kordofan, Sudan, found two different patterns of infection. In four villages, all with large open reservoirs (hafirs), the one-year period prevalence was over 34 per cent, and was not strongly related to age. In the remaining 23 villages, the prevalence did not exceed 20 per cent but was greater in adults than in children. The former pattern suggested contamination of the water carried home, while the latter appeared to be associated with casual use of water sources outside the village. Guinea worm disease was associated with the use of certain water sources, particularly in the poorly-maintained hafirs, but not with hand pumps, when these functioned, or open dug wells. In this context, open dug wells seem to be a more cost-effective intervention for guinea worm control than boreholes with hand pumps or the rehabilitation of hafirs.

Key words: guinea worm; dracunculiasis; Sudan; water supply; epidemiology; hafirs; wells; hand pumps; cyclops; UNICEF; maintenance.

INTRODUCTION

Guinea worm disease (dracunculiasis) is the only human infection which is exclusively transmitted in drinking water. Its eradication has been adopted as a goal for the International Drinking Water Decade. Some countries, such as India, are making progress in this direction[1,2] but in parts of Africa the disease has been spreading as a result of water development projects[3] and increased mobility[4]. The disease has long been present in parts of the Sudan[5], but there is reason to fear its introduction to new areas due to increased movement of refugees from war and famine[6].

The chief symptom of the disease is a blister, usually on the leg, from which the female worm, 50–80 cm long, gradually emerges. The lesion is so painful that many sufferers are incapacitated for one to two months. Wetting of the blister to relieve the burning sensation causes the release of thousands of larvae. If these reach water containing *Cyclops* (a small aquatic crustacean sometimes known as a water flea) the *Cyclops* become infected. The disease is acquired by drinking water containing infected *Cyclops*. One year later, the blister appears and the cycle starts again.

The control of the disease requires an intervention which is technically simple; the provision of a clean water supply. However, difficulties may arise in maintaining the supply and in achieving the exclusive use of it, both of which require changes in human behaviour. This paper describes a study of the relation between water source choice and guinea worm disease in southern Kordofan District, Sudan.

SUBJECTS AND METHODS

Study Area and Population

Al-Buram Council, in South Kordofan, is in a savannah region; since 1985 it has had less than 500 mm annual rainfall. Since the 1972–73 drought there have been major programmes to improve water supply in the area by drilling boreholes and rehabilitating the large open reservoirs known as hafirs. Groundwater is normally confined to small fissures in the basement rock and borehole yields are poor.

The area is inhabited mainly by Nuba peoples, in villages of 1 000 inhabitants and over, usually strung out along the contours of the rocky hillsides. Most of the agricultural work in the relatively distant plains farms is the task of men. Women help them with winnowing and storing, and also work in the home and on the nearby hill farms. Young boys usually herd goats, sheep and calves, while youths of 12 to 20 years herd cattle and sheep in the cattle camps beyond the cultivation area. Girls help their mothers with domestic work, carry food to those working in the fields or at the cattle camps, and help with sowing, weeding, and reaping.

Survey

A total of 27 villages in Al-Buram Rural Council were chosen randomly, 13 from a list of villages which had been provided with handpumps and 14 from a list of villages which had not. Six trained interviewers, three of them female, each visited

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three to four households selected at random in each village and interviewed the head of household or, if absent, another adult household member. The interviews were conducted in Arabic. The survey was carried out in April 1987 at the height of the guinea worm transmission season, so that it was possible to confirm a large proportion of the reported cases by visual inspection.

A case of dracunculiasis was defined as the emergence of at least one female worm during the previous 12 months, and the month of onset of symptoms was established using an agricultural calendar. Other questions covered the drinking water sources used by the households in the dry season (October to April), when the peak transmission rate occurs. The interviews were concluded by explaining the mode of transmission and appropriate personal protection measures. Samples of water from the sources in most villages, roughly 20 litres from each, were filtered to test for the presence of cyclops, using a 0.5mm nylon mesh in the shape of a domestic kitchen sieve. This had been pierced in the centre and a small sample bottle suspended beneath the hole. Cyclops retained by the sieve were washed down into the bottle. Live *Cyclops* in sample bottles, visible to the naked eye, were an effective aid to health education.

Water Sources

Five main types of dry season water source are commonly used in the study area. Many households use more than one source, even in the dry season.

