Parasitological indicators of onchocerciasis relevant to ivermectin control programmes in the Amazonian focus of southern Venezuela

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SUMMARY

In the previous paper it was concluded that those aged ⩾15 years of both sexes could comprise the indicator group for rapid epidemiological assessment (REA) of onchocerciasis in the Amazonian focus. This paper explores relationships between community microfilarial (mf) prevalence, intensity, and nodule prevalence in 20 Yanomami communities, that would allow identification of REA methods in the region. The mean nodule ratio (prevalence of nodules/prevalence of mf) was 0·54 when onchocercomata in the indicator group were considered. The Spearman correlation coefficient between mf and nodule prevalence was 0·686 ($P = 0{\cdot}001$). Palpation of nodules had 92% specificity and 32% sensitivity when compared to skin-snipping for the diagnosis of onchocerciasis. The predictive value positive increased from 75% to 81% when the indicator group was used. A microfilarial prevalence > 75% in this group would be indicative of hyperendemic status in the village, between 30 and 75% of mesoendemicity, and < 30% of hypoendemicity. For the assessment of infection intensity, biopsies may be taken from the iliac crest for all endemicity levels. Five of the hyperendemic villages surveyed in this work had a community microfilarial load (CMFL) greater than 10 mf/skin snip; the remaining 5 had a CMFL between 5 and 9. These levels of infection merit high priority ivermectin treatment. In Latin America, communities at both moderate and severe risk are included in mass chemotherapy programmes (i.e. when mf prevalence is over 20%). Roughly, a nodule prevalence in the indicator group > 10% would suggest a community mf prevalence > 20% with a sensitivity of 85% and a specificity of 71%. A multiple linear regression model of the arc-sine transformed mf prevalence in the village (all ages) on nodule prevalence in those aged ⩾ 15 years and altitude of the village explained 72% of the variance. The model combining nodule and altitudinal information had a sensitivity of 92% and a specificity of 71% in comparison to an estimated mf prevalence of 21% or more. It is suggested that the usefulness of the REA methods proposed be assessed in other areas of the Amazonian onchocerciasis focus.

Key words: onchocerciasis, rapid epidemiological assessment, parasitological indicators, nodule prevalence, altitude, southern Venezuela, Yanomami.

INTRODUCTION

Developing appropriate ways to deliver the microfilaricidal drug ivermectin to communities affected by human onchocerciasis has become an important area of research. Rapid epidemiological assessment (REA) of onchocerciasis has been proposed for use in endemic zones where the epidemiology of the infection and its associated morbidity is not well documented. The objectives of REA are to identify high-risk communities for the prioritization of mass treatment with ivermectin. Many of the affected areas are remote and resources for the distribution of the drug are limited, therefore, it may be necessary to focus initially on communities with the highest infection rate and only expand coverage to include other areas at a later date (WHO, 1992; IACO, 1992; Ngoumou, Walsh & Macé, 1994).

In Africa, it has been suggested that the indicator age-group, in which REA should be carried out, is a sample of 30 males aged 20 years and over, as they are more likely to be infected than females and better disposed to being examined (Taylor, Duke & Muñoz, 1992). Initially, one of the parameters included was the community microfilarial load (CMFL), defined as the geometric mean density of microfilariae per skin snip (ss) in adults aged ⩾ 20 years including those negative for infection (Remme *et al*. 1986). This parameter has been proposed as a parasitological index measuring the intensity of

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infection and the risk of blindness in a whole community (Remme *et al*. 1989). However, because the estimation of CMFL requires an accurate count of microfilariae (mf) from skin biopsies, its usefulness in REA has been questioned. It has, nevertheless, been agreed that the intensity of mf infection in the community should be measured wherever possible, as it is a useful marker for surveillance in the early phases of an ivermectin-based control programme (WHO, 1992).

