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ORIGINAL ARTICLE

Are intestinal parasites fuelling the rise in dual burden households in Venezuela?

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Background: In developing countries undergoing rapid economic development, the number of dual burden households (i.e. co-existing overweight/obesity and stunting) is increasing. While intestinal parasites are prevalent in these countries, their contribution to dual burden households has so far been neglected. We studied the association between intestinal parasite infection and belonging to a dual burden household in a rural community of Venezuela.

Methods: We examined 225 individuals. A dual burden household was defined as a household with at least one overweight/obese adult (BMI $>$ 25) and at least one stunted child (height -for-age z score $<$-2). Intestinal parasite (*Giardia lamblia* and geohelminth) infection was determined by faecal smears.

Results: In this community, 47.3% of the individuals were infected with intestinal parasites. Among adults, 65.2% were overweight/obese and 13.8% of the children were stunted. More than one in four households (26.8%) were dual burden households. Being infected with *G. lamblia* & geohelminths was significantly associated with being in a dual burden household (OR = 4.75, 95% CI: 1.01–22.20, n = 188), indicating a triple burden of disease in this community in Venezuela.

Conclusion: While the relationship between intestinal parasite infection and stunting has been well established, these results indicate a need to further explore the association of intestinal parasite infection with dual burden households.

Keywords: *Giardia lamblia*, Geohelminths, Dual burden, Overweight/obesity, Stunting, Venezuela

Introduction

Countries undergoing rapid economic growth have experienced an accelerated emergence of overweight/obesity prevalence.[1–3] Furthermore, the swift increase of overweight/obesity occurrence often exceeds reductions in child undernutrition.[2] Thus, these countries experience public health burdens related to the consequences of both overweight and obesity in adults and undernutrition in children.[3–5] This so-called dual burden exists not only at the national or regional level, but also within households.[5,6] A comprehensive worldwide analysis of multiple national surveys shows this phenomenon to be most frequent in Latin America with reported prevalences exceeding 10%.[6]

Early explanations of dual burden focused mainly on the obesity-related household environment.[7] More recently, Popkin hypothesized biological explanations, e.g. genetic predisposition and disease patterns related to infection.[1] However, to our knowledge, the role of intestinal parasites in dual burden has not yet been investigated. The relationship between chronic undernutrition (stunting) in childhood and intestinal parasite infections (in particular *Ascaris lumbricoides*, *Trichuris trichiura*, hookworm and *Giardia lamblia*) has been well established.[8–10] Furthermore, intestinal parasites, stunting and overweight/obesity are all known to be strongly related to poverty in the context of Latin America.[11–13]

The World Bank classifies Venezuela as an upper middle income country.[14] In spite of a high level of economic development and emerging overweight/obesity Venezuela still experiences a high burden of intestinal parasites and childhood stunting.[15–17] We set out to explore whether intestinal parasite infection and dual burden households were associated in a rural community in Venezuela.

Methods

We carried out a pilot study of 92 adults and 133 children from 41 households in a rural community in the state of Carabobo, Venezuela. Parasitological, anthropometrical and socioeconomic status data were collected between March and May 2010. Written informed consent was obtained from all adults and caretakers of the children. The study adheres to local ethical criteria and was approved by the ethics board of the VU University of Amsterdam.

Anthropometric measurements were taken from 210 individuals at the local school by a trained investigator following the methods of Lohman.[18] Height was measured using an anthropometric tape fixed to the wall. Natural waist circumference was measured at the narrowest part of the torso using a Holtane LTD-Harpenden anthropometric tape and was recorded to the nearest 0.1 cm. Weight was measured using a calibrated Tanita HD 334 digital scale and was recorded to the nearest 0.1 kg.

