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Earth-eating and reinfection with intestinal helminths among pregnant and lactating women in western Kenya

Alfred I. Luoba[1], P. Wenzel Geissler[2], Benson Estambale[3], John H. Ouma[4], Dorcas Alusala[1], Rosemary Ayah[5], David Mwaniki[5], Pascal Magnussen[6] and Henrik Friis[7]

1 *Division of Vector-borne Diseases, Ministry of Health, Kisumu, Kenya*
2 *London School of Hygiene and Tropical Medicine, London, UK*
3 *Department of Microbiology, University of Nairobi, Nairobi, Kenya*
4 *Maseno University, Maseno, Kenya*
5 *Kenya Medical Research Institute, Nairobi, Kenya*
6 *Danish Bilharziasis Laboratory, Charlottenlund, Denmark*
7 *Institute of Public Health, University of Copenhagen, Copenhagen, Denmark*

Summary We conducted a longitudinal study among 827 pregnant women in Nyanza Province, western Kenya, to determine the effect of earth-eating on geohelminth reinfection after treatment. The women were recruited at a gestational age of 14–24 weeks (median: 17) and followed up to 6 months postpartum. The median age was 23 (range: 14–47) years, the median parity 2 (range: 0–11). After deworming with mebendazole (500 mg, single dose) of those found infected at 32 weeks gestation, 700 women were uninfected with *Ascaris lumbricoides*, 670 with *Trichuris trichiura* and 479 with hookworm. At delivery, 11.2%, 4.6% and 3.8% of these women were reinfected with hookworm, *T. trichiura* and *A. lumbricoides* respectively. The reinfection rate for hookworm was 14.8%, for *T. trichiura* 6.65, and for *A. lumbricoides* 5.2% at 3 months postpartum, and 16.0, 5.9 and 9.4% at 6 months postpartum. There was a significant difference in hookworm intensity at delivery between geophagous and non-geophagous women ($P = 0.03$). Women who ate termite mound earth were more often and more intensely infected with hookworm at delivery than those eating other types of earth ($P = 0.07$ and $P = 0.02$ respectively). There were significant differences in the prevalence of *A. lumbricoides* between geophagous and non-geophagous women at 3 ($P = 0.001$) and at 6 months postpartum ($P = 0.001$). Women who ate termite mound earth had a higher prevalence of *A. lumbricoides*, compared with those eating other kinds of earth, at delivery ($P = 0.02$), 3 months postpartum ($P = 0.001$) and at 6 months postpartum ($P = 0.001$). The intensity of infections with *T. trichiura* at 6 months postpartum was significantly different between geophagous and non-geophagous women ($P = 0.005$). Our study shows that geophagy is associated with *A. lumbricoides* reinfection among pregnant and lactating women and that intensities built up more rapidly among geophagous women. Geophagy might be associated with reinfection with hookworm and *T. trichiura*, although these results were less unequivocal. These findings call for increased emphasis, in antenatal care, on the potential risks of earth-eating, and for deworming of women after delivery.

keywords geophagy, pica, *Ascaris*, *Trichuris*, hookworm, reinfection, deworming, women, pregnancy, nutrition, Kenya

