Tropical Biomedicine 37(2): 363–371 (2020)

Post-era mass drug administration: an update on intestinal parasitic infections in urban poor communities in Peninsular Malaysia

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Received 11 November 2019; received in revised form 13 January 2020; accepted 15 January 2020

Abstract. The health impact of a Malaysian national helminth control program which provided school-based anthelmintic chemotherapy from 1974 to 1983 was re-visited after three decades post MDA and associated risk factors amongst urban poor communities identified. Stool samples collected were screened using the formalin ethyl-acetate concentration technique recovered at least one species of helminth and/or protozoan. Despite a steady decline observed between 1974-1983 however, post MDA infections continue to persist in pockets of communities moderately (18.9%; n=39/206) with higher infection recorded amongst PPR flat residents (22.5%, n=16/71). Among risk factors identified, waste management method was the primary factor for *Ascaris lumbricoides* infections (n=33; 16.0%), whereas age, education, employment and source of drinking water were significant risk factors for cryptosporidiosis. Despite the government's efforts to improve health through the provision of basic amenities to the general public, higher prevalence values amongst PPR flat dwellers suggests the need to implement targeted chemotherapeutic treatment of, once a year deworming as recommended by World Health Organization when the baseline prevalence of soil-transmitted helminth infections in the community is over 20%, in addition to preventive measures though improvements in health awareness programs and improved waste management methods.

INTRODUCTION

Malaysia has undergone a cumulative growth in urbanization from 43.2% (1989) to 76% (2018) resulting in an urban population boom from 27% (1970) to 71% (2010) (Siwar *et al.*, 2016) and a downward trend in the incidence of urban poverty over the past three decades from 16.5% in 1970 to 1.0% in 2012 (Sherina *et al.*, 2011; CIA, 2019). However, the number of urban poor residents in cities is still considerably large (Zainal *et al.*, 2012), with pockets of urban poverty remaining in different states of the country due to the migration of low-income groups from rural to urban areas. This has also been accompanied by the inflow of foreign workers and a rise in the cost of living. The population boom over such a short time scale has exerted pressure on local governments especially in fulfilling provision for services and infrastructures, creating job opportunities and providing houses for urban dwellers (Elhadary & Samat, 2012). Inadequate amenities and a housing shortage have led to the deterioration of living standards and an increase in urban environmental deterioration, pollution, congestion, diseases, squatters, improper dumping of garbage and a mismanagement of sanitation services (Elhadary & Samat, 2012). The more recent deterioration of living standards among the

urban population was highlighted by UNICEF (2018) in that 99.7% of children occupying low cost flats in Kuala Lumpur live in poverty and 7% in absolute poverty.

Southeast Asia (SEA) has the highest reported prevalence of soil-transmitted helminths (STHs) worldwide with infections occurring in 11 SEA countries (Jex *et al.*, 2018). STHs have not only been recognized as a major public health problem since the 1970s in Malaysia (Bisseru & Ahmad, 1970), but also continue to be a concern especially among the poverty-stricken communities (Sinniah *et al.*, 2014). Studies on different population groups and demographic profiles have provided evidence of variable prevalence of gastrointestinal helminths and protozoans especially among groups such as the Orang Asli (44.33-99.2%) (Al-Mekhlafi *et al.*, 2008; Nas *et al.*, 2013) plantation and rural communities (32.3-70.0%) (Chia *et al.*, 1978; Al-Mekhlafi *et al.*, 2008; Sinniah *et al.*, 2014) urban dwellers (20.6–90.9%) (Chia *et al.*, 1978; Sinniah *et al.*, 2014), fishing communities (54.2–98.0%) (Anuar *et al.*, 1987; Sinniah *et al.*, 1988), flat dwellers (5.1–57.0%) (Kan, 1983; Sinniah *et al.*, 2002; Sinniah *et al.*, 2014) and migrant workers in Malaysia (13.1%–62.9%) (Sahimin *et al.*, 2016; Sahimin *et al.*, 2018).

In 2020, the global target is to eliminate morbidity among children due to soil-transmitted helminthiases. Over 598 million children in endemic countries (69% of all children at risk) were treated with albendazole and mebendazole medicines in 2017 (WHO, 2018). A national helminth control program was undertaken by the Ministry of Health Malaysia from 1974 to 1983 to improve the standards of education, sanitation and anthelminthic treatment exclusively for school children. Several studies have shown a steady decline in infections among urban dwellers 90.9% to 20.6% (Chia *et al.*, 1978, Sinniah *et al.*, 2014), flat dwellers 57% to 5.5% (Kan, 1983; Sinniah *et al.*, 2014) and rural communities 90.0% to 32.3% (Bisseru & Ahmad, 1970; Sinniah *et al.*, 2014), reflecting the successful impact of MDA and improvement in their living conditions.