Anthropometric measurements were used to calculate indicators of nutritional status, based on WHO criteria. Using these definitions adults were classified as underweight if BMI <18.5, overweight if BMI >25 and obese if BMI >30. Adults were also classified as overweight or obese using WHO criteria for waist circumference, defined for females as having a waist circumference of $\geq$80 cm for overweight and $\geq$88 cm for obesity, and for males $\geq$94 cm for overweight and $\geq$102 cm for obesity.[19] Children aged 0–5 years were considered stunted if their height-for-age was two z-scores below the WHO reference median, and underweight if their weight-for-age was two z-scores below the WHO reference median. Children under five years of age were considered to be overweight if their BMI-for-age was two SD above the WHO reference median and obese if their BMI-for-age was three SD above the WHO reference median. For the older children, aged 5–19 years, being overweight was defined as one SD and being obese as two SD above the reference median of the BMI-for-age z score.[20] This age group was classified into the underweight class if their BMI-for-age was two z-scores below the reference median.

Intestinal parasite infections were determined in 188 individuals by wet mount of 100ml from a vortex homogenized 1:3 suspension faeces/SAF (sodium acetate, acetic acid, formaline) fixative, and iron haematoxilyn stained smears from samples on two consecutive days.[21] Children found to be positive for geohelminth (*Ascaris lumbricoides*, *Trichuris trichiura* and hookworm) were treated with albendazole (WHO recommendation). *Giardia lamblia* positives were referred to the local health centre. The analysis was focussed on *Ascaris lumbricoides, Trichuris trichiura*, hookworm and *G. lamblia* as the association between stunting and these selected parasites is well established.[8–10]

Socioeconomic status was determined based on an index (the Graffar method) modified for Venezuela by Mendez[22] and used extensively for this purpose in Venezuela. Following the Graffar method an index was used to classify the population into five strata: high, medium high, medium, relative poverty and critical poverty. This index is based on a compilation of the following measures: family income, mother's education level, profession of the head of the family and housing conditions.

All statistical analyses were performed with SPSS Statistics 17.0 (SPSS Inc., Chicago, IL, USA) and a p-value of $\leq$0.05 was considered statistically significant. Logistic regression was used for determining associations between infection and overweight/obesity or stunting. Dual burden households were defined as households with at least one overweight/obese adult (BMI $>$ 25) and at least one stunted child (height -for-age z score $<$-2). To compare characteristics of dual burden households to non dual burden households χ^2 analysis was used. We used generalized estimating equations models to adjust for correlated data when assessing the association between individual parasitic infection and likelihood of belonging to a dual burden household. Generalized estimating equations models were run using participants with data on intestinal parasitic infections. Subsequently, the covariates were entered using a stepwise forward approach to examine possible confounding or effect modification. Only relevant confounders, i.e., those which satisfied a change-in-estimate criterion of $\geq$10%, and significant effect modifiers were included in the final multiple logistic regression models. Age (in categories 0–5, 5–18 and older than 19 years) and gender were included as covariates in the adjusted model. Models were run on 188 individuals with full data.

Table 1. Characteristics of study population

		n/Total	%
Female		121/225	53.4
Age	0–5	46/225	20.0
	5–19	87/225	38.7
	>19	92/225	40.9
Children	Stunted	18/129	14.0
	Underweight	3/129	2.3
	Overweight	10/129	7.8
	Obese	4/129	3.1
Adults	Underweight	2/80	2.5
	Overweight	31/80	38.9
	Obese	21/80	26.3
Infection	Geohelminths	72/188	38.3
	Giardia lamblia	28/188	14.9
	Intestinal parasite infection (geohelminths or *G. lamblia*)	89/188	47.3

Results

Table 1 shows that among the children of this rural community, 14.0% (18/129) were stunted, 7.8% (10/129) overweight, 3.1% (4/129) obese and 2.3% (3/129) underweight. Among adults, 3% (2/80) were underweight, 39% (31/80) overweight and 26% (21/80) obese. Using BMI and waist circumference classifications for overweight and obesity generated identical results. In this population 47.3% (89/188) were infected with one of the intestinal parasites, 38.3% (72/188) with geohelminths and 14.9% (28/188) with *G. lamblia*.