(1) **Hafir**. These are open reservoirs with a storage capacity of 10 to 50 Ml, excavated by earthmoving machinery and used by the community and by herdsmen from other villages. Seasonal flow from an adjacent stream (wadi) is diverted into the hafir. A valve on the large inlet pipe is closed by the watchman when the hafir is full, and an outlet pipe leads to a well, from which water is drawn for human consumption. The hafir is usually protected by a fence to prevent direct access, but this was often found to be damaged and the outlet well disused. People frequently wade into the hafir for water, and sometimes bathe beside it.

(2) **Karkour**. Many households divert run-off from adjacent hillsides into these excavated basins, where it is stored. They usually serve individual households, and are used by an estimated 40 per cent of the population as long as the water lasts. A karkour is usually covered with logs and stones, but the users wade in when collecting water (Fig. 1).

(3) **Mashisha**. These are shallow waterholes dug in dry river beds, each usually serving several households (Fig. 2). Their yield is poor and by the end of each day practically all the water has been scooped out from them, so that there is no permanent body of water in which *Cyclops* can become established.

(4) **Hand dug wells**. Wells are approximately 20 m deep and 1.5 m in diameter. Only a few are lined, and none has a parapet wall. They are available for use by the community at large.

(5) **Handpumps**. Boreholes fitted with India mark II handpumps exist in 13 of the 27 study villages. However, not all the inhabitants are adequately served by them since the pumps are often too few, too far away, or out of action.

RESULTS

Prevalences by Village, Age and Sex

The one-year period prevalence of dracunculiasis was recorded in 495 households with 3 242 members. Prevalence rates for individual villages ranged between 0 and 65 per cent (Fig. 3). The overall prevalence was 12.3 per cent. In four villages, all with hafirs, the prevalence was over 34 per cent, while in none of the remaining 23 villages did it exceed 20 per cent. No significant differences in prevalence between males and females were found, whether for the whole study (males 13.0 per cent, females 11.7 per cent) or taking the four heavily-infected villages separately. However, a slightly higher prevalence among males over 30 years was noticeable in the 23 less infected villages.

Patterns of age-specific prevalence differed between the four villages with high prevalence and the remainder (Fig. 4). In the four most infected villages, there was no significant difference in dracunculiasis prevalence between those under and those over 10 years of age ($X^2 = 2.07$, $p > 0.1$), although among children under five years the prevalence was less than for other age groups ($X^2 = 7.7$, $p < 0.01$). In the other villages there was a progressive increase in prevalence with age. The prevalence in children aged 5–9 was significantly lower than in the older age groups ($X^2 = 15.8$, $p < 0.001$), and among children under five it was lower still.

Prevalence According to Water Source

The prevalence of guinea worm disease among households using a single type of water source varied according to the type used. The results are given in Table I in descending order of prevalence. The same order is followed in Table II, which gives the results for users of multiple sources; those using each type are counted against it, excluding those included in previous lines of the Table. With the exception of the low prevalence among the relatively small number of mashisha users, the same descending trend can be seen. In the following discussion, unless otherwise stated, the users of each type of source are taken to include those listed against that type in both Tables I and II.

(a) **Hafir**. The prevalence of infection among hafir users was twice that in any other group. Among exclusive hafir users it was 37.6 per cent, not significantly greater than among those using hafirs together with other sources (35.3 per cent). How-