However, rapid increase in the urban population over a relatively short period of time exerts pressure on city living that may impact on the quality of life and expose the vulnerable to a range of communicable and non-communicable disease. Poverty can also restrict accessibility to quality healthcare and education, whilst a poor educational background perpetuates health problems through little or lack of awareness of good health practices. Therefore, the present study was undertaken to re-assess STHs and protozoan infection levels following the lapse of MDA more than 3 decades and also to identify associated risk factors among vulnerable groups in particular, the urban poor community.

MATERIALS AND METHODS

Recruitment of volunteers, questionnaire and ethical clearance

The present investigation was carried out through a social well-being community program in the states of Wilayah Persekutuan Kuala Lumpur, Selangor and Malacca.

The study cohort comprised residents from Program Perumahan Rakyat (PPR) flat developments and other urban poor settlements, which consisted of communities from villages within the urban municipality and orphans and children from selected low-income childcare centers. PPR low-cost flats are high density housing units for qualified individuals or families categorized as B40 with a total household income of less than RM 2,500 per month (Economy Planning Unit, 2015). The Economic Planning Unit (EPU) indicated that 2.3% B40s in Kuala Lumpur, 12.3% in Selangor and 2.4% in Malacca (Economy Planning Unit, 2015) comprising 2.7 million households survived on a mean monthly income of RM 2,537 (Economy Planning Unit, 2015).

It should be noted that urban villages comprise original settlements, which were created from rapid urbanization and economic development of cities, within an urban boundary with its own organizations and nearest to a city center (Hao, 2015). The

Welfare Department recorded 2.3 million children below 4 years of age with only 4,302 registered childcare centers and 3,173 caregivers certified (Shah, 2018). Therefore, children living in cramped spaces in selected orphanages and childcare centers were also included as part of this study cohort.

Residents from the PPR flats and other urban poor settlements were recruited from Kuala Lumpur (urbanization = 100%), Selangor (urbanization = 91.4%) and Malacca (urbanization = 86.5%) from October 2016 to February 2018 as in Table 1. All sampling sites were characterized with a tropical climate comprising high levels of humidity and temperature ranging between 30°C and 36°C plus periodic rainfall during the year.

Using observation and questionnaires, residents were asked to provide details on socio-demographic, factors, environmental health, lifestyle habits and recent illnesses. Each individual was required to answer all questions prior to consent being obtained for stool collection. This study was approved by the Medical Ethics Committee of the University Malaya Medical Centre (UMMC), Malaysia (Reference number: MEDIC NO: 20143-40). All adults and childrens' guardians were provided with written and informed consent to participate in the study.

Sample collection and screening

Following collection, stool samples were immediately preserved in 2.5% potassium dichromate to prevent parasite eggs /oocysts from disintegrating and maintained at 4°C until required. For the formalin ethyl-acetate concentration technique, approximately 1-2 g of each faecal sample were mixed with 7 ml formalin and 3 ml ethyl acetate and centrifuged for 5 min at 2500 rpm. Following centrifugation, a drop of pellet was placed on a clean glass slide and stained with Lugol's iodine. Slides were examined under a light microscope at 10x and 40× magnification for the presence of helminths/protozoans. A portion of pellet was smeared on a second slide and left to dry. Once dried, each slide was fixed in methanol for 5 minutes, flooded with strong carbol fuchsin for up to 10 minutes, rinsed under tap water and then decolourised in 3% acid alcohol before final rinsing. Each slide was counterstained with 0.25% malachite green for 30 seconds, rinsed and blotted dry prior to examination under oil immersion at 1000x.

