29. Jahrgang Heft 1 März 1978 Seite 1–136

Tropenmedizin und Parasitologie

Organ der Deutschen Tropenmedizinischen Gesellschaft

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Tropenmed. Parasit. 29 (1978) 61-70

Epidemiology of Poly-Parasitism

I. Occurrence, Frequency and Distribution of Multiple Infections in Rural Communities in Chad, Peru, Afghanistan, and Zaire* **

A.A. Buck, R.I. Anderson, A.A. MacRae

The Johns Hopkins University, School of Hygiene and Public Health, Department of Epidemiology, Baltimore, Maryland, USA

A. Fain

Institut de Médicine Tropicale Prince Léopold, Antwerp, Belgium

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Summary

Parasitic diseases are predominantly rural diseases. They are often associated with poverty, illiteracy, poor sanitation and high risks of exposure to environmental and biological hazards. Because these factors are also essential determinants in the epidemiology of a variety of other infections with quite different etiologies, occurrence of multiple infections in the same people is common. In the tropics, polyparasitism may involve diseases of major public health importance such as malaria, schistosomiasis, filarial infections, trypanosomiasis, and others. The paper presents data on the frequency and types of multiple infections with different parasitic and other infectious agents for thirteen villages of Chad, Peru and Afghanistan. The age and sex patterns of a number of observed combinations of parasitic and other diseases are shown for different ecological zones. Concomitant infections with up to five species of filarial worms are found in residents of villages in the Congo River Basin of Zaire. The specific types of combinations of these infections vary from place to place and appear to be closely linked to ecological factors.

Zur Epidemiologie der Polyparasitosen

1. Vorkommen, Häufigkeit und Verteilung von Mischinfektionen in Dörfern von Chad, Peru, Afghanistan und Zaire

Erkrankungen durch Parasiten befallen vorwiegend die Landbevölkerung. In vielen Entwicklungsländern gehören sie noch heute zu den ungelösten Gesundheitsproblemen. Parasitosen sind dort am stärksten verbreitet und verlaufen klinisch am schwersten, wo Armut, Analphabetentum, ungünstige Umweltverhältnisse und Mangel an medizinischen Einrichtungen zusammentreffen. Dieselben Bedingungen, die für das Fortbestehen endemischer Parasitosen verantwortlich sind, haben auch für die Verbreitung zahlreicher anderer Infektions- und Ernährungskrankheiten wesentliche Bedeutung. Daher ist der Nachweis multipler Infektionen verschiedenster Ätiologie, einschließlich des Mehrfachbefalls mit Parasiten, ein recht häufiger Befund bei klinischen und epidemiologischen Untersuchungen in Entwicklungsländern. In den Tropen und Subtropen beschränken sich die Polyparasitosen nicht nur auf die Darmhelminthen sondern schließen Mischinfektionen mit den Erregern wichtiger Tropenkrankheiten – vor allem der Malaria, Schistosomiasis, Filariasis, Trypanosomiasis und Leishmaniasis – mit ein.

In der vorliegenden Arbeit wird über das Vorkommen und die Verbreitung tropischer Polyparasitosen und anderer chronischer Infektionskrankheiten in der Bevölkerung von 13 Dörfern in Chad, Peru und Afghanistan berichtet. An Beispielen werden geographische Unterschiede im Infektionsspektrum sowie Besonderheiten in der Alters- und Geschlechtsverteilung multipler Infektionen erläutert. Bei Einwohnern von 10 verschiedenen Dörfern im Kongobecken von Zaire konnte ein Mehrfachbefall mit bis zu fünf verschiedenen Filarienarten festgestellt werden. Zwischen den Mischinfektionen der einzelnen Orte bestanden erhebliche Unterschiede sowohl in der Zusammensetzung der Arten als auch in der Häufigkeit der einzelnen Filariosen. Die gefundenen Variationen entsprachen weitgehend geographischen Besonderheiten der einzelnen Endemiegebiete.