Intestinal parasite infections were detected in 50% (9/18) of the stunted children and 35% 18/52) of the overweight/obese adults. Being infected with any of the intestinal parasites was not significantly associated with stunting in children (OR: 1.88;

Table 2. Comparison of non dual burden household members to dual burden household members

Variable		Non dual burden household *n*/Total	%	Dual burden household *n*/Total	%	p
Female		78/148	52.7	43/77	55.8	NS
Stunting (children)		1/79	1.3	17/50	34.0	<0.01
Overweight/obesity (adults)		37/58	63.7	15/22	68.2	NS
Age categories	0–5	35/148	23.6	21/77	27.3	NS
	5–19	56/148	37.8	32/77	41.6	
	>19	67/148	45.3	25/77	32.5	
Socioeconomic status (Graffar)	Relative poverty	67/141	47.5	27/72	37.5	NS
	Critical poverty	74/141	52.5	45/72	62.5	
Intestinal parasite infection	*Geohelminth*	42 /126	33.3	30/62	48.4	0.05
	Giardia lamblia	14/126	11.1	14/62	22.6	0.04
	Intestinal parasite	51/126	40.4	38/62	61.3	0.01

NS: non significant.

CI: 0.54-6.56; p = 0.32) or being overweight/obese in adults (OR: 1.47; CI: 0.51-4.27; p = 0.48).

The prevalence of dual burden households was 27% (11/41). A further exploration (Table 2) compares dual burden and non dual burden households with respect to the measured data. In dual burden households prevalence of both stunting and intestinal parasite infection were significantly higher than in non dual burden households. No differences were observed for gender, age, overweight/obesity, or socioeconomic status. The entire population fell into the two lowest of the five socioeconomic status strata, i.e., relative poverty and critical poverty.

Generalized estimating equations models (Table 3) showed that individuals with intestinal parasites were more than twice as likely to belong to a dual burden household as compared to those without (only geohelminth infection OR = 2.05, CI: 1.03–4.09, p = 0.04; only *G. lamblia* OR = 2.81, CI: 0.98–8.10, p = 0.06; both geohelminth infection and *G. lamblia* OR = 3.80, CI: 1.06–13.56, p = 0.04). This association remained significant for geohelminth infection and *G. lamblia* after controlling for age, gender and poverty level (OR = 4.75, CI: 1.01–22.20, p = 0.05). Table 4 shows the parasite specific results stratified by poverty level. In the relative poverty stratum opposite patterns were seen for geohelminth and *G. lamblia* positives, although not all results were statistically significant. In the critical poverty group, all ORs pointed to an increased risk, with the strongest association in those individuals that were infected both with *G. lamblia* and geohelminths (OR = 6.06, 95% CI: 1.18–31.15, p = 0.03).

Table 3. Association between geohelminth and *Giardia lamblia* infection with being a member of a dual burden household adjusted for age, gender and poverty level

Crude model	OR	95% CI	p
No infection	1		
Only geohelminth infection	2.05	1.03–4.09	0.04
Only *Giardia lamblia* infection	2.81	0.98–8.10	NS
Geohelminth and *G. lamblia* infection	3.80	1.06–13.56	0.04
Adjusted for age, gender and poverty level			
No infection	1		
Only geohelminth infection	1.63	0.77–3.44	NS
Only *G. lamblia* infection	1.87	0.56–6.20	NS
Geohelminth and *G. lamblia* infection	4.75	1.01–22.2	0.05

n = 188 in these models; NS= non significant.

Discussion

In this rural community in Venezuela, a high prevalence of adult overweight/obesity (65%) was observed, exceeding that of stunting in children (13.8%). Similarly high overweight/obesity prevalences of over 40% have been reported in other Latin American countries.[23] Prevalence of parasite infection was 47.3%, which is in line with earlier studies in Venezuela.[16,24,25] Furthermore, 26.8% of the households could be classified as dual burden households. This is amongst the highest prevalences of dual burden households ever reported, i.e. 18% in Guatemala and 16% in the Kyrgyz Republic.[6,7,26] Furthermore being infected with intestinal parasites was significantly associated with being in a dual burden household (OR = 2.11, 95% CI: 1.11–4.00).

