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Journal of Mathematics and Statistical Science, 241-247 | Science Signpost Publishing

Intestinal Parasite Infection Amongst Preschool-Age Children in te Democratic Republic o Congo: A Multilevel Analysis

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Abstract

Intestinal parasite (IP) infections, such as hookworm infection, constitute a public health concern in less developed countries. Little is known about the epidemiology of IP infection in preschool-age children in the Democratic Republic of Congo (DRC). This study explored the epidemiology of IP infection in preschool-age children from the DRC and investigated whether the unobserved variations of this infection were between households or communities. Demographic Health Survey (DHS) collected data on preschool-age children with/without a record of a drug prescription for IP infection were used. Multilevel logistic regression analysis was applied due to the hierarchy nature of the data. The prevalence of IP infection was significantly different amongst the 11 regions and was higher in urban areas in the DRC. The random effect model showed that there were significant variations of IP infection due to unobserved household level factors. High prevalence of IP infection is a public health concern in the DRC and can remain a national health threat for as long as poverty persists.

Keywords: intestinal parasite infection, ascaris lumbricoides, strongyloides stercoralis, larvae, multilevel logistic regression, random effect.

1 Introduction

Intestinal parasite (IP) infection is a world-wide public health concern [1]. Its prevalence remains higher in Sub-Saharan Africa and varies within and between countries. Amongst school-age children, IP infection is suggested to be not only associated with high morbidity and mortality but also with poor school performance, physical weakness, growth retardation and the spread of other health disorders such as anaemia [2-4]. Intestinal parasite infection is often associated with behavioural, environmental and socioeconomic factors. Poor personal and environmental sanitation, limited access to clean water, poverty and overcrowded living conditions have been found closely related with IP infection [2]. It is suggested that hookworms such as *ascaris lumbricoides*, *strongyloides stercoralis* are the most common IPs found in Sub-Saharan Africa [5]. Transmission of IP to the definitive host is through oral route or by skin penetration (Figure 1). The epidemiological information on the prevalence of IP infection is one of the prerequisites to develop appropriate control measures. Surprisingly, despite the public health importance of these infections and the potential consequences, little is known about their epidemiology in preschool-

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age children in the Democratic Republic of Congo (DRC). It remains also unclear whether these infections in children vary between households or communities.

The aims of this study were to explore the epidemiology of IP infection in preschool-age children from the DRC and to use multilevel approach to investigate whether unobserved variations of IP infection in these children were at the household or the community level. The results from this study could help in providing key information which may encourage policy makers to design effective strategies to control IP infection amongst preschool-age children at an appropriate population level within the DRC.

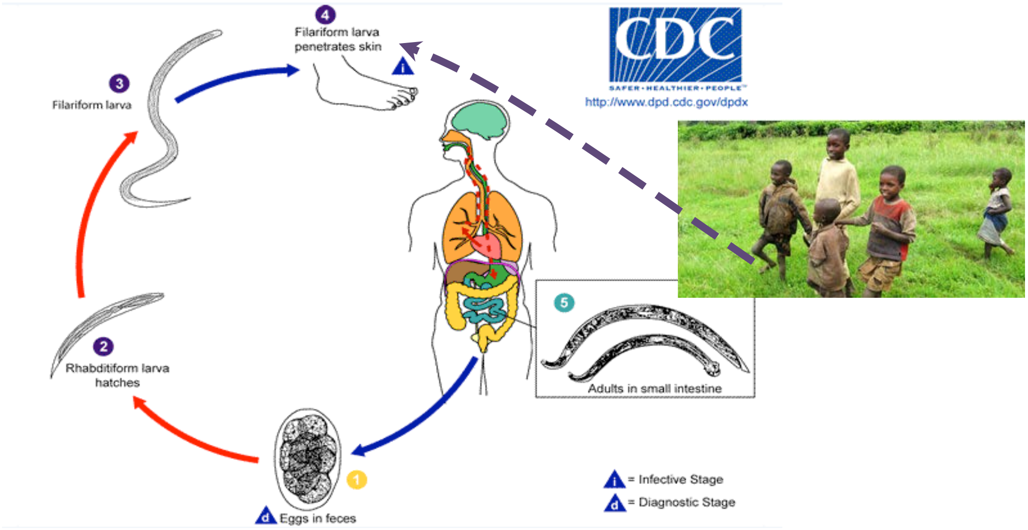

Figure 1. Life cycle of intestinal parasites (hookworms). Eggs of hookworms are passed in the faeces (*Stage 1*). Under favourable climatic conditions such as moisture, warmth or shade, larvae grow in the faeces and/or the soil (*Stage 2*) and become larvae that are infective (*Stage 3*). On contact with human being, the larvae penetrate the skin and carried through the blood vessels to the lungs. They then penetrate into the pulmonary alveoli, ascent the bronchial tree to the pharynx, and are finally swallowed (*Stage 4*). The larvae reach the small intestine, where they reside, mature and make eggs (*Stage 5*) [6].