*The studies were supported in part by the Department of the Army, U.S. Army Medical Research and Development Command, Washington, D.C., USA.

**Meinem verehrten Lehrer, Prof. Dr. R. Aschenbrenner, zum 71. Geburtstag gewidmet (A.A.B.).

0303–4208/78 1300–0061 $ 06.00

There has been a renaissance of tropical medicine. This is evidenced not only by signs of renewed scientific interest and intensified research in the medical and biological disciplines but also by explicit statements of public concern about the impact of tropical diseases on community life and economic development. Most prevalent and of greatest public health importance among the tropical diseases are parasitic infections, notably malaria, schistosomiasis, filariasis, trypanosomiasis, leishmaniasis and the intestinal helminths and protozoa. The optimistic prognosis of previous years that malaria eradication was imminent and that most of the other parasitic diseases could be controlled with available methods has given way to more cautious views about the prospects for their control. This sober assessment is based on a number of well-publicized developments. Foremost among them are the difficulties of the global malaria eradication programme; the spread of schistosomiasis in areas with man-made water impoundments; recognition of the economic consequences of onchocerciasis in West Africa, and of Chagas' disease in Latin America; the firm establishment of endemic filariasis in some urban centres of South-east Asia; and the resurgence of African sleeping disease in areas with expanding tourism.

Traditionally, control programmes have been concerned with single diseases. Their operations have been "vertically" oriented with little concern for other health problems in the same area. Concentration of efforts on a few essential methods has been the key for successful disease control in some outstanding examples (endemic treponematoses, smallpox, vitamin A deficiency, etc.). However, the approach is less effective when applied to the control of chronic parasitic disease with their complicated life cycles, non-pathognomonic disease manifestations, high frequency of clinically inapparent infection, and absence in the human host of a clear demarcation between susceptibility and immunity to the specific infection.

The important parasitoses of the tropics are predominantly rural diseases and are usually associated with poverty, illiteracy, poor sanitation and high risks of exposure to environmental and biological hazards. These factors are essential as determinants not only of the parasitic diseases, but also of a host of other communicable diseases, including some that are transmitted by vectors, spread through person-to-person contact or by common vehicle. Under these conditions, a number of the tropical parasitoses occur as co-endemic infections in the same community. Some of these diseases as, for example, malaria and filariasis may share the same vectors. Intercurrent with the parasitic diseases are other acute and chronic infections, malnutrition, trauma, and non-infectious diseases.

Difficulties in diagnosing parasitic diseases are particularly great in many of the rural areas where they are most prevalent and severe. The diagnostic problems are enhanced by multiple infections and by the mimicry of the clinical picture of even the advanced stages of certain chronic parasitic diseases. All of these factors have been responsible for gross errors of reporting, leaving many of the parasitic diseases unrecognized and lumped together with other ill-defined conditions in the anonymous pool of undiagnosed and often undiagnosable illness.

The World Health Organization has established a Special Programme for Research and Training in Tropical Diseases in which six groups of diseases take prominent place, namely malaria, schistosomiasis, filariasis, trypanosomiasis, leishmaniasis and leprosy (WHO 1974, 1976). In this, and in the following papers (Buck et al., 1978 a, b, c) attempts are made to describe and analyse various epidemiological features of poly-parasitism. Special consideration is given to parasites that fall within the range of the diseases that are included in the Special Programme of WHO. Except for some studies of multiple infections with intestinal helminths and protozoa (Hinz 1966, Saugrain 1967, Brant 1969, Best et al. 1976), nutrition and infection (Scrimshaw et al. 1968, Abd-el-Aal et al. 1970, Beaton and Bengoa 1976), multiple infections with malaria parasites (Colbourne et al. 1950, Jelliffe et al. 1964, Willett 1972), combined infections with filarial worms (Fain et al. 1974), and a few clinical observations on multiple disease states (Colbourne