Regarding the sites for taking the biopsies, it has been suggested that 1 snip from the iliac crest in Africa, or 1 from the scapula and 1 from the iliac region in Latin America, would be sufficient for use in REA (Taylor *et al*. 1992), although the latter has not been systematically tested in Latin American foci. Yet, true REA indicators not requiring mf counts, and consequently cheaper and less invasive, need to be identified for stratifying areas with different levels of endemicity and epidemiological patterns. In relation to this, the prevalence of palpable nodules in adult males appears to be a good indicator of the risk of onchocercal blindness in African savanna settings (WHO, 1992). Also, the true prevalence of onchocerciasis infection in a community is estimated as approximately twice the prevalence of palpable nodules (Taylor *et al*. 1992; WHO, 1992, 1995).

In southern Venezuela, it has been shown that onchocerciasis endemicity increases with altitude and depends on the species composition and abundance of the anthropophilic *Simulium* vectors (Vivas-Martínez *et al*. 1998). Above an elevation of 200 m, communities are expected to be hyperendemic and therefore merit high priority for mass ivermectin distribution. Below this threshold, endemicity ranges from low to moderate levels and parasitological indicators are necessary to complement entomological and altitudinal information for the purposes of risk assessment and determination of treatment strategy.

Vivas-Martínez *et al*. (2000) inspected the profiles of onchocercal infection by age, sex, and endemicity in 20 Yanomami communities of southern Venezuela, and concluded that a suitable indicator age-group in this region would comprise males and females aged $\geqslant 15$ years rather than only adult males. This paper explores how measures of infection prevalence estimated from this indicator group (by themselves or combined with already described non-parasitological indices), relate to the extent of infection in the whole community. Also addressed, is the question as to whether it is possible to correctly allocate villages to categories of high or low priority for mass ivermectin treatment according to the guidelines proposed by the Onchocerciasis Elimination Programmes for the Americas (OEPA), in which communities at moderate and severe risk would warrant high priority treatment (mf prevalence $\geqslant 21\%$), and those that are hypoendemic ($\leqslant 20\%$ mf infection) would have lower priority (Blanks *et al*. 1998).

MATERIALS AND METHODS

Study area and parasitological methods

The study population consisted of 836 people ($\geqslant 5$ years of age) out of a source population of 1225 Yanomami Amerindians inhabiting 20 communities (ranging from 26 to 145 people each) situated along the river systems Ocamo–Putaco and Orinoco–Orinoquito. Details of the geographical area, climate, vegetation, and location of the villages can be found in Vivas-Martínez *et al*. (1998). The methods of parasitological examination for dermal mf and palpable nodules, skin-snipping (2 biopsies from the scapula and 2 from the iliac crest), snip incubation, specific identification of mf, and estimation of the number of mf/mg of skin have been described (Vivas-Martínez *et al*. 2000). In the villages of Harau-theri A and Harautheri B nodule palpation was not conducted. Since this would have reduced the number of communities to 18, data from the villages of Niyayowë-theri (Yarzábal *et al*. 1985) and Coyowë-theri (gathered by CAICET, 1995) were included for the purposes of the analyses presented in this paper.

Data analysis

For each village, mf prevalence and intensity, as well as nodule prevalence were age- and sex-adjusted using the direct method (Kirkwood, 1988) and their CMFL calculated (Remme *et al*. 1986). To facilitate comparison with published data, arithmetic mean (AM) intensities of mf infection per person in the village (all ages) are presented. Standardized microfilarial and nodule prevalence were also estimated for the proposed indicator group (those aged $\geqslant 15$ years, both sexes). Villages were classified according to the endemicity levels (hypoendemic: $\leqslant 20\%$; mesoendemic: 21–59%; hyperendemic: $\geqslant 60\%$ mf prevalence), and priority categories for ivermectin treatment (low: $\leqslant 20\%$; high: $\geqslant 21\%$ mf infection), that have been proposed for Latin American foci (OEPA, 1996; Blanks *et al*. 1998). Exact confidence limits were calculated for the proportion of people with mf and nodules in each village (Armitage & Berry, 1994).