Statistical analysis

Prevalence data are shown with 95% confidence limits (CL95) as described by Rohlf & Sokal (1995) using bespoke software. Prevalence's were analyzed using maximum likelihood techniques based on log linear analysis of contingency tables using the software package SPSS (Version 22). Infection was considered a binary factor (presence/absence of parasites) and analyses were conducted using intrinsic factors such as host sex (2 levels: males and females), age (7 age classes: those<12 years old, 12–18 years old, 19–24 years old, 25–34 years old, 35–44 years old, 45–55 years old and those >55 years old) and ethnicity (3 ethnics: Malay, Chinese and Indian). Extrinsic factors included location (3 locations: Kuala Lumpur, Selangor and Malacca), settlements (2 categories: flats/ PPR house and others), education attainment (4 levels: primary school, secondary school, university and no formal schooling) and employment status (employed and unemployed).

RESULTS

Socio-demographic factors

Stool samples from 206 participants were examined from Pantai Dalam, Kuala Lumpur (n=70; 34.0%), Bukit Bintang Kuala Lumpur (n=22; 10.7%), Bandar Tun Razak, Kuala Lumpur (n=9; 4.4%), Gombak, Selangor (n=76; 36.9%) and Alor Gajah, Malacca (n=29; 14.1%) as shown in Figure 1 and Table 1.

Demographic data of stool samples were obtained from 55.3% females and 44.7% males. The majority were children less than 12 years old (n=60; 29.1%) and predominantly Malay (n=176; 85.4%), followed by Indian (n=16; 7.8%) and Chinese (n=14; 6.8%). A large proportion of the population resided in Kuala Lumpur (n = 147; 71.4%) followed by Selangor (n=30; 14.6%) and Malacca (n=29; 14.1%) with the majority of the

Figure 1. Location of study sites from urban poor communities in Peninsular Malaysia.

Table 1. Study locations with GPS coordinates and number of participants

Area	Coordinates	Number of participants
Alor Gajah, Malacca	2.373966, 102.211406	29
Gombak, Selangor	3.283647, 101.607723	76
Bandar Tun Razak, Kuala Lumpur	3.091852, 101.721012	9
Bukit Bintang, Kuala Lumpur	3.146838, 101.709775	22
Pantai Dalam, Kuala Lumpur	3.111944, 101.660721	70
Total		**206**

population residing in urban settlements (n=135; 65.5%) or low cost PPR flats (n=71; 34.5%) (Table 2).

Prevalence of intestinal parasitic infections

An overall infection value of 18.9% (n=39) was recorded, with the roundworm, *Ascaris lumbricoides* being the most dominant helminth species (n=33; 16.0%), followed by the protozoans *Cryptosporidium* spp. (n=5; 2.4%) and *Giardia* sp. (n=1; 0.5%). Only one case of *Giardia* sp. was detected [0.5% (0.01–2.67)], from a female child below 12 years old.

Table 2. Prevalences of *Ascaris lumbricoides* and *Cryptosporidium* spp. amongst the urban poor communities in Peninsular Malaysia, relative to socio-economic factors; *significant at 0.05

Factors		Helminth		Protozoa	
		Ascaris lumbricoides		*Cryptosporidium parvum*	
		% [95% C1]	P-value	% [95% C1]	P-value
Intrinsic Factors					
Sex	Male (n=92)	11.9[6.1-20.3]	0.109	1.0[0.0-5.9]	0.155
	Female (n=114)	19.3[12.5-27.7]		3.5[0.9-8.7]	
Age	<12 (n=60)	11.6[4.8-22.5]	0.661	8.3[2.7-18.4]	0.049
	12-18 (n=5)	40.0[5.2-85.3]		0.0[0.0-0.0]	
	18-24 (n=12)	25.0[5.4-57.1]		0.0[0.0-0.0]	
	25-34 (n=21)	19.0[5.4-41.9]		0.0[0.0-0.0]	
	35-43 (n=26)	19.2[6.5-39.3]		0.0[0.0-0.0]	
	44-54 (n=27)	18.5[6.3-38.0]		0.0[0.0-0.0]	
	>55 (n=55)	12.7[5.2-24.5]		0.0[0.0-0.0]	
Ethnicity*	Malay (n=176)	16.4[11.3-22.8]	0.030	2.8[0.9-6.5]	0.450
	Chinese (n=14)	28.5[8.3-58.1]		0.0[0.0-0.0]	
	Indian (n=16)	0.0[0.0-0.0]		0.0[0.0-0.0]	
Extrinsic Factors					
Location	Kuala Lumpur (n=147)	18.3[12.4-25.5]	0.212	2.7[0.7-6.8]	0.456
	Selangor (n=30)	6.6[0.8-22.0]		3.3[0.0-17.2]	
	Melaka (n=29)	13.7[3.8-31.6]		0.0[0.0-0.0]	
Living settlements	PPR/ Flats (n=71)	21.1[12.3-32.4]	0.154	1.4[0.0-7.6]	0.471
	Others (n=135)	13.3[8.1-20.2]		2.9[0.8-7.4]	
Education attainment*	No formal education (n=60)	11.6[4.8-22.5]	0.624	8.3[2.7-18.3]	0.005
	Primary (n=53)	16.9[8.0-29.8]		0.0[0.0-0.0]	
	Secondary (n=77)	19.4[11.3-30.0]		0.0[0.0-0.0]	
	University (n=16)	12.5[1.5-38.3]		0.0[0.0-0.0]	
Employment status*	Employed (n=68)	17.6[9.4-28.8]	0.657	0.0[0.0-0.0]	0.044
	Unemployed (n=138)	15.2[9.6-22.3]		3.6[1.2-8.2]	