et al. 1950, Laurie 1954, Jelliffe et al. 1964, Hughes and Hunter 1970, Buck et al. 1971, Smith et al. 1976), little is known about the frequency, distribution, types of combinations and the pathological effects of poly-parasitism in the general population of tropical countries. Such knowledge would be needed for a number of reasons. Of direct practical importance are questions concerning the effects of different disease combinations on the accuracy of the clinical and laboratory diagnosis (Buck and Anderson 1972), on the severity of disease (Buyst 1975, Downes 1975), on the bioavailability and toxicity of drugs used for treatment (Buck 1975) and on interference with immune responses (McGregor and Barr 1962, Greenwood et al. 1972, WHO 1972, Moore et al. 1974, Brito et al. 1976). Equally important would be the knowledge of the effects of vector control programmes for individual diseases on the transmission of other endemic vector-borne infections that occur in the same population, as for example, malaria and filariasis.

Materials and Methods

The results reported here are based on multidisciplinary studies in which the total populations of thirteen villages in Chad, Peru and Afghanistan were examined. Detailed descriptions of the geographical and ethnical characteristics of the areas and of the population samples are published elsewhere (Buck et al. 1968, 1970, 1972). In summary, the communities represent geographically contrasting rural areas. Of the villages listed in Table 2, three (Nos. 1, 2 and 4) are situated in the dry Sudan-type savannah of Chad, one (No. 3) is located in the more humid wooded savannah at 7°N latitude, and one community (No. 5) represents an oasis in the Sahara. In Peru, village No. 1 lies in the low Amazon Basin; No. 2 is located in the trans-Andean jungle region at an altitude of 800 m; village No. 3 is situated in the arid zone of the western slopes of the Andes at 2000 m. above sea level; and village No. 4 lies in the high plateau area above Lake Titicaca at 3500 m elevation. The four communities in Afghanistan represent: (1) the Hindu Kush at 2,500 m altitude; (2) the fertile lowlands of north-eastern Afghanistan, south of the Amu Darya River; (3) the agricultural development area of the Helmand Valley bordering the southern semi-desert of Afghanistan at 750 m altitude, and (4) an ancient village in a valley encircled by the Paropamisus Mountains, 1360 m above sea level. Some essential demographic characteristics of the population samples with regard to their comparability for epidemiological differences, are summarized in Table 1.

The population samples of all 13 villages have a broad base as indicated by the large proportion of children. The similarity of the age and sex distribution combined with the generally high percentage of participation in the various types of examinations and procedures of the study indicate general similarity and good comparability of the population samples. Bias that could have resulted from differ-

Table 1. Total Populations, Sex Ratios, Proportion of Children < 10 Years and Frequency of Participation in Specified Procedures of Epidemiological Studies in 13 Villages.

Village	Country	Total No. population from census	Sex ratio (M/F)	Population percent < 10 years	Participation (%) of census population			
					Physical examination	Stool sample	Urine sample	Blood[1] sample
1	Peru	442	0.9	37	95.0	87.8	–	90.3
2	Peru	492	1.1	36	88.0	74.4	–	82.9
3	Peru	295	0.9	22	92.9	76.9	–	90.5
4	Peru	240	0.7	30	91.7	88.3	–	90.4
5	Chad	379	0.8	27	99.5	96.3	96.8	97.9
6	Chad	401	0.9	33	99.7	94.0	96.7	98.7
7	Chad	365	1.0	38	99.4	92.9	95.3	99.4
8	Chad	379	0.8	36	98.7	91.8	99.4	95.8
9	Chad	217	0.8	32	94.9	88.5	75.1	91.2
10	Afghanistan	349	1.2	26	91.1	87.4	88.0	86.2
11	Afghanistan	373	1.1	26	99.2	96.0	96.8	96.2
12	Afghanistan	330	1.1	41	89.1	81.8	80.3	80.0
13	Afghanistan	358	0.8	27	97.5	93.9	93.0	90.2
Totals		4 620	0.9	32	95.0	88.4	91.7	91.5

[1] 10 ml venous blood and/or finger blood samples

ences in laboratory methods and in test performance by different investigators has been kept at a minimum because the work was carried out by the same research team using similar criteria and techniques of measurement in each of the three country studies. The routine diagnosis for parasitic and other infections was the same in all 13 villages regardless of whether a specific disease was known or suspected to exist in an area.