The ratio between the prevalence of nodules and the prevalence of a positive skin snip was calculated for each community (Taylor *et al*. 1992), and the rank correlation coefficient (Spearman's) between prevalence of onchocercomata and prevalence of mf was estimated. However, since standard linear regression analysis involving variables that are proportions is not appropriate (the random variation is expected to be binomial rather than normal), a

Table 1. Age and sex-adjusted microfilarial prevalence and intensity in the surveyed communities of the Amazonian onchocerciasis focus of southern Venezuela including 2 hyperendemic villages previously studied* (see text)

Code no. and village name	Altitude (m)	mf Prevalence (%)	Intensity AM mf/mg	Intensity CMFL mf/ss
(A) Ocamo–Putaco				
(3) Kashorawë-theri†	60	0·00	0·00	0·00
(1) Ocamo	90	2·41	0·06	0·02
(2) Iyewëi-theri	60	5·43	0·01	0·02
(15) Yepropë-theri	150	5·79	0·58	0·19
(8) Maweti-theri	140	24·32‡	0·60	0·43
(16) Toothothopiwei-theri	125	33·87‡	1·32	0·72
(13) Yoreshiana A	690	63·59¶	23·40	5·40
(14) Yoreshiana B	475	65·38¶	37·91	18·00
(9) Awei-theri	162	66·75¶	64·70	41·41
(10) Pashopeka-theri	240	79·76¶	25·41	13·50
(23) Niyayowë-theri*	950	77·53¶	66·45	44·67
(B) Orinoco–Orinoquito				
(6) Shashanawë-theri	50	0·00	0·00	0·00
(4) Yohoopë-theri	50	2·86	0·01	0·01
(18) Purima-theri	110	13·87	0·34	0·19
(11) Mahekoto-theri	140	41·38‡	6·97	1·59
(22) Harau-theri B	740	62·88¶	17·77	6·32
(12) Cerrito	165	64·63¶	13·75	4·92
(20) Harau-theri A	642	66·25¶	29·95	7·00
(25) Coyowë-theri*	250	74·01¶	46·73	12·87
(21) Hokotopiwei-theri	400	74·77¶	60·92	34·82
(17) Hasupiwei-theri	200	78·39¶	40·66	7·00
(19) Maiyo-theri	720	86·75¶	33·37	18·60

* In Coyowë-theri 28 people were positive for infection out of 36 examined.
† Includes 4 people from the nearby community of San Benito.
‡ Mesoendemic communities.
¶ Hyperendemic communities.

suitable transformation (arcsine or $y = \sin^{-1}\sqrt{p}$) was chosen. A step-wise (forward) multiple linear regression analysis of community mf prevalence (using its angular transformation) on prevalence of nodules and other possible explanatory variables was conducted weighting the minimization function (least squares) by the number of people examined for skin mf in each village. The angular transformation and the weighted analysis stabilized the variance and normalized the distribution of the residuals (Armitage & Berry, 1994).

All statistical analyses were performed using Stata ver. 5.0 (Stata® Corporation, College Station, TX).

RESULTS

Eighteen out of the 20 villages investigated were positive for *O. volvulus* infection. Microfilarial prevalence varied between 2·4 and 86·8 % and nodule prevalence between 1·0 and 47·6 % in the positive villages. The arithmetic mean intensity of infection ranged from 0·01 to 64·70 mf/mg and the CMFL from 0·02 to 41·41 mf/ss (Table 1). Taking into account all 20 villages, 7 of them were identified as hypoendemic, 3 as mesoendemic, and 10 as hyperendemic. The communities of Niyayowë-theri and Coyowë-theri were also hyperendemic. The prevalence of nodules in the community, in the indicator group, and the quotient between the prevalence of nodules and that of mf are summarized in Table 2.

Parasitological indicators

Community microfilarial load as an indicator of onchocerciasis level which warrants ivermectin distribution. Five of the hyperendemic villages surveyed in this work had a CMFL $\geqslant 10$ mf/ss. The remaining 5 had a CMFL between 5 and 9 (Table 1). According to the guidelines, reviewed and supported by WHO (1992) for West African savanna settings, these levels of infection would merit high priority ivermectin treatment. The communities of Niyayowë-theri and Coyowë-theri also had CMFL values greater than 10 mf per skin snip.