2 Data and Methods

Retrospective cross-sectional data of preschool-age children from the DRC along with information on whether they had a drug prescription for IP infection in the last 6 months were collected in 2007 by the Demographic Health Survey (DHS). These data were collected using a two-stage probabilistic sampling method. The DRC was divided into stratum (districts) where communities were randomly selected, and the households within these were then randomly chosen. The overall prevalence and 95% CI of IP infection and by each potential risk factor was calculated. Univariate and multivariable multilevel logistic regressions were used to assess the odds of having IP infection in these children against the potential risk factors. With the final multivariable multilevel model, an equivalent standard multivariable logistic regression model was fitted to assess the benefit of applying multilevel technique to the data with hierarchy nature. Odds ratios with 95% CIs were reported. Variance components and the associated standard error were presented for the multivariable multilevel logistic model. Statistical significance was set at 5%. Statistical software StataSE 12 and MLWin 2.27 were used to analyse the data.

Multilevel technique was to account for data with hierarchy nature such as those from this study. Most DHS use communities such as villages or townships as clusters in the sampling process. Clustering can introduce lack of independence between individuals in the outcome variable because of unobserved common influences on, such as shared beliefs concerning food, cultural practices, and use of health services [7]. Models that do not account for this type of survey design can underestimate the standard errors and overestimate the significance of independent variables [8].

Table 1. The weighted percentage (WP) of intestinal parasite infection in preschool-age children in DRC, Africa

Risk factor	Category	n/N[1]	WP (%)[2]
Child's age (year)	<1	48/156	(33)
	1 to <2	78/149	(50)
	2 to <3	48/120	(44)
	3 to <4	44/97	(50)
	4 to <5	32/67	(42)
Gender	Male	133/300	(45)
	Female	117/289	(42)
Type of place of resident	Rural	131/396	(35)
	Urban	119/193	(60)
Region of resident	Kinshasa	34/41	(83)
	Bas-Congo	8/15	(60)
	Bandundu	19/44	(16)
	Équateur	34/62	(56)
	Orientale	13/39	(48)
	North Kivu	14/48	(25)
	Maniema	38/83	(46)
	South Kivu	12/47	(38)
	Katanga	12/68	(17)
	Kasai-Oriental	30/59	(51)
	Kasai-Occidental	36/83	(45)
Source of drinking water	Piped	14/23	(47)
	Others	236/566	(43)
Type of toilet facility	None	34/117	(28)
	Pit/buck	201/451	(46)
	Flush	15/21	(64)
Had diarrhoea recently	No	164/402	(40)
	In last 2wks	86/187	(50)
Consumed any dark green leafy vegetable	No	62/204	(40)
	Yes	164/345	(43)
Consumed any meat, poultry, seafood, eggs	No	87/236	(48)
	Yes	139/314	(40)
Maternal age (year)	15 to 24	77/192	(41)
	25 to 34	120/274	(43)
	35 to 49	53/123	(49)
Maternal education level	None	41/166	(27)
	Primary	115/273	(45)
	Secondary+	94/150	(55)
Household wealth status	Poorest	33/80	(37)
	Poorer	36/106	(39)
	Average	34/91	(34)
	Richer	35/57	(64)
	Richest	35/70	(49)
	Overall	**250/589**	**(43)**

[1] n: number infected, N: total number in category.
[2] Observations were weighted to account for under or over sampling within communities, hence weighted percentages are presented.

Potential risk factors included in this study were child's age (5 one-year age bands), gender, type of place of residence (rural, urban), region of residence (11 regions of DRC), source of drinking water (piped, others), type of toilet facility (none, pit/buck, flush), had diarrhoea recently (no, in last 2 weeks), consumed any dark green leafy vegetable (no, yes), consumed any meat, poultry, seafood, eggs (no, yes), maternal age (15 to 24, 25 to 34, 35 to 49), maternal education level (none, primary, secondary orhigher). The household wealth status, which was derived from the household assets using principal component analysis; the scores were then categorised into quintiles (poorest, poorer, average, richer, richest) [9].