Introduction

Geophagy is the habit of deliberately eating earth and is common among many societies (Abrahams & Parsons 1996; Anell & Lagercrantz 1958; Halstead 1968). It is widespread in sub-Saharan Africa, particularly among women, who eat a variety of earth types, especially earth collected by termites and smooth, dried clay mined from particular places and traded (Vermeer 1971; Geissler *et al.* 1997; Saathoff *et al.* 2002). Geophagy has long been suspected to be a source of geohelminth infection (Anell & Lagercrantz 1958; Halstead 1968; Hunter 1973), but only recently has the practice been associated with infection with *Ascaris lumbricoides* and, although less conclusively, *Trichuris trichiura*, among institutionalized orphans in Jamaica (Wong *et al.* 1991) and schoolchildren in western Kenya (Geissler *et al.* 1998a), KwaZulu-Natal in South Africa (Saathoff *et al.* 2002) and Lusaka, Zambia (Nchito *et al.* 2004). The impact of geophagy on pregnant women in terms of helminth infections has not been previously studied, although anecdotal evidence suggests that it is particularly common in this group (Anell & Lagercrantz 1958). Our own preparatory surveys showed that 46% of the pregnant women in the study area regularly ate earth, preferring termite mound earth and locally mined 'soft stone' (Prince *et al.* 1999; Luoba *et al.* 2004). Given the role that helminth infections play in exacerbating malnutrition, and the crucial importance of maternal nutrition during pregnancy for birth outcomes and maternal health, we investigated the relationship between geophagy and helminth infection in this group. A longitudinal birth cohort study in Bondo District, western Kenya, afforded us an opportunity to do this. Prevalence and intensities of intestinal helminths (*A. lumbricoides*, *T. trichiura* and *Necator americanus*) in this area are high (Thiong'o *et al.* 2001; Olsen *et al.* 2003). This paper reports our findings on geophagy as a risk factor in helminth infection among pregnant and lactating women in western Kenya.

Materials and methods

Study area and population

The study was conducted in two locations of Usigu Division, Bondo District, Nyanza Province, Kenya. The area extends from the shores of Lake Victoria in the south to the swampy banks of river Yala in the north. The population is mainly Luo with a few Luhya migrants. Most community members are subsistence farmers growing maize, sorghum and cassava, and commercial fishermen. Most families keep Zebu cattle for milk and all homes keep goats, sheep and chicken. Most families depend on cash remittances from relatives working elsewhere. The total population was 25 459 in 1998 (Kenyan-Danish Health Research Project (KEDAHR), unpublished data), with a 1:1.1 ratio of male to female. About 52% (6900) of the women are of childbearing age (14–49 years).

The soil in the area is of volcanic origin belonging to the Nyanzian system. It is dominantly red to dark brown friable clay with a laterite layer or horizon; the red clay is overlaid by a greyish brown horizon. The iron content increases with depth. Close to the lake, stretches of 'black cotton soil', grumosolic black clay, are found (Government of Kenya 1970). The women and children in this area are deficient in most micronutrients including iron due mainly to the typical cereal-based diet with few animal products (Mwaniki *et al.* 2002).

Ethics

Permission to conduct this study was granted by the Ministry of Health and Kenyatta Hospital Scientific and Ethical committee in Kenya and the Danish National Ethical committee on behalf of the collaborating Danish institutions. Local community leaders were briefed about the objectives of the study. We explained the aims and methods of the study to participating women, who gave written consent before investigations began; they were told that they were free to leave the study at any time without giving reasons.

Study design

The study was part of a longitudinal intervention cohort study undertaken by KEDAHR between 1998 and 2001. Expecting women were recruited between week 14 and 24 of gestation. They were parasitologically examined and interviewed about their earth-eating habits at baseline, midterm (28–32 weeks gestation), delivery and 3 and 6 months postpartum, using a combination of group conversation and individual interview as outlined by Geissler *et al.* (1997). We told participants that the study's aims were to identify effects and possible causes of the earth-eating habit, taking care to convey an unprejudiced attitude towards the practice in order not to influence their reporting or geophagy itself. Once we had established a link between geophagy and helminth infection, the findings were reported back to the women when they received anthelminthic treatment.

Parasitological examinations

Stool samples were collected on 2 consecutive days and duplicate 50 mg Kato Katz cellophane thick smears were made (World Health Organization (WHO) 1991). The slides were examined within an hour for hookworm eggs and on the following day for other intestinal helminth eggs. Intensity was expressed as mean eggs/g of faeces (epg) of the two samples. After the second examination, a clinician treated all women with a single dose of mebendazole 500 mg (Vermox), the drug and dosage recommended by the locally responsible Medical Officer.

Data analysis

Data were entered in duplicate and analysed using SPSS™ 10 software. Descriptive statistics were used to assess the prevalence of infections. Intestinal helminth egg counts were $\log_{10}$-transformed to obtain normal distribution before analysis for intensities. Chi-square tests were used to test for differences in proportions, while a *t*-test and one-way ANOVA were used to assess differences in intensities of infection between groups. A significance level of $P = 0.05$ was used in all tests.