The ratio between the prevalence of nodules and the prevalence of a positive skin snip. When both the prevalence of mf and of onchocercomata were

Table 2. Age and sex-adjusted nodule prevalence and ratio between nodule prevalence and mf prevalence in communities of the Amazonian onchocerciasis focus of southern Venezuela

Code no. and village name	Nodule prevalence in the community (%)	Nodule prevalence in the indicator group (%)	Nodule ratio	
			Whole village ⩾ 5 yr	Indicator group ⩾ 15 yr
(A) Ocamo-Putaco				
(3) Kashorawë-theri*	3·48	5·33	—	—
(1) Ocamo	0·99	1·48	0·41	0·61
(2) Iyewëi-theri	0·00	0·00	0·00	0·00
(15) Yepropë-theri	7·80	11·36	1·35	1·96
(8) Maweti-theri	0·00	0·00†	0·00	0·00
(16) Toothothopiwei-theri	7·20	11·07†	0·21	0·33
(13) Yoreshiana A	37·61	52·31¶	0·59	0·82
(14) Yoreshiana B	18·09	20·51¶	0·28	0·31
(9) Awei-theri	12·20	17·34¶	0·18	0·26
(10) Pashopeka-theri	6·01	8·99¶	0·08	0·11
(23) Niyayowë-theri	25·37	27·07¶	0·33	0·35
(B) Orinoco–Orinoquito				
(6) Shashanawë-theri	0·00	0·00	—	—
(4) Yohoopë-theri	0·00	0·00	0·00	0·00
(18) Purima-theri	17·97	24·46	1·30	1·76
(11) Mahekoto-theri	21·39	31·99†	0·52	0·77
(12) Cerrito	31·83	31·20¶	0·43	0·42
(25) Coyowë-theri	37·70	47·12¶	0·51	0·64
(21) Hokotopiwei-theri	25·04	27·57¶	0·34	0·37
(17) Hasupiwei-theri	47·57	48·87¶	0·61	0·62
(19) Maiyo-theri	31·77	37·75¶	0·37	0·44
	Nodule ratio	Mean ± S.D.	0·42 ± 0·38	0·54 ± 0·54
		Range (+ve villages)	(0·08–1·35)	(0·11–1·96)

* Includes 4 people from the nearby community of San Benito.
† Mesoendemic communities,
¶ Hyperendemic communities.

Table 3. Sensitivity, specificity, and predictive value positive for palpation of nodules as a screening method for mf infection in southern Venezuela

	Skin-snip +ves	Skin-snip −ves	Total
Nodule +ves	112	38	150
Nodule −ves	234	418	652
Total	346	456	802*
Sensitivity (95% CL)	32·4%	(27·5–37·6)	
Specificity (95% CL)	91·7%	(88·7–94·0)	
PV +ve (95% CL)	74·7%	(66·9–81·4)	

* Excludes data from Harau-theri A and B (people were not examined for palpable nodules), but includes data from Coyowë-theri (gathered by CAICET in 1995).

measured in the whole examined population of the community (i.e. those aged ⩾ 5 years), the quotient between these 2 variables averaged 0·42 (S.D. = 0·38) and ranged from 0·08 and 1·35 in the villages positive for both mf and nodules (Table 2). When the numerator was the prevalence of nodules in the indicator group (those aged ⩾ 15 years), the mean ratio increased to 0·54 (S.D. = 0·54; range 0·11–1·96).

Presence of palpable nodules and mf status. Table 3 shows, for the whole surveyed population, that nodule palpation is highly specific for *O. volvulus* infection although it is less sensitive than the skin snip. The predictive value positive improved from 75 to 81% when only those aged ⩾ 15 years were considered.

Iliac versus scapular skin snips. Table 4 summarizes data on the sensitivity of skin biopsy in the scapular and iliac body regions in villages at the 3 endemicity levels. It can be seen that iliac crest skin-snipping is more sensitive in each case.