3 Results

The DHS surveyed 589 preschool-age children, from 304 households within 203 communities, about whether they had a record of a drug prescription for IP infection in the last 6 months, and of these, 250 children had a prescription, which implied the overall prevalence of IP infection of 43%. The prevalence of this infection was higher amongst children aged between 1 and <5 years than those aged<1 year. With regard to the type of place of residence, it was much more prevalent in urban area (60%) compared to rural area (35%). There were substantial regional differences in the prevalence of IP infection, with Kinshasa, the capital of the DRC, being the most prevalent region (83%) amongst the others such as Bandundu (16%) and Katanga (17%) (Table 1).

Univariate multilevel logistic regression revealed that the risk factors child's age, types of place of residence, region of residence, type of toilet facility, consumed dark green leafy vegetable, and maternal education level were significantly associated with IP infection. A backward elimination strategy considering all 12 risk factors and a 5% significance level was used to develop the final multilevel model (Table 2). The 'type of toilet facility' factor was no longer significant to the outcome, while 'had diarrhoea recently' returned as a statistically significant factor in this multivariable model.

The multivariable multilevel logistic model showed that children who were aged 1 to <2 years had more than two folds of odds of having IP infection (OR=2.21, 95%CI=1.25 to 3.91) compare to those aged<1 year. Children who consumed dark green leafy vegetables (OR=2.05, 95% CI=1.29 to 3.26) and whose mother were educated at primary, secondary or higher level (OR=2.05, 95%CI=1.21 to 3.49; OR=3.50, 95%CI=1.79 to 6.86 respectively) also have increasing odds of being infected. There were significant regional differences in the DRC in the odds of getting the infection. Interestingly, compared with children from other regions, those from the capital city, Kinshasa, has at least twice as more odds of having intestinal parasites.

Table 2. Estimated odds ratio (95% CI) of intestinal parasite infection in preschool-age children in DRC against risk factors from the univariate multilevel, multivariable multilevel, and multivariable (standard) logistic regression models (N=549)

		Univariate multilevel logistic model		Multivariable multilevel logistic model		Multivariable (standard) logistic model	
Risk factor	**Category**	**OR**	**(95% CI)**	**OR**	**(95% CI)**	**OR**	**(95% CI)**
Child's age (year)	<1	1		1		1	
	1 to <2	**2.53**	**(1.53, 4.20)**	**2.21**	**(1.25, 3.91)**	**2.13**	**(1.25, 3.64)**
	2 to <3	1.49	(0.87, 2.55)	1.59	(0.87, 2.88)	1.57	(0.90, 2.75)
	3 to <4	1.56	(0.87, 2.81)	1.72	(0.89, 3.35)	1.64	(0.88, 3.06)
	4 to <5	1.93	(0.92, 4.04)	1.94	(0.84, 4.48)	1.91	(0.87, 4.20)
Type of place of resident	Rural	1		1		1	
	Urban	**3.03**	**(2.02, 4.54)**	**1.81**	**(1.09, 3.02)**	**1.85**	**(1.16, 2.95)**
Region of resident	Kinshasa	1		1		1	
	Bas-Congo	0.22	(0.05, 1.00)	0.62	(0.12, 3.29)	0.62	(0.13, 2.88)
	Bandundu	**0.18**	**(0.06, 0.56)**	**0.25**	**(0.07, 0.89)**	**0.24**	**(0.07, 0.77)**
	Équateur	**0.24**	**(0.08, 0.73)**	0.57	(0.17, 1.98)	0.62	(0.20, 1.96)
	Orientale	**0.10**	**(0.03, 0.35)**	**0.23**	**(0.06, 0.88)**	**0.25**	**(0.07, 0.85)**
	North Kivu	**0.09**	**(0.03, 0.30)**	**0.22**	**(0.06, 0.77)**	**0.21**	**(0.07, 0.70)**
	Maniema	**0.19**	**(0.06, 0.55)**	0.44	(0.14, 1.44)	0.44	(0.15, 1.33)
	South Kivu	**0.07**	**(0.02, 0.24)**	**0.19**	**(0.05, 0.73)**	**0.19**	**(0.06, 0.67)**
	Katanga	**0.05**	**(0.02, 0.17)**	**0.13**	**(0.04, 0.46)**	**0.14**	**(0.04, 0.44)**
	Kasai-Oriental	**0.23**	**(0.08, 0.69)**	0.38	(0.11, 1.26)	0.40	(0.13, 1.21)
	Kasai-Occidental	**0.18**	**(0.06, 0.51)**	0.39	(0.12, 1.22)	0.39	(0.13, 1.14)
Had diarrhoea recently	No	1		1		1	
	In the last 2 wks	1.34	(0.90, 1.99)	**1.68**	**(1.06, 2.66)**	**1.65**	**(1.07, 2.53)**
Consumeddrk green veg	No	1		1		1	
	Yes	**2.08**	**(1.40, 3.10)**	**2.05**	**(1.29, 3.26)**	**2.07**	**(1.35, 3.16)**
Maternal education level	None	1		1		1	
	Primary	**2.24**	**(1.38, 3.64)**	**2.05**	**(1.21, 3.49)**	**2.05**	**(1.26, 3.35)**
	Secondary+	**5.16**	**(2.96, 8.99)**	**3.50**	**(1.79, 6.86)**	**3.55**	**(1.91, 6.60)**
Random effect	Household level only			Var Comp (SE) 0.741 (0.321)			