The exact laboratory methods, types of physical examination, health interviews, measurements of physiological variables, studies of the vectors of disease, and of environmental factors are described elsewhere (Buck et al. 1968, 1970, 1972). For the routine diagnosis of parasitic diseases, standard concentration techniques are used. Unless stated otherwise, all prevalence estimates of parasitic infections listed in this and the other three papers (Buck et al. 1978 a, b, c) are based on the demonstration of the causative agents in direct examinations of single specimens of blood, urine, stool, and of skin biopsies. It can be assumed that the reported frequencies of infections are underestimates of the true prevalence of most diseases.

In each of the thirteen villages, data for more than a hundred variables per person were collected by the physicians and scientists who had no prior knowledge of the results of tests and examinations carried out by other members of the research team.

The data on human infections with various species of filarial worms in Zaire are based on studies by Fain et al. (1974) in 10 villages, three in the rain forest; three in the secondary forest, near the narrows of the Congo River; and one in a swampy area near the Congo, at the edge of a mangrove forest. Examination of dermic fluid obtained by skin scarification was the only method used by the authors to diagnose infection and to identify the different species of blood-borne and skin-dwelling microfilariae.

Results

The parasitic and other important communicable diseases that were diagnosed in the cross-sectional studies are listed in Table 2 by country and village. Not included in the Table are common diseases of usually short duration such as diarrhoea, respiratory infections other than tuberculosis, skin infections, noncommunicable diseases and infectious states determined by serological tests for a battery of arbo-virus infections. Classification of a specific disease as a "public health problem" is arbitrary and is based on the criteria listed in the right-hand column of Table 2.

In some parts of the world, especially in Africa, poly-parasitism may involve multiple infections with closely related agents causing further difficulty in diagnosis and treatment. One such example is presented in Figure 1 for the Republic of Zaire where infections with as many as five different species of filarial worms are co-endemic and are often found together in the same persons. Fig. 1 also shows the

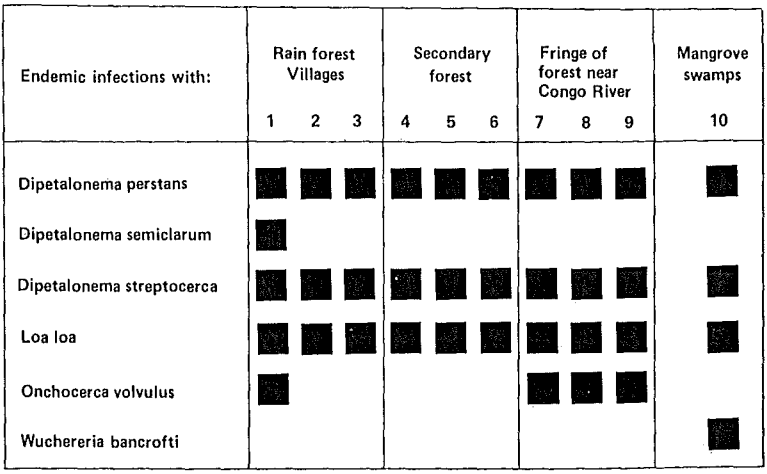

Fig. 1. Multiple occurrence of six endemic filarial infections in four different ecological settings in the Republic of Zaire. (Prepared from data published by A. Fain et al., 1974.)

Table 2. Endemic Infections and Chronic Infectious Diseases of General and Local* Public Health Importance, in Geographically and Culturally Contrasting Villages of Chad, Peru and Afghanistan.