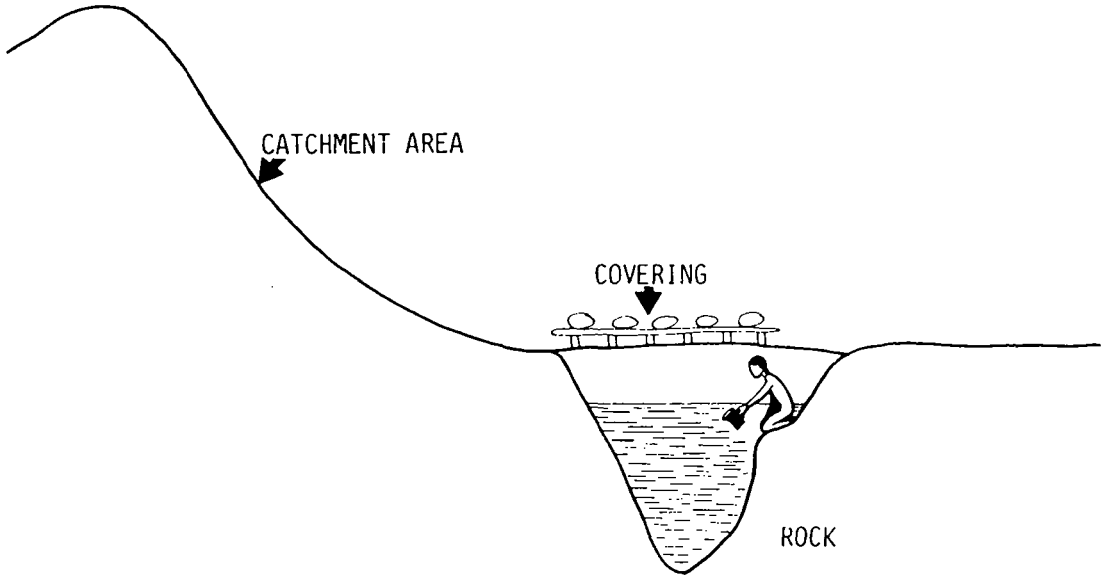

Fig. 1. Sketch of a karkour

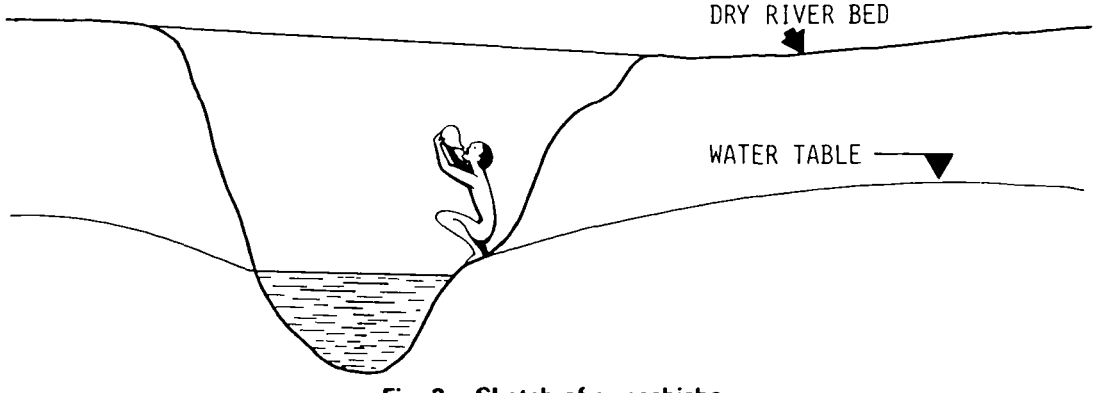

Fig. 2. Sketch of a mashisha

TABLE I. GUINEA WORM INFECTION BY DRY SEASON WATER SOURCE TYPE: HOUSEHOLDS USING A SINGLE TYPE

Source type	No. of persons	No. infected	Prevalence, %
Hafir	210	79	37.6
Karkour	74	14	19.0
Mashisha	58	3	5.2
Dug well	1033	39	3.8
Handpump	204	7	3.4
Other	36	0	0.0
Total	1615	142	8.8

TABLE II. GUINEA WORM INFECTION BY DRY SEASON WATER SOURCE TYPE: HOUSEHOLDS USING MULTIPLE SOURCES

No.	Source type	No. of persons	No. infected	Prevalence, %
1	Hafir and others	451	159	35.3
2	Karkour and others, excluding 1	100	18	18.0
3	Mashisha and others, excluding 1, 2	79	2	2.6
4	Dug well and others, excluding 1–3	968	78	8.1
5	Handpump and others, excluding 1–4	29	0	0.0
	Total	1627	257	15.8