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Table 4. Sensitivity of scapular and iliac skin biopsies by endemicity level in the Amazonian focus of southern Venezuela

Endemicity level	Studied communities	Overall crude prevalence (%)	No. examined	Scapular or iliac +ve	Scapular or +ve only	Iliac +ve only	Iliac and scapular +ve	Sensitivity of scapular snips (%)	Sensitivity of iliac snips (%)
Hypoendemic	1,2,4,15,18	4·9	244	12	0	8	4	33	100
Mesoendemic	8,11,16	34·2	146	53	3	34	16	35	94
Hyperendemic*	9,10,12,13, 14,17,19,21	69·6	270	198	14	48	136	75	93

* These data do not include the values for Harau-theri A and B since at these localities skin samples were taken only from the iliac crest.

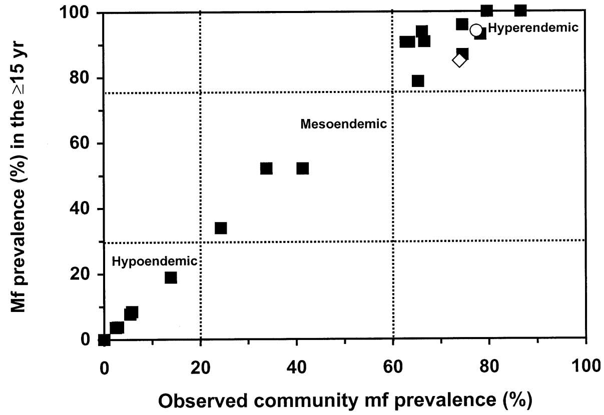

Fig. 1. Microfilarial prevalence in the indicator group (those aged ⩾ 15 years) *versus* mf prevalence in the whole community (⩾ 5 years). (■) Villages studied in this work. (○, ◇) Denote, respectively, the villages of Niyayowë-theri (raw data from Yarzábal *et al.* 1985) and Coyowë-theri (raw data gathered by the onchocerciasis control programme, CAICET, 1995). The vertical and horizontal dotted lines indicate, respectively, the endemicity thresholds for the community (males and females of all ages) and for the indicator group. Although in this study, not changing the thresholds for the indicator group would have resulted in essentially a 100 % correct classification, recently gathered data show that this procedure would have produced at least 6 % misclassifications (data not shown).

Indicators of mf prevalence at the community level. Figure 1 shows the relationship between mf prevalence in the indicator group and in the whole community for the examined villages. A microfilarial prevalence > 75 % in those aged ⩾ 15 years would be indicative of hyperendemic status in the village (all ages), between 30 and 75 % would indicate mesoendemicity, and < 30 % hypoendemicity. These higher, and therefore more stringent, thresholds were chosen to reflect the fact that in the Amazonian focus prevalence increases with age, so that the proportion infected in the indicator group is higher than that in all ages for the same endemicity level.

The relationship between the age- and sex-adjusted prevalence of palpable nodules in the indicator group and of skin mf in the community is depicted in Fig. 2 with prevalence of nodules on the *y* axis to facilitate comparison with the results reported for West African settings (Buck, 1974; WHO, 1992). The Spearman rank correlation coefficient between these two variables was 0·686 ($P =$ 0·001). The exact 95 % confidence limits for both prevalence of nodules and mf are also shown. Although the villages fall clearly into 3 categories, hypo-, meso-, and hyperendemic according to mf prevalence, the situation is less clear-cut according to nodule prevalence due to much greater variation. However, as a rule of thumb, a nodule prevalence in

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Table 5. Results of multiple linear regression of the arcsine transformation of community mf prevalence (y) on nodule prevalence in those aged $\geqslant$ 15 years (x_1) and altitude of the village (x_2)

(The model is: $y = b_0 + b_1 x_1 + b_2 x_2 + b_{12} x_1 x_2$. The intercept b_0 was not significantly different from zero and subsequently dropped from the model; $b_{12} x_1 x_2$ is the interaction term.)