Disease or infection	Chad					Peru				Afghanistan				Diagnostic criteria and definitions
	1	2	3	4	5	1	2	3	4	1	2	3	4	
Malaria (*P. falciparum, malariae, vivax*)	●*	●*	●*	●*		●					●*2	●		Parasitaemia, clinical dx; * uncontrolled hyperendemic; *2 epidemic recurrence
Chagas' Disease						●		●*						Clinical + serological dx (CF test); * recognized public health problem
Leishmaniasis							●							Clinical dx of "uta"
Toxoplasma gondii	?	?	?	?	?	●	●*	●	●	●	●	●	●	IHA tests 1:64+; * prevalence > 90%
Wuchereria bancrofti		●	●											Microfilariae in day and/or night blood
Loa loa		●	●	●										Microfilariae in day blood (routine smear)
Dipetalonema perstans		●	●	●										Microfilariae in day blood (routine smear)
Onchocerca volvulus		●*												Microfilariae in skin biopsy, clinical dx; *> 80%
Schistosoma haematobium	●*	●	●*		●									Eggs in urine by sedimentation concentration; *> 50% peak prevalence
Schistosoma mansoni		●*												Eggs in stool (MF-ether concentration); *> 50% peak prevalence
Fasciolidae								●		●		●		Eggs in stool (MF-ether concentration)
Echinococcus granulosus										●	●	●	●*	IHA test 1:160+; veterinary pathology; *> 30% total prevalence
Hookworm		●	●	●		●	●*							Eggs in stool (quantitative); *> 50% total; heavy infections
Strongyloides stercoralis		●	●				●							Larvae in stool (MF-ether concentration)
Ascaris lumbricoides						●*	●*		●	●*	●	●	●*	Eggs in stool (MF-ether); *> 50% total, heavy infections
Trichuris trichiura						●	●		●					Eggs in stool (MF-ether); all > 50% total prevalence
Taenia saginata			●		●				●	●				Eggs + proglottids in stool; clinical observations
Hymenolepsis nana							●				●	●	●	Eggs in stool; > 5% total prevalence
Entamoeba histolytica	●	●	●	●	●	●	●		●	●	●	●	●	Cysts (excl. *E. hartmanni*) in stool > 5% total
Number of locally important public health problems*	3	5	2	3	1	2	5	1	2	3	2	1	5	
Number of endemic infections in village	10	16	14	9	7	11	13	6	9	10	12	11	13	

Continuation Table 2

Disease or infection	Chad 1	2	3	4	5	Peru 1	2	3	4	Afghanistan 1	2	3	4	Diagnostic criteria and definitions
Balantidium coli						●	●		●					Parasite in stool (MF-ether concentration)
Histoplasma capsulatum or duboisi				●			●							Histosplasmin skin + CF tests; chest radiography
Treponematoses: syphilis	●	●	●		●						●		●	FTA abs. test > 10% reactions total
yaws				●*										* 40% FTA and TPI reactions
pinta							●*							* 22% FTA, 35% TPI
bejel													●*	* 25% FTA, 30% TPI
Gonorrhea	●*													Clinical + bacteriological dx in patients seeking treatment
Tuberculosis	●	●*	●	●	●*	●	●*	●	●*	●*	●*	●*	●*	Chest roentgenograms: 1%(+) TB; * > 2% clinical rate
Leprosy		●*	●	●*		●							●	Clinical + microscopic dx; * > 1 case in sample
Trachoma	●				●						●		●*	Ophthalmol dx, inclusion bodies; * severe, blinding disease
Louse-borne typhus	●						●	●	●*	●*	●	●	●	CF test *R. prowazecki;* * > 30% total; history; body lice
Murine typhus	●	●	●							●	●	●	●	CF test *R. mooseri,* > 1% total prevalence
Tick-borne typhus	●	●	●											CF test *R. rickettsi,* > 10% total prevalence
Q-Fever		●			●	●		●	●	●	●	●	●	CF test *C. burneti,* > 3% total prevalence
Number of locally important public health problems*	3	5	2	3	1	2	5	1	2	3	2	1	5	
Number of endemic infections in village	10	16	14	9	7	11	13	6	9	10	12	11	13	

various combinations of multiple infections with filarial worms for the different types of environment in which the villages are located.