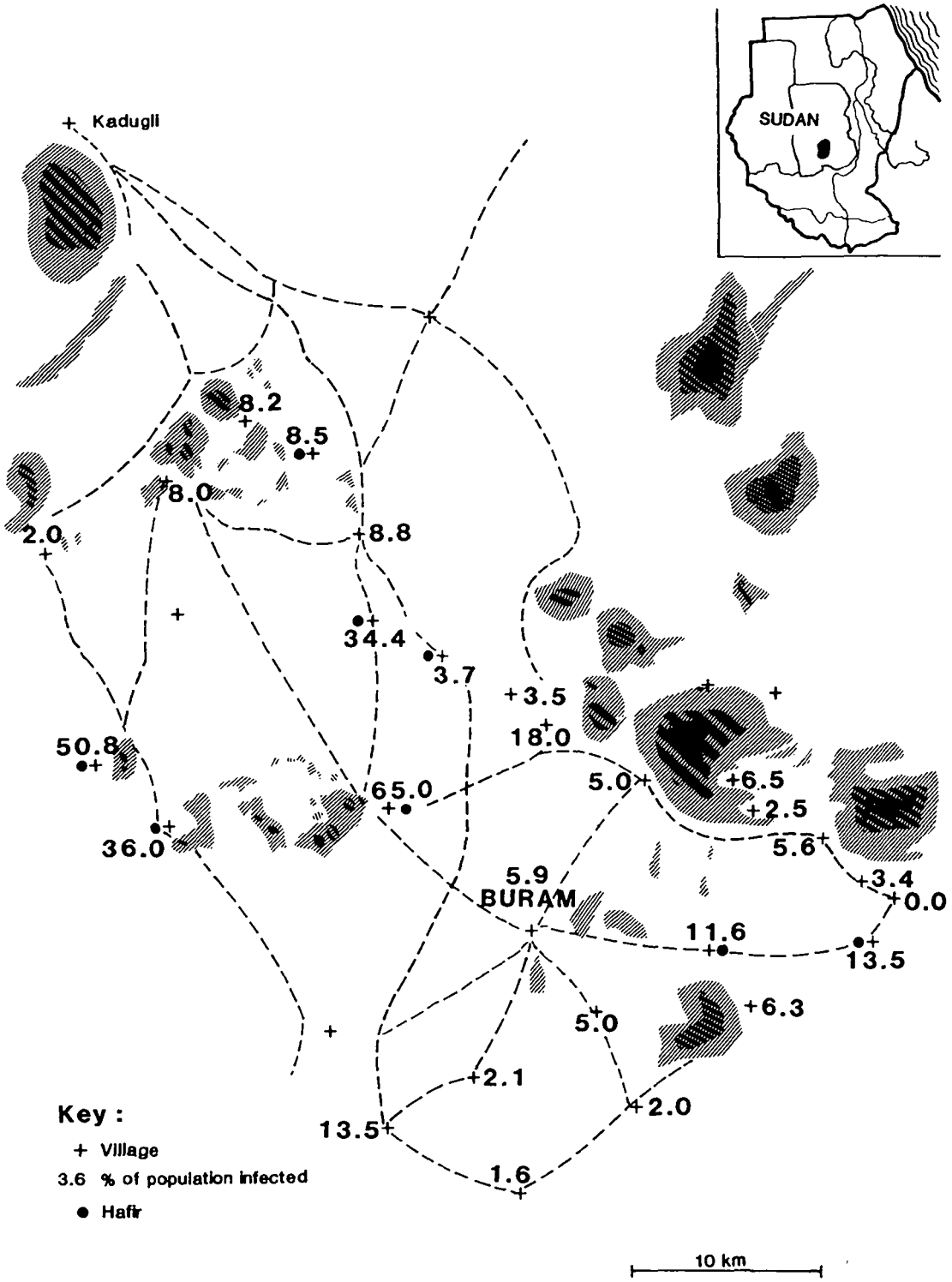

Fig. 3. Map of survey area showing village prevalence rates and location of hafirs