Intrinsic and extrinsic effects on prevalence of intestinal parasitic infections

Infections with *A. lumbricoides* and *Cryptosporidium* spp. were analyzed using the minimum sufficient model and the backwards stepwise selection, relative to intrinsic factors such as host age, sex and ethnicity in Table 2. In the case of *A. lumbricoides*, ethnicity ($\times^2_4$ = 7.005, P = 0.030) was the only factor found to be significant, although this might be attributed to disproportionate group sampling. Host age ($\times^2_4$ = 12.642, P = 0.049) appeared to be the only significant risk factor in *Cryptosporidium* spp. infections.

Of four extrinsic factors considered such as location, living settlement, education attainment and employment status, none were found to significantly influence the prevalence of *A. lumbricoides*. On the other hand, a significant increase in *Cryptosporidium* spp. infections was associated with the lack of both education attainment ($\times^2_1$ = 12.642, P = 0.005) and the status of employment ($\times^2_1$ = 4.067, P = 0.044) (Table 2).

Lifestyle factors effects on prevalence of intestinal parasitic infections

Of the six lifestyle factors considered in Table 3, including preferred types of drinking water, waste disposal method, preferred cooking of meat, eating styles, frequency of hand washing and pet keeping, only waste disposal and filtration of drinking water

Table 3. Prevalences of *Ascaris lumbricoides* and *Cryptosporidium* spp. amongst the urban poor communities in Peninsular Malaysia, relative to lifestyle factors; *significant at 0.05

Factors		Helminth		Protozoa	
		Ascaris lumbricoides		*Cryptosporidium* spp.	
		% [95% C1]	P-value	% [95% C1]	P-value
Preferred type of drinking water	Boil (n=132)	15.9[10.1-23.2]	0.954	0.7[0.0-4.1]	0.041
	Filter (n=74)	16.2[8.6-26.6]		5.4[1.4-13.2]	
Waste management method*	Local municipality (n=107)	11.2[5.9-18.7]	0.05	1.8[0.2-6.5]	0.739
	No proper method (n=99)	21.2[13.6-30.5]		3.0[0.6-8.6]	
Preferred method of cooking meat	Fully cooked (n=205)	15.6[10.9-21.3]	0.055	2.4[0.8-5.6]	0.824
	Medium/ Half cooked (n=1)	100.0[2.5-100.0]		0.0[0.0-97.5]	
Eating styles	Utensils (n=14)	28.5[8.3-58.1]	0.219	0.0[0.0-23.1]	0.399
	Bare hands (n=192)	15.1[10.3-20.9]		2.6[0.8-5.9]	
Frequency of hand washing	Less than 3 times (n=5)	20.0[0.5-71.6]	0.602	0.0[0.0-52.1]	0.461
	3-5 times (n=37)	10.8[3.0-25.4]		5.4[0.6-18.2]	
	>5 times (n=164)	17.0[11.6-23.7]		1.8[0.3-5.2]	
Pets ownership	Yes (n=24)	20.8[7.1-42.1]	0.507	0.0[0.0-14.2]	0.263
	No (n=182)	15.3[10.4-21.4]		2.7[0.9-6.2]	

showed significant higher prevalences of *A. lumbricoides* ($\times^2_1 = 3.848, P = 0.050$) and *Cryptosporidium* spp. ($\times^2_1 = 4.182, P = 0.041$) respectively.