The following are selected examples to show different types of combinations of important parasitic infections in two villages of tropical Africa. Listed in Table 3 are the age-specific prevalence ratios for each of six locally endemic parasitic infections. Five of them represent diseases that are included in the Special Programme for Research and Training in Tropical Diseases of the World Health Organization. The prevalence estimates are based on examinations made during the peak period of the dry season. The frequency of parasitemia for *Plasmodium falciparum* would have been much higher had the study been done during the rainy season. Fig. 2 shows the percent of male residents of the same village who have patent infections with one or more of the six parasites. The results indicate that even in a cross-sectional study with single examinations of stool, urine and blood specimens, only a few persons at any age are free from infection; most have two or more infections simultaneously.

The general importance of poly-parasitism in African villages in further emphasized in the example shown in Table 4. In this village of Laka tribesmen, only about 11 % of the resi-

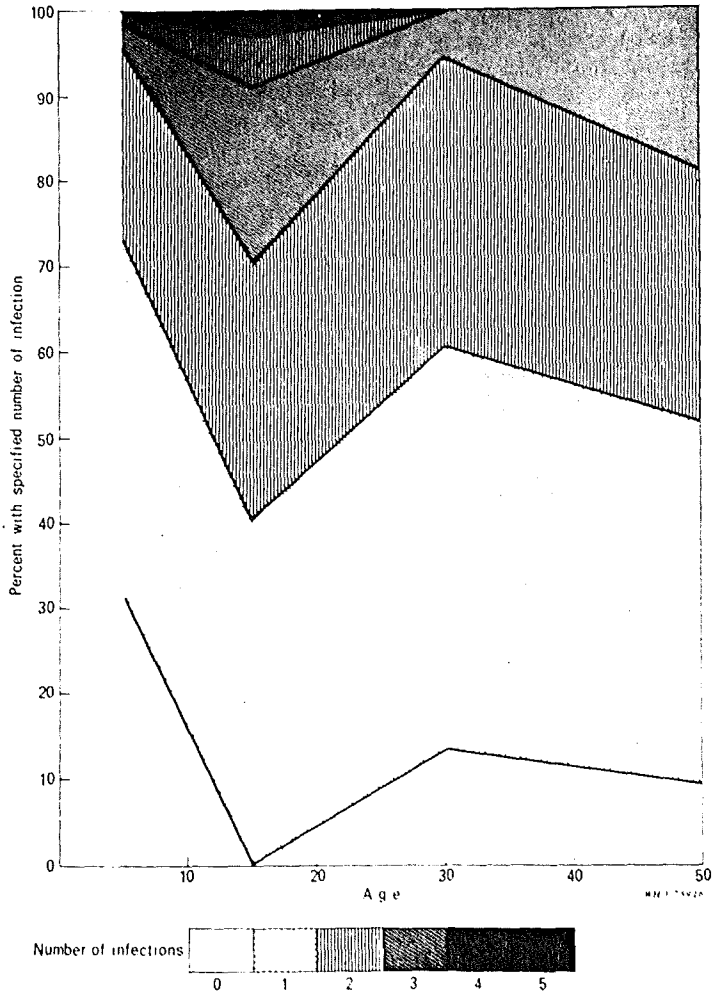

Fig. 2 Percent of males with one or more infections of *malaria, Loa loa, Dipetalonema perstans, Wuchereria bancrofti, Schistosoma haematobium, Schistosoma mansoni and hookworm, village of Quarai, Chad.*

dents are found free from infection in single examinations of blood, stool, urine and skin biopsies. Most frequent in the community are persons who have two parasitic infections; they represent 38% of the total population. Despite the differences in the life cycles of the various parasites, three percent of both the males and females have infections with at least four different parasites. The most prevalent diseases in the village are, in order of frequency, onchocerciasis, schistosomiasis (*Schistosoma mansoni*), *Dipetalonema perstans* infections and malaria.