Results

We recruited 824 pregnant women at 14–24 weeks gestational age and followed them up to 6 months postpartum after anthelminthic treatment. As reported previously (Luoba *et al.* 2004), 45.7% were geophagous. The age of the women or their area of residence (a rough proxy of socio-economic differences) had no impact on this prevalence; neither were basic socio-economic factors significantly linked to geophagy (Luoba *et al.* 2004). The women indicated a clear preference for particular kinds of earth: 54.2% ate 'soft stone' while 42.8% ate earth from termite mounds, others ate earth from earthen walls of houses and from gullies. Few suggested that they mixed or switched between these types. The prevalence of geophagy remained high during pregnancy, and declined to 34.5% and 29.6% at 3 and 6 months postpartum, respectively; the mean daily earth intake was 44.5 g during pregnancy, which declined to 25.5 g during lactation; among women eating 'soft stone' the mean amount of earth eaten daily was 54.2 g, while it was 28.5 g among those eating termite mound earth (Luoba *et al.* 2004). Cure rates after treatment with a single dose of mebendazole 500 mg were 79% for *A. lumbricoides*, 70% for *T. trichiura* and 41% for hookworm.

Reinfection

During the first follow-up examination at midterm, 700 women tested negative (successfully treated or initially uninfected) for *A. lumbricoides*, 670 for *T. trichiura* and 479 for hookworm. They were therefore included in the analysis for reinfection. As shown in Table 1, at delivery 11.2% of the women had been reinfected with hookworm, 4.6% with *A. lumbricoides* and 3.8% with *T. trichiura*. During the second follow up at 3 months postpartum, the reinfection rates were 14.8% for hookworm, 6.6% for *A. lumbricoides* and 5.2% for *T. trichiura*. At 6 months postpartum, hookworm reinfection had increased to 16.0%, *A. lumbricoides* to 9.4% and *T. trichiura* to 5.9%. While reinfection rates thus showed a steady increase, reinfection intensities did not show a clear-cut pattern.

Ascaris lumbricoides

Geophagous women had higher reinfection rates of *A. lumbricoides* during follow up than non-geophagous ones (Table 2). Reinfection increased from 6.0% at delivery to 10.5% at 3 months postpartum compared with 3.3–3.4% among non-geophagous women ($P < 0.001$). The difference between the reinfection rates of the two groups was even wider at 6 months postpartum (13.8% *vs.* 5.8%, $P < 0.001$). We found no significant differences in infection intensities between geophagous and non-geophagous women during follow up. The relative risk for reinfection with *A. lumbricoides* at delivery comparing geophagous and non-geophagous was 1.48 (95% CI: 0.84–2.61) compared with 2.16 (95% CI: 1.28–3.66) at 3 months postpartum and 2.44 (95% CI: 1.50–3.98) at 6 months postpartum.

Geophagous women were stratified by type of earth eaten: 139 women ate earth from termite mounds, 183 ate other types of earth (mostly 'soft stone', a white chalky stone that can be found in riverbeds or bought on local markets) and were grouped together. There were significant differences in reinfection rates between women eating different types of earth (Table 3) and non-geophagous ones at delivery, 3 and 6 months postpartum ($P = 0.002$, $P < 0.001$ and $P < 0.001$, respectively). The type of earth

Table 1 Reinfection rates and intensities of intestinal helminths at delivery, 3 and 6 months postpartum*

	Delivery	3 months postpartum	6 months postpartum
Hookworm			
Prevalence†	11.2 (8.2–14.2)	14.8 (11.0–18.0)	16 (12.0–20.0)
Intensity‡	147 (59–365)	57 (26–103)	74 (44–125)
Ascaris lumbricoides			
Prevalence†	4.6 (2.6–6.6)	6.6 (4.6–8.6)	9.4 (6.4–12.4)
Intensity‡	239 (57–1014)	1429 (192–10641)	828 (100–6883)
Trichuris trichiura			
Prevalence†	3.8 (2.0–6.0)	5.2 (3.2, 8.2)	5.9 (4.0–8.0)
Intensity‡	61 (24–160)	62 (40–96)	53 (30–96)

* Only women who were found initially uninfected or successfully treated at 32 weeks gestation.