Coefficients	Estimate	P	95% CL
b_1	1·4560	< 0·001	1·0528–1·8592
b_2	0·1023	< 0·001	0·0664–0·1382
b_{12}	−0·0027	< 0·001	−0·0040–0·0014
n	20		
r	0·85		
R^2	0·72		

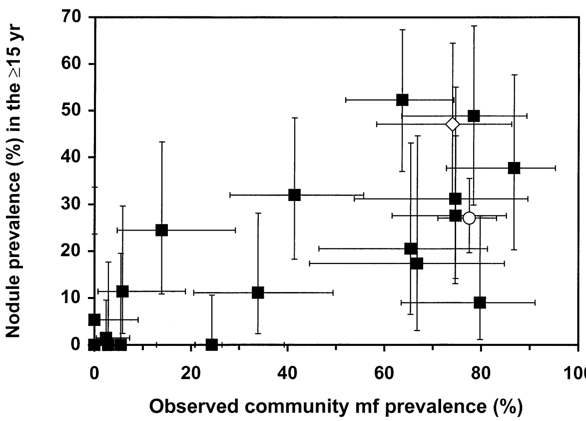

Fig. 2. Nodule prevalence in the indicator group *vs*. mf prevalence in the community with error bars (95% CL) for both variables. Markers as in Fig. 1.

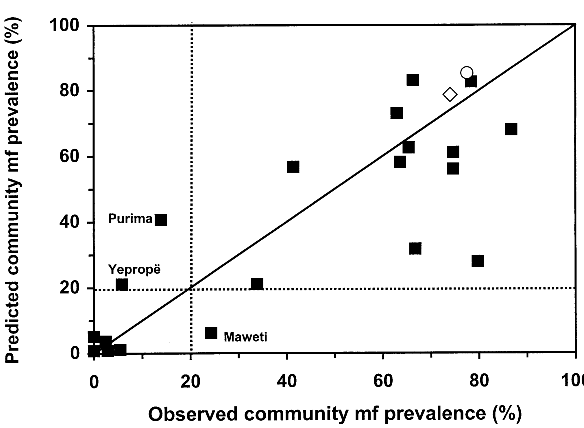

Fig. 3. The community mf point prevalence predicted by the multiple linear regression model presented in Table 5 plotted against the mf prevalence obtained by skin-snipping. Markers as in Fig. 1. The line of slope = 1 indicates perfect agreement between predictions and observations.

the indicator group greater than 10% would suggest a community mf prevalence over 20%. This would have a sensitivity of 85% and a specificity of 71% compared to a microfilarial prevalence in all ages $\geqslant$ 21%, and would indicate that 13 of the 20 communities would warrant high priority treatment, including 11 of the 13 villages at moderate and severe risk (meso- and hyperendemic).

In the Amazonian focus of southern Venezuela, altitude had already been found to be an important predictor of mf prevalence (Vivas-Martínez *et al*. 1998). The results of a step-wise multiple linear regression analysis, including prevalence of nodules in the indicator group, river system along which the community is located, and altitude of the village as explanatory variables of the angular-transformed mf prevalence were as follows: the model using prevalence of onchocercomata as the only predictor explained 57% of the variance ($r = 0·76$); using prevalence of nodules, river system, and their interaction increased the determination coefficient to 62% ($r = 0·79$); in the model with all the latter plus altitude and its interaction with the remaining variables, river system became non-significant and was subsequently dropped. The best model used nodules, altitude, and their interaction, explaining 72% of the observed variation ($r = 0·85$). The coefficients of this model are presented in Table 5. Figure 3 makes a comparison between the community mf point prevalence predicted according to this model and that according to the age–sex adjusted values estimated from skin-snipping. Using both altitude of the village and prevalence of nodules in the indicator group had a sensitivity of 92% (12 out of 13 communities) and a specificity of 71% (5 out of 7) in comparison to a microfilarial prevalence in all ages of 21% or more. Of the 13 communities that would warrant high priority treatment, Maweti-theri (at moderate risk and with an estimated nodule prevalence of 0%) would not receive ivermectin. Conversely, the hypoendemic villages of Yepropë-theri and Purima-theri would have been treated. All hyperendemic communities would have been correctly targeted, including Pashopeka-theri despite its low nodule prevalence.