Multiple infestations with intestinal parasites have been studied more frequently than other types of poly-parasitism because of their world-wide distribution and the relative ease with which stool specimens can be obtained for detailed parasitological examination (Hinz 1966, Saugrain 1967, Grant 1969, Best et al. 1976). There are only a few publications on multiple infections with blood-borne parasites, notably on malaria and microfilaraemia and on malaria and trypanosomiasis in hospital patients (Buyst 1975). Community patterns of disease and infections show considerable

Table 3. Prevalence of Infections with Malaria (*P. falciparum* and *P. malariae*), *L. loa, D. perstans, W. bancrofti, S. mansoni, S. haematobium* and hookworm in the Village of Quarai, by Age and Sex.

Age	Number in group			Percent with infection (M: males; F: females; T: total)								
				Malaria			*L. loa*			*D. perstans*		
	M	F	T	M	F	T	M	F	T	M	F	T
0–9	82	57	139	40.2	35.1	36.6	2.4	7.0	4.5	25.6	19.3	24.6
10–19	37	35	72	16.2	14.3	15.3	13.5	5.7	9.7	62.2	62.9	62.5
20–39	38	58	96	7.9	13.8	11.5	2.6	8.6	6.3	76.3	77.6	76.0
40+	21	33	54	14.3	3.0	7.4	19.1	15.2	16.7	85.7	87.9	87.0
Total	178	183	361	25.3	18.6	21.1	6.7	8.7	7.7	51.1	58.5	55.1

Age	Number in group			Percent with infection (M: males; F: females, T: total)											
				W. bancrofti			*S. mansoni*			*S. haematobium*			Hookworm		
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
0–9	82	57	139	2.5	1.8	2.2	0	0	0	29.6	7.0	20.0	3.9	14.0	8.2
10–19	37	35	72	10.8	11.4	11.1	10.8	0	5.6	73.0	60.0	66.7	13.5	14.3	13.9
20–39	38	58	96	7.9	3.5	5.2	0	0	0	21.9	31.0	27.1	18.4	6.9	11.5
40+	21	33	54	19.1	15.2	16.7	0	0	0	9.5	21.2	16.7	9.5	27.3	20.4
Total	178	183	361	7.3	6.6	7.0	2.2	0	1.1	34.5	27.3	30.9	9.7	14.2	12.1

geographical variations. Significant differences in the prevalence and distribution of chronic parasitic infections may even be found within the boundaries of a village. The variety of disease combinations in rural populations and the frequency of multiple infections are presented in Fig. 3 for three villages in the African Savannah, one community in the trans-

Table 4. Percent With Specified Numbers of Multiple Infections With Malaria (*P. falciparum* and *P. malariae*), *L. loa, D. perstans, W. bancrofti, O. volvulus, S. haematobium, S. mansoni* and Hookworm in 380 Villagers of Ouli Bangala, Chad, by Age and Sex.

Age	Number of infections in same persons (M: males; F: females, T: total)												Number in group		
	0			1			2			3					
	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
0–9	35.0	18.5	27.2	23.3	51.8	36.8	33.3	24.1	29.0	8.3	5.6	7.0	60	54	114
10–19	5.9	10.5	8.3	29.4	22.8	25.9	41.1	43.9	42.6	21.6	17.5	19.4	51	57	108
20–39	4.1	3.0	3.5	36.7	41.8	39.7	34.7	37.3	36.2	18.5	14.9	16.4	49	67	116
40+	0	0	0	22.2	25.0	23.8	50.0	58.3	54.8	22.2	12.5	16.7	18	24	42
Total	14.6	8.9	11.6	28.7	37.1	33.2	37.6	38.1	37.9	16.3	12.9	14.5	178	202	380