† Percentage (95% CI); number at delivery, 3 and 6 months postpartum are: hookworm 411, 411 and 405; *A. lumbricoides* 590, 606 and 593; and *T. trichiura* 573, 575 and 561.

‡ Geometric mean (95% CI) eggs/g for infected women only.

Table 2 Reinfection rates and intensities of *Ascaris lumbricoides* among geophagous and non-geophagous women at delivery, 3 and 6 months postpartum*

	Geophagous (n = 320)		Non-geophagous (n = 378)		
	N	Values† (95% CI)	*N*	Values† (95% CI)	*P*-value
At delivery					
Prevalence	268	6.0 (4.0–9.0)	323	3.4 (1.4–5.4)	0.14
Intensity		411 (177–956)		360 (126–1024)	0.83
3 months postpartum					
Prevalence	275	10.5 (6.8–14.2)	331	3.3 (1.3–5.3)	<0.001
Intensity		443 (193–1017)		1080 (264–4410)	0.25
6 months postpartum					
Prevalence	268	13.8 (9.6–18.0)	325	5.8 (3.2–8.4)	<0.001
Intensity		404 (190–640)		536 (164–1745)	0.46

* Only women who were found initially uninfected or successfully treated at 32 weeks gestation.
† Values for prevalence are expressed as percentage; values for intensity are expressed as geometric mean eggs/g for infected women only.

Table 3 Reinfection rates and intensities of *Ascaris lumbricoides* among women eating termite mound earth, compared with those eating other earth or no earth at all at delivery, 3 and 6 months postpartum*

	Geophagous			
	Ant hill (n = 138)	Other earth (n = 182)	Non-geophagous (n = 378)	*P*-value
At delivery				
Prevalence†	10.7 (4.9–15.6)	2.6 (0.1–5.1)	3.4 (1.4–5.4)	0.002
Intensity‡	451 (151–1350)	311 (46–2118)	360 (126–1024)	0.90
3 months postpartum				
Prevalence†	18.5 (11.4–25.6)	4.5 (1.2–7.8)	3.3 (1.3–5.3)	<0.001
Intensity‡	404 (150–1090)	589 (80–4346)	1080 (264–4410)	0.48
6 months postpartum				
Prevalence†	23.3 (15.5–31.1)	6.6 (2.6–10.6)	5.8 (3.2–8.4)	<0.001
Intensity‡	349 (160–761)	349 (127–959)	536 (164–1745)	0.76

* Only women who were found initially uninfected or successfully treated at 32 weeks gestation.
† Percentage (95% CI), at delivery (termite mound, n = 112; other earth, n = 156; non-geophagous, n = 323); 3 months postpartum (termite mound, n = 119; other earth, n = 156; non-geophagous, n = 331); 6 months postpartum (termite mound, n = 116; other earth, n = 152; non-geophagous, n = 325).
‡ Geometric mean (95% CI) eggs/g for infected women only.

eaten did not cause differences in the intensity of infection. Reinfection rates in all groups followed a linear upward trend.

Trichuris trichiura

There was no difference in *T. trichiura* reinfection rates between geophagous and non-geophagous women at any point of the follow up. However, the intensity was higher in geophagous compared with non-geophagous women at 6 months postpartum (83 *vs.* 37 geometric mean epg, $P = 0.005$) (Table 4).