DISCUSSION

Table 1 shows that half of the surveyed communities (plus 2 villages previously studied) were hyperendemic, with mf prevalence beyond 60% and CMFL greater than 10 mf/ss in 5 villages, and from 5 to 9 in the remainder. In savanna settings of West and Central Africa these levels of infection have been associated with increased risk of onchocercal blindness, requiring urgent or highly desirable mass ivermectin treatment respectively (WHO, 1992). The implementation of large-scale ivermectin delivery programmes is very difficult in remote areas such as the Amazonian focus in southern Venezuela, making it crucial to identify appropriate REA indicators. It has already been shown that at altitudes greater than 200 m above sea level communities are hyperendemic (Vivas-Martínez *et al*. 1998). However, parasitological indicators are necessary to complement information on elevation and blackfly species composition and abundance.

It is important to make sure that when skin-snipping is necessary, snips are taken from the body region that ensures maximum sensitivity. Our results indicate that in southern Venezuela this is the iliac crest at all endemicity levels, perhaps reflecting a higher parasite concentration in the lower half of the body as suggested by Moraes *et al*. (1978) in the Brazilian part of the focus. However, as control progresses skin-snipping is likely to become less sensitive (Taylor *et al*. 1989), and other methods, such as serodiagnostic tests to measure incidence in children, will become necessary (Bradley *et al*. 1998; Botto *et al*. 1999).

An almost linear relationship was found between mf prevalence in the indicator group (males and females aged $\geqslant 15$ years) and that of the community, according to which a prevalence $> 75\%$ in the former is indicative of hyperendemic status in the latter. This differs from the revised criteria advocated in Africa, where the indicator group consists of males over 20 years of age, and a prevalence of 90% suggests hyperendemicity (WHO, 1992).

In Africa, it has been proposed that the prevalence of palpable nodules may be considered as the rapid indicator of choice when assessing onchocerciasis endemicity, assuming that nodule prevalence represents approximately half the true prevalence of onchocerciasis (Taylor *et al*. 1992). It is also recommended that palpation of nodules be carried out in the adult male indicator group (WHO, 1995). More recently, a slope of 1·60 has been reported for the regression of community mf prevalence on nodule prevalence determined in adult males according to WHO protocols, which would permit rapid assessment of onchocerciasis prevalence using non-invasive methods in the Congo (Law *et al*. 1998). However, a standard linear regression is not strictly suitable when analysing percentages. In this study, nodule prevalence (measured for all ages) is likely to represent somewhat less than half the microfilarial prevalence, but the nodule ratio improves for the indicator group. However, considerable variation was observed in nodule prevalence within endemicity level. The ability of this indicator (assessed in those aged $\geqslant 15$ years) to estimate the point prevalence of mf in the community, and allocate villages into categories for mass ivermectin treatment improved when altitude of the village was also considered. The mesoendemic community classified as having low treatment priority was Maweti-theri, with an observed nodule prevalence of 0%, an intensity of infection of 0·6 mf/mg, and a CMFL of 0·4 mf/ss (more similar to those recorded in hypoendemic areas). Regarding the two communities that would receive high treatment priority being at low risk, Yepropë-theri had a prevalence of onchocercomata of 11·4% and it is located at 150 m above sea level, close to the altitude threshold for high endemicity in the southern Venezuela onchocerciasis focus (Vivas-Martínez *et al*. 1998). Purima-theri is at 110 m of elevation, but 24·5% of those aged 15 years and over presented with palpable nodules.

In this study, and for the purposes of delivering mass ivermectin treatment to communities at moderate and severe risk, the sensitivity and specificity of the proposed rapid assessment method (altitude above sea level and prevalence of nodules in the $\geqslant 15$-year-olds), were 92% and 71%, respectively, when tested against a community mf prevalence $\geqslant 21\%$. These figures compare favourably with a recent evaluation of nodule prevalence (in adult males) as a REA method to target communities for ivermectin distribution in West Africa (nodule prevalence $\geqslant 20\%$ in this indicator group had 94% sensitivity and 50% specificity in relation to a community mf prevalence $\geqslant 40\%$ for 32 villages in Benue State, Nigeria (Whitworth & Gemade, 1999)). Analysis of data from ongoing studies will prove invaluable to validate the usefulness of these indicators for rapid epidemiological assessment in other areas of the onchocerciasis focus of southern Venezuela.

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