Age	Number of infections in same persons (M: males; F: females, T: total)									Number in group		
	4			5			6					
	M	F	T	M	F	T	M	F	T	M	F	T
0–9	0	0	0	0	0	0	0	0	0	60	54	114
10–19	2.0	5.3	3.7	0	0	0	0	0	0	51	57	108
20–39	2.0	1.5	1.7	2.0	1.5	1.7	2.0	0	0.9	49	67	116
40+	5.6	4.2	4.8	0	0	0	0	0	0	18	24	42
Total	1.7	2.5	2.1	0.6	0.5	0.5	0.6	0	0.3	178	202	380

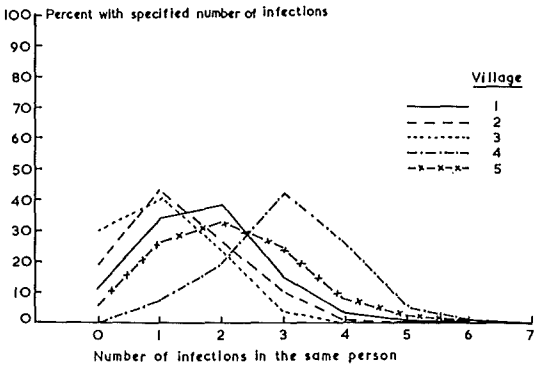

Fig. 3 Frequency distribution of five village populations in Chad, Peru and Afghanistan by the number of specified infections in the same persons.

Village:	1	2	3	4	5
Country:	Chad	Chad	Chad	Peru	Afghanistan
Diseases + infections type:	Malaria *L. loa* *D. perstans* *W. bancrofti* *O. volvulus* *S. haematobium* *S. mansoni*	Malaria *L. loa* *D. perstans* *W. bancrofti* *S. haematobium* Hookworm	Malaria *D. perstans* Hoekworm Yaws	Hookworm *T. trichiura* *S. stercoralis* *E. histolytica* Pinta *H. capsulatum* *A. lumbricoides*	*A. lumbricoides* *E. histolytica* *T. spiralis* *E. granulosus* *R. prowazecki* *C. burneti* Endemic syphilis Tuberculosis
number	8	6	4	7	8

Amazonian jungle, and for one town in the barren environment of north-western Afghanistan. In addition to parasitic infections, other important communicable diseases of local and general importance are considered, namely the treponematoses (yaws, pinta and endemic syphilis); histoplasmosis in Peru; and typhus, Q-fever and active, clinical tuberculosis in Afghanistan.

Fig. 3 shows the frequency distribution of the numbers of multiple infections for each of the five villages. In spite of the high percentage of young children in the population samples, there are few uninfected individuals in each of the villages.

Discussion

The term poly-parasitism has epidemiological and clinical implications; epidemiologically it is synonymous with co-endemicity of parasitic diseases in a *population* and clinically with the presence of multiple infections in the same *individual.* Hence poly-parasitism is of importance to both the clinician and the epidemiologist in developing countries. As a frequent and widespread phenomenon poly-parasitism is not confined to the intestinal parasites but involves many other agents, including those that cause some of the most important public health problems in the tropics. Research on poly-parasitism can provide new answers to some old questions of practical significance to disease control and prevention. Little is known as yet about the possible effects of various types of multiple infections on morbidity; on interference with response to immunization; on bioavailability of drugs, and on the types and frequency of untoward side reactions; on interaction with nutrition; and on influences on the sensitivity and specificity of the clinical and laboratory diagnosis. There are also administrative and economic implications of poly-parasitism for disease control programmes, for manpower training, and for

field research and surveillance projects. Some of the questions raised will be examined in the three subsequent papers which deal with disease combinations and with their statistical association (Buck et al. 1978a) with the effects on the diagnostic capacities of screening tests (Buck et al. 1978b), and with the combined effects of multiple infections on the state of health (Buck et al. 1978c).

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Dr. A.A. Buck, Chief Medical Officer, Research Co-ordination, Epidemiology and Training, Division of Malaria and other Parasitic Diseases, World Health Organization, CH-1211 Geneva 27, Switzerland