It is important to address some limitations of our study. First the study was cross sectional and ecological in that analysis is based on group level comparisons, i.e. the household level. Therefore these results should be interpreted cautiously as they do not provide evidence contributing to an argument for a causal relationship, but is rather hypothesis generating. Additionally, this analysis is based on a convenience sample of those

Table 4. Association between geohelminth and *Giardia lamblia* infection with being a member of a dual burden household stratified by poverty level

Model adjusted for age and gender, stratified by poverty	Relative poverty			Critical poverty		
	OR	95% CI	p	OR	95% CI	p
No infection	1.00			1.00		
Only geohelminth infection	0.57	0.14–2.34	NS	3.02	1.11–8.22	0.03
Only *G. lamblia* infection	2.67	0.39–18.07	NS	2.25	0.46–10.91	NS
Geohelminth and *G. lamblia* infection	NR			6.06	1.18–31.15	0.03

n = 188 in these models; NR: No regression possible due to low number of individuals, NS: non significant.

community members who actively came forward to participate. Since we did not systematically screen all family members per household, some stunted children or overweight/obese adults may have been missed, resulting in misclassification of dual burden households as non dual burden households. Thus misclassification may have attenuated our associations. Furthermore the small numbers of this pilot study may have led to loss of power and consequently to a loss of statistical significance in certain relationships. However underpowered studies can still contribute to the literature by providing important information about the strength of association, the direction of the effect and consistency of the results in comparison to the literature. For example, the limited power could explain why we found no statistically significant association between intestinal parasitic infection and stunting. In spite of limited power, the direction of the association is consistent with the direction of effect shown by others.[8,9] Longitudinal studies in other populations using larger sample sizes are needed to corroborate our findings, and to clarify these associations.

To our knowledge we are the first to find an association between intestinal parasite infection and dual burden at household level. The association is strong and shows that the most vulnerable individuals, i.e. those of the lowest socioeconomic status strata with double (*G. lamblia* and geohelminth) infections, are most affected. Even though this is only a pilot study we would like to speculate on the observed association. First, these associations may be explained by reverse causality, in particular that stunted children are more susceptible to infection. Additionally overweight and obesity may also be related to poor immune function and thus risk of parasitic infection. Furthermore poverty may explain or confound all three outcomes. If so, these study results show a common environment of poverty that contributes simultaneously to parasitic infection and child undernutrition, and overweight and obesity in rural Venezuela. Finally research in Brazil has shown that children who experience energy restriction in early life may be metabolically programmed to deposit more fat and suffer from overweight and obesity in conditions of excess energy.[27–29] Sawaya et al. showed that a combination of dietary and anti-parasitic measures was able to reverse these metabolic changes.[30] Moreover, dietary interventions alone targeting undernutrition seem to have led to overweight/obesity in countries like Chile.[3] These results suggest that parasitic infection may be involved in the relationship between child stunting and overweight/obesity. Also, they are consistent with our observation that individuals with a parasitic infection are more likely to belong to a dual burden household than those without. It may thus be that parasitic infections contribute both to child stunting and overweight/obesity risk (i.e. 'triple burden'). Further research is needed to study this hypothesis in more detail.

In conclusion, Venezuela appears to be experiencing a triple burden of disease: overweight/obesity in adults, stunting in children and intestinal parasite infection in both children and adults. In addition, the three diseases are linked to social and economic constraints, resulting in a negative spiral that culminates in poor health and disease. Understanding the root causes of these phenomena is important for planning well targeted strategies to reverse this spiral and prevent overweight/obesity and its complications. While the relationship between intestinal parasite infection and stunting has been well established, the association of intestinal parasite infection with dual burden households merits further exploration.

Authors' contributions: MCP, CD, EP and RNI conceived the study; MCP, CD and NtK designed the study protocol; NtK, RNI and RR carried out the data collection; RR and RNI did the intestinal parasite diagnosis. MCP, NtK, CD, KP performed analysis and interpretation of these data. MCP and CD drafted the manuscript. KP, CD, EP, NtK, RR and RNI critically revised the manuscript for intellectual content. All authors read and approved the final manuscript. MCP and CD are guarantors of the paper.

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