Effect sizes from both multivariable logistic regression models were similar in their direction and magnitude, though the standard errors were generally smaller with the standard model suggesting an overestimation of statistical significance of the effects. Multivariable multilevel logistic model with both household and community levels set as random effects suggested that the unobserved variations in the odds of having IP infection in children was mainly due to household level factors (variance component (vc) = 0.549; standard error(se) = 0.376), but unlikely due to community level factors (vc = 0.187, se = 0.237), hence household level random effect was left in the final model.

4 Conclusion and Discussion

The results of this paper provide the first quantitative estimate of the prevalence of IP infection in preschool-age children in the DRC. This type of infection is a public health concern in the DRC. The prevalence is high and varies within the country. The results suggest that older preschool children, who live in an urban area and region, who recently had diarrhoea, consume dark green leafy vegetables, whose mother had higher level of education are more likely to have IP infection in the DRC.

By age group, the results suggest that the odds of IP infection increase with age and is higher amongst those children aged between 1 and <2 years. This could be because children at this age usually start crawling on the floor, playing with soil and constantly sucking their fingers [10, 11].This is consistent with a study conducted in an urban slum of Karachi in Pakistan [12].

Poor urban conditions, habitation and environmental factors promote the survival and transmission of IPs [13]. Urban sprawl in less developed countries in general and in Sub-Saharan African countries (including the DRC) in particular, has revealed that necessary information and existing tools for urban policy are insufficient in providing an adequate healthy living environment. Human settlements are concentrated in poorly organised and loosely planned urban areas with limited access to sanitation and clean water [14]. This is still the case in most urban areas of the DRC and could explain higher odds of IP infection observed amongst children from urban areas, such as the capital city, Kinshasa. With the civil war, and rural-urban migrations, Kinshasa has experienced tremendous growth and is the third megacity on the African continent after Lagos (Nigeria) and Cairo (Egypt). Kinshasa is sometimes referred to as a vibrant city of sharp contrast; commercial affluence and extreme poverty. The population in Kinshasa is estimated at 9.5 million people and is expected to reach 15.6 million people in 2015. A greater number of populations in Kinshasa live in squatter and slum settlements without electricity and safe water, and in crowded living conditions perhaps are the main reasons of spreading the infection[15].

Diarrhoea is one of the signs and symptoms of IP infection and with the higher odds of having the infection observed in children who had recent diarrhoea; this result is what one would expect it to be.

Children who consumed dark green leafy vegetables are significantly associated with higher odds of having the infection compared to those who did not. This is not surprising given the following reasons: (1) IPs are predominant in areas where human faeces are used as fertilizer and where defecation is mostly through soil [16]. This technique is also used in the DRC. (2) Inadequately washed and prepared vegetables were found to be related with higher prevalence of IP infection in children from Nigeria, India and Saudi Arabia [17-19].

Measures to reduce IP infection should include education on personal hygiene, environmental sanitation and clean water supply while at the same time treating infected individuals. These interventions should be targeted at the household level.

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Published: Volume 2017, Issue 8 / August 25, 2017