Hookworm

The proportion of women found free of hookworm infection at midterm was smaller compared with other worms; this was because of a poor cure rate of 41% (149). Thus, only 479 women could be included in the follow up for hookworm reinfection. As seen in Table 5, there were no significant differences in the reinfection rates with hookworm between the geophagous and non-geophagous women at any point of the follow up. There was a significant difference in the intensity of hookworm egg counts between geophagous and non-geophagous women

Table 4 Reinfection rates and intensities of *Trichuris trichiura* among geophagous and non-geophagous women at delivery, 3 and 6 months postpartum*

	Geophagous (n = 315)		Non-geophagous (n = 355)		
	N	Values† (95% CI)	*N*	Values† (95% CI)	*P*-value
At delivery					
Prevalence	267	3.4 (1.2–5.6)	306	4.2 (1.9–6.5)	0.58
Intensity		54 (19–152)		58 (27–126)	0.90
3 months postpartum					
Prevalence	269	6.3 (3.3–9.3)	306	4.2 (1.9–6.5)	0.26
Intensity		73 (41–130)		42 (29–62)	0.12
6 months postpartum					
Prevalence	262	6.4 (3.9–9.9)	299	5.3 (2.5–7.5)	0.35
Intensity		83 (57–118)		37 (25–55)	0.005

* Only women who were found initially uninfected or successfully treated at 32 weeks gestation.
† Values for prevalence are expressed as percentage; values for intensity are expressed as geometric mean eggs/g for infected women only.

at delivery (153 *vs.* 77 epg, $P = 0.03$), but not at the 3- or 6-month follow up. The highest relative risk for reinfection with hookworm was at 6 months (1.14, 95% CI: 0.87–1.39) comparing geophagous and non-geophagous women, but this difference was not statistically significant. When geophagous women were stratified by type of earth eaten and compared with non-geophagous women, reinfection among the termite mound group was higher than in the other groups, but there was no statistical difference in the rates of reinfection between geophagous and non-geophagous women at any point of the follow up (Table 6).

However, there was a significant difference in intensity of hookworm between women eating different types of earth and non-geophagous at delivery ($P = 0.02$). No significant difference was noted in the intensities of hookworm between the groups at 3 and 6 months postpartum.

Discussion

Geohelminths are prevalent in the study area as reported by Geissler *et al.* (1998a) and Thiong'o *et al.* (2001). The area has all the factors that favour transmission and maintenance of intestinal helminths in the community: humid conditions, optimal temperatures for larval development and egg viability and widespread economic deprivation. Geophagy is common among pregnant women, as previously reported from the same area as well as other Kenyan populations (Geissler *et al.* 1998c; Prince *et al.* 1999). The association of geophagy with geohelminth infections has been shown among school-age children (Wong *et al.* 1988; Geissler *et al.* 1998a; Glickman *et al.* 1999; Saathoff *et al.* 2002), but this is the first study suggesting that earth-eating is a major cause of helminth infection among pregnant women.

The prevalence of *A. lumbricoides* at baseline was 16.3% with an intensity of 815 epg. The prevalence was 9.4% at the close of the follow-up period, which was 58% of the baseline rate. This reinfection rate is low compared with that reported from schoolchildren in the same area and among adults in the neighbouring district (Geissler *et al.* 1998b; Olsen *et al.* 2000). The increase in reinfection of *Ascaris* showed a positive trend and was markedly associated with geophagy. This positive association of *A. lumbricoides* and geophagy has been documented in other studies (Wong *et al.*

Table 5 Reinfection rates and intensities of hookworm among geophagous and non-geophagous women at delivery, 3 and 6 months postpartum follow up*

	Geophagous (n = 225)		Non-geophagous (n = 254)		
	N	Values† (95% CI)	*N*	Values† (95% CI)	*P*-value
At delivery					
Prevalence	187	9.6 (5.3–13.9)	224	12.5 (8.1–16.9)	0.35
Intensity		153 (83–282)		77 (55–106)	0.03
3 months postpartum					
Prevalence	190	16.8 (11.6–22.0)	221	13.1 (8.6–17.6)	0.29
Intensity		57 (42–78)		54 (37–77)	0.76
6 months postpartum					
Prevalence	184	17.4 (11.8–23.0)	221	14.9 (10.1–19.7)	0.50
Intensity		67 (52–86)		60 (44–83)	0.62

* Only women who were found initially uninfected or successfully treated at 32 weeks gestation.
† Values for prevalence are expressed as percentage; values for intensity are expressed as geometric mean eggs/g for infected women only.