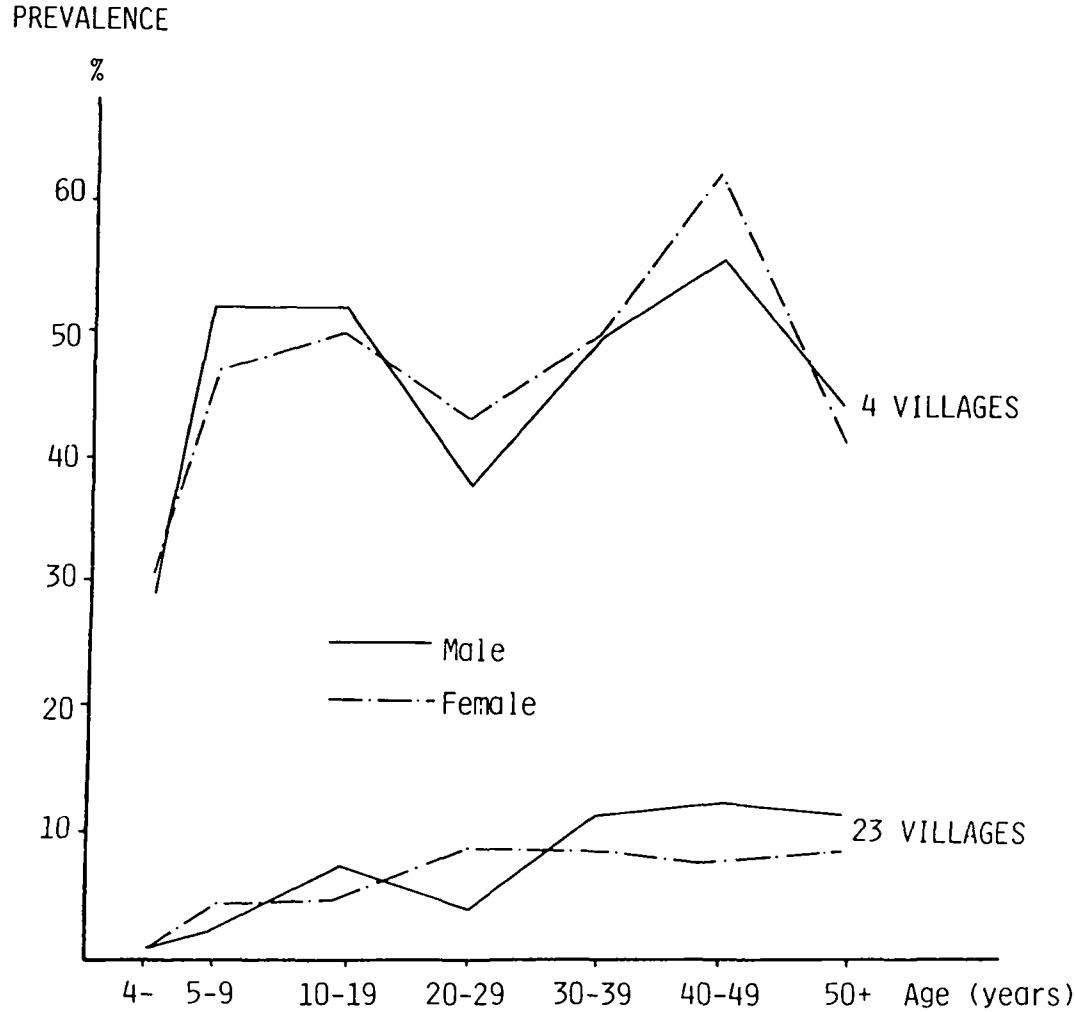

Fig. 4. Dracunculiasis prevalences by age and sex

ever, when the latter are divided between those using a hafir as their primary and their secondary source, a significant difference emerges. The prevalence among those with a hafir as secondary source (103/362 = 28.5 per cent) was significantly lower than among all other hafir users (135/299 = 45.2 per cent; $X^2 = 19$, $p<0.001$).

Roughly one-half of all the cases detected were hafir users living in the four heavily infected villages (Table III) and many persons interviewed in the remaining 23 villages believed that they had caught the infection in the past by drinking contaminated water from the hafir in one of those four villages when they had been there during the 1984–85 drought. Nevertheless, water from all eight hafirs used in the study area was found to contain *Cyclops*.

(b) **Karkour.** Not only did households using a karkour have a relatively high prevalence of infection; there were also signs of transmission between members of these households. Considering all 34 such households, including those which also used a hafir, those in which at least one member had suffered from dracunculiasis in the previous year had a prevalence of 36.5 per cent (61/176). This was significantly higher than that among the households free of infection in the previous year (8/67 = 14.0 per cent; $X^2 = 12$, $p < 0.001$). In addition, one household with 14 members was found to have 12 cases of guinea worm. If cases were randomly distributed among karkour users, the probability of this occurring by chance would be 1.4×10^{-5}. *Cyclops* were found in roughly one-half the water samples from karkours, including some which were quite dark inside.