Table 6 Reinfection rates and intensities of hookworm among women eating termite mound earth, compared with those eating other earth or no earth at all at delivery, 3 and 6 months postpartum follow up*

	Geophagous			
	Termite mound (n = 95)	Other earth (n = 130)	Non-geophagous (n = 254)	P-value
At delivery				
Prevalence†	15.4 (7.4–23.4)	5.5 (1.1–9.9)	12.5 (8.1–16.9)	0.07
Intensity‡	208 (90–478)	83 (35–198)	77 (55–106)	0.02
3 months postpartum				
Prevalence†	21.5 (12.3–30.7)	13.5 (7.0–20.0)	13.1 (8.6–17.6)	0.17
Intensity‡	55 (34–89)	61 (39–93)	54 (37–77)	0.9
6 months postpartum				
Prevalence†	19.5 (10.5–28.5)	15.9 (8.9–22.9)	14.9 (10.1–19.7)	0.64
Intensity‡	61 (42–88)	72 (49–105)	60 (44–83)	0.75

* Only women who were found initially uninfected or successfully treated at 32 weeks gestation.
† Percentage (95% CI), at delivery (termite mound, n = 78; other earth, n = 109; non-geophagous, n = 224); 3 months postpartum (termite mound, n = 79; other earth, n = 111; non-geophagous, n = 221); 6 months postpartum (ant hill, n = 77; other earth, n = 107; non-geophagous, n = 221).
‡ Geometric mean (95% CI) eggs/g for infected women only.

1991; Geissler *et al.* 1998b; Glickman *et al.* 1999; Saathoff *et al.* 2002). This association is likely to be causal as *A. lumbricoides* infection is mainly through the ingestion of material contaminated with the eggs.

The type of earth most strongly associated with *Ascaris* infection came from termite mounds, which corroborates findings of other studies (Geissler *et al.* 1998b; Saathoff *et al.* 2002). Termite mounds were common in the study area and often situated near or in the homes. These mounds are sometimes used as screens behind which to defecate, thereby contaminating the surrounding area with *A. lumbricoides* eggs. The contamination can be spread by wild and domestic animals, for example, cattle, poultry and monkeys, which are common near homesteads. It was observed that termite mound earth is sometimes eaten at the source, a habit that would facilitate the direct ingestion of helminth eggs.

In contrast to termite mound earth, the ingestion of other kinds of earth (mainly soft stone and, to a lesser extent, earth from walls) seemed to have little impact on reinfection with *Ascaris*. This was the case although the handling of soft stone is not always hygienic (mined in the hills, it is transported to the main road, split into smaller lumps on the ground, packed into sacks for wholesale markets, and sold to retailers who spread it on the ground for retail sale) and could lead to contamination with helminth eggs.

The different reinfection rates of women and schoolchildren could be explained by the fact that children are very active; pregnant women at this stage may be tired and confined to the home at the time of delivery; moreover, adult women tend to be more hygiene conscious than children and thus more careful when they collect the earth they intend to eat. *Ascaris lumbricoides* intensities at 6 months postpartum were comparable with the ones at baseline. This is in agreement with studies that reported higher intensities in children during reinfection than pretreatment (Henry 1988; Albonico *et al.* 1995; Olsen *et al.* 2000), but not among adults (Olsen *et al.* 2000). Among schoolchildren in the same region, intensities did not attain the baseline means after 11 months (Geissler *et al.* 1998b). Likewise, studies in Kwale District did not reach the baseline mean intensities even at 18 months after treatment (Magnussen *et al.* 1997). The mean intensities of infections among the women were not as high as has been reported in children and unlike the prevalence they were not significantly different between geophagous and non-geophagous groups, as previously found by Geissler *et al.* (1998b) and Saathoff *et al.* (2002).