The dramatic difference in prevalence between users of hafirs and karkours and users of the other types of source can to some extent be attributed to the fact that more than one-half the hafir users, and almost one-half the karkour users in the study, lived in the four most heavily infected villages where

TABLE III. GUINEA WORM INFECTION BY DRY SEASON WATER SOURCE: HEAVILY INFECTED VILLAGES VERSUS THE OTHERS

Source type	4 heavily infected villages			23 remaining villages		
	No. of persons	No. infected	Prevalence, %	No. of persons	No. infected	Prevalence, %
Hafir	389	195	50.1	272	43	15.8
Karkour	72	24	33.3	102	8	7.8
Mashisha	—	—	—	137	5	3.6
Dug well	46	13	28.3	1955	104	5.3
Handpump	—	—	—	233	7	3.0
Other	—	—	—	36	0	0.0
Total	507	232	45.8	2735	167	6.1

no-one was classified as a handpump user and very few as well users (Table III). Even within the remaining 23 villages, the prevalence among hafir and karkour users was significantly greater than among each of the other categories.

(c) **Mashisha**. The prevalence of infection among mashisha users was remarkably low, considering the lack of protection from contamination of this type of source with *Dracunculus* larvae. This would seem to be due to the absence of *Cyclops* in them.

(d) **Wells**. Among those using a well as their only source, the prevalence of infection was not much greater than for handpump users (Table I) indicating that a hand-dug well can be a relatively safe source of water. Those using a well together with other sources are at greater risk (Table II), but this is partly due to the 13 cases in this category in the four heavily infected villages. No *Cyclops* were found in water samples from any well.

(e) **Handpumps**. In theory, a handpump should be the safest source of all. However, relatively few households used handpumps exclusively. In addition to the 233 individuals listed in the Tables as handpump users, a further 1 226 people using handpump water were excluded from this category as they also used the sources listed higher in the Tables. Problems of distance, breakdown, queuing, and inadequate yield were cited with roughly equal frequency as reasons leading people to use other sources, such as hafirs, even in the knowledge of the risk of infection with guinea worm.

DISCUSSION

The results reported here are based on a recall period of up to one year, which could lead to some underreporting of cases[7]. If anything, therefore, the prevalences reported here are underestimates. However, the timing of the study meant that for most cases the recall period was much shorter, and a large proportion of cases were still current.

The similar overall prevalences found in both sexes correspond to other findings in West Africa[8]. On the other hand, the slightly higher prevalence among males over 30 in the less infected villages (Fig. 4), although not significant, is a result also obtained by Ilegbodu *et al*[9].

Some published studies from West Africa[9,10] have found a significant increase in prevalence with age over five years, while others have found none[11,12]. In this study, both patterns have been found in a single area, one in the four most infected villages and the other in the remaining 23 (Fig. 4). In the four villages, the age–prevalence curve is suggestive of a high and uniform degree of exposure to contaminated water, presumably the water carried home for domestic purposes. Only children under five, some of whom are breast fed and so less likely to consume water, have a slightly lower prevalence.

The rising curve in the remaining villages corresponds to a progressively increasing degree of exposure to contaminated water. This cannot be the water used at home, for if it were, the prevalence among children aged 5–9 would be the same as for adults. It must, therefore, be from sources used while away from home, when travelling, visiting, watering livestock, or working in the fields. In practice, each of these 'casual' sources is the normal source for another village.

The consequences for guinea worm control are important. Provision of improved water supplies is not enough to prevent transmission if there is continued casual use of contaminated sources in the fields or in neighbouring villages.

The results also shed light on the suitability of several types of water source for guinea worm control. While the hafirs as originally built with an outlet well were well-designed to prevent transmission, the lack of adequate maintenance of the outlet well and protective fencing, together with inappropriate use by some individuals, has transformed them into the most important foci of the disease in the region. The handpumps, on the other hand, are not sources of disease; but their inadequacies in terms of number, yield, and maintenance oblige many would-be users to drink water from riskier sources. Installation of more handpumps is not necessarily a feasible solution. It would be expensive, and by placing a greater burden on the maintenance system would lead to more and probably longer breakdowns.

These maintenance problems do not seem to affect the existing hand dug wells. The finding that they are a relatively safe source agrees with the observation that infection is not associated with deep narrow draw-wells[5]. Assistance to the community in the construction of hand dug wells, where feasible, might secure readier access to water and more effective guinea worm control at less cost.

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