There was a 5.9% prevalence of *T. trichiura* at 6 months postpartum, corresponding to 24% of the baseline prevalence. This was low compared with the reinfection rates found by Olsen *et al.* (2000) and Magnussen *et al.* (1997) in other areas of Kenya and by Geissler *et al.* (1998a) in schoolchildren in the same area. There was a significant difference in the intensities of infections with *T. trichiura* between geophagous and non-geophagous women, which corroborated findings by Geissler *et al.* (1998a). This is biologically plausible as the mode of infection is through ingestion of contaminated material. The fact that there was no difference in reinfection rates between geophagous and non-geophagous women could be explained by the fewer eggs of *T. trichiura*, compared with *A. lumbricoides*, in the environment. Moreover, *T. trichiura* eggs last less long in the soil than those of *A. lumbricoides* because they are highly sensitive to desiccation, and unlike *A. lumbricoides* eggs, they lack the thick sticky albumin coating that would allow them to adhere to earth particles. They are easily swept away or washed to lower layers owing to their smooth surface coating.

We found that the hookworm cure rate was poor after treating with mebendazole as a 500 mg single dose. This has also been documented by studies among schoolchildren in Tanzania and all age groups in Mali (Albonico *et al.* 1994). The rate of reinfection with hookworm was 16% at 6 months postpartum which was about 32% of the baseline prevalence. This agreed with results within the same range obtained in other studies in Kenya (Magnussen *et al.* 1997; Olsen *et al.* 2000). Likewise, intensities were low during reinfection and compared well with the findings of the same studies in Kenya. There was a significant difference in intensities of hookworm between geophagous and non-geophagous women at delivery, which could be attributed specifically to eating termite mound earth. A possible explanation is that children in the area have a tendency to defecate around termite mounds, and that these women hence have acquired the infection in the course of their search for earth from these mounds. The moist earth around the mounds would be more conducive for the survival of the hookworm filariform larvae than other types of earth.

Conclusion

This study has shown that geophagy is associated with *A. lumbricoides* reinfection among pregnant women. We also found that intensities built up more rapidly after anthelminthic treatment among geophagous women than non-geophagous ones. This calls for an emphasis on the potential risks of earth-eating and on ways of reducing these risks in antenatal health education. As geophagy is a common and widely accepted pregnancy-related habit, women are unlikely to refrain from it (Geissler 2000). Interventions ought therefore to aim at improving the practice rather than object to it. One way of reducing the potential hazards of earth-eating could be to bake the earth while preparing food on a firewood or charcoal stove, which already is practiced by some women in the area and which according to some enhances the flavour (Geissler 2000); alternatively, earth could be obtained from deep holes, as is common in Natal, South Africa (Saathoff *et al.* 2002). Such advice could be included in antenatal care.

Women of reproductive age should be treated for helminth infections. A single dose of mebendazole 500 mg was not an effective tool in hookworm treatment. Instead, albendazole should be used in future control measures, ideally twice a year, especially as it has been suggested to be safe in pregnancy (WHO 1986, 1996). Anthelminthic treatment could be given together with other treatments over the course of the pregnancy, such as, for example, intermittent prophylactic antimalarial treatment, or after delivery, with treatment for bilharziasis. As geophagy seems to be an important factor in the transmission of *A. lumbricoides*, further studies should be undertaken to understand its potential risks and benefits, including its role in nutrition (particularly with iron and other micronutrients), as well as to find ways of improving it by selecting earth, preparing it before ingestion, or by providing safer supplements, or through a combination of health education coupled with prompt treatment of the high risk groups.

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Authors

Alfred I. Luoba and **Dorcas Alusala**, Division of Vector-borne Diseases, Ministry of Health, Kisumu, Kenya. E-mail: alwoba@yahoo.com

P. Wenzel Geissler, Department of Public Health and Policy, Health Policy Unit, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK. E-mail: wenzel.geissler@lshtm.ac.uk (corresponding author).

John H. Ouma, Maseno University, Maseno, Kenya.

Benson Estambale, Department of Microbiology, University of Nairobi, Nairobi, Kenya.

Rosemary Ayah and **David Mwaniki**, Kenya Medical Research Institute, Nairobi, Kenya.

Pascal Magnussen, Danish Bilharziasis Laboratory, Charlottenlund, Denmark.

Henrik Friis, Institute of Public Health, University of Copenhagen, Copenhagen, Denmark.