DISCUSSION

Intestinal parasitic infections (IPI) occur primarily in populations from low income countries lacking proper facilities for sanitation. Human infections usually occur via the oral /faecal route and from contaminated food and water supplies. In Malaysia, the occurrence of IPI have declined from 52.4% in the 1970's to 1.0% in 2012, largely due to a 96% and 98.2% improvement in access to sanitation facilities and drinking water sources respectively and in both urban and rural areas (CIA, 2019). However, after 3 decades post-MDA and improvements of basic amenities, IPI continues to persist with moderate infections (18.9%) in the urban poor population. PPR flat dwellers showed an increase in prevalence from 8.1% (Sinniah *et al.*, 2002) to 22.5% (present study). On the other hand, the prevalence of infection among other urban poor settlements was 17.0% (present study) which demonstrated a steady decline compared with 90.9% in 1978 (Chia *et al.*, 1978). PPR was initially established by the Ministry of Housing & Local Government in Malaysia to fulfill the need for low cost housing, following demolition of squatter dwellings. Through a "zero slum" settlement program by the year 2020, local authorities successfully relocated slum dwellers through an affordable housing scheme to own a modest unit in a multi-storey low cost flat equipped with clean water supply, sanitation and electricity. However, majority of PPR flat developments are vastly overcrowded with indiscriminate methods of waste disposal and this situation is reflected in the relatively high prevalence (22.5%) of parasitic infections among these residents in the present study compared with previous studies (Kan, 1983; Sinniah *et al.*, 2002; Sinniah *et al.*, 2014).

The three parasite species identified in the present study included the ascarid nematode *Ascaris lumbricoides* and two protozoan species *Cryptosporidium* spp. and *Giardia* sp. Previously, 6 parasite species

were reported by Sinniah *et al*. (2014) including *A. lumbricoides*, *Trichuris trichiura*, *Blastocystis hominis*, *Giardia* sp., *Entamoeba histolytica* and *E. coli* and up to 4 species from flat dwellers including *A. lumbricoides*, *T. trichiura*, *B. hominis* and *E. coli*. The trichurid nematode, *T. trichiura* rather than *A. lumbricoides* appeared to be the most prevalent species reported by Sinniah *et al.* (2014) but the present results concur with global findings highlighting *A. lumbricoides* as the most common helminth occurring in underprivileged communities (WHO, 2018). High numbers of *A. lumbricoides* eggs have also been recently reported as contaminating public parks in Peninsular Malaysia (Rahman *et al.*, 2015).

The present study highlights significant relationship between the prevalence of *A. lumbricoides* with host ethnicity ($\times^2_4 = 7.005$, $P < 0.030$) amongst urban poor dwellers and likely attributed to disproportionate group sampling rather than racial susceptibility or resistance to infection. As the nature of participation to this study was open to volunteers, it was not possible to screen more samples within the time frame of this study. Nevertheless, transmission of *A. lumbricoides* among urban poor dwellers appeared to be related to poor waste management. Indiscriminate garbage disposal, which is particularly rampant in PPR low-cost flats, is not only a matter of poor civic consciousness, but is also attributed to the lack of maintenance of services such as functioning elevators. Without such a facility, residents tend to dispose rubbish directly and indiscriminately down to the ground level. This poor attitude then attracts stray animals and pests to scavenge for food, litter and contaminate the environment with *A. lumbricoides* eggs. Both poor hygiene practices and behavior in turn facilitate the transmission of roundworm infections especially to children in the community.

The presence of intestinal protozoan infections in this study cohort is predominantly dependent on human behavior, particularly during ingestion and defecation, personal hygiene, and cleanliness. Low prevalence of *Cryptosporidium* spp. was recorded among the urban poor, although prevalence does vary among different cohort groups (Sahimin *et al.*, 2018). In the present study, *Cryptosporidium* spp. was particularly evident in children below 12 years old and those with no formal education and unemployed. Food and water-borne illnesses due to *Giardia* sp. and *Cryptosporidium* spp. is uncommon in Malaysia (Sahimin *et al.*, 2018), but the present findings confirm that transmission of these parasitic protozoan occurred through contaminated water supplies, particularly through the consumption of filtered rather than boiled water. Minute oocysts of *Cryptosporidium* sp., 2-6 µm in size, not only readily pass through filtration mechanisms within water dispensers but also resists most chemical disinfectants and chlorination. Oocysts on the other hand are susceptible to drying and ultraviolet sunlight but can be eradicated by boiling drinking water.

An examination of larger numbers of stool samples from the three selected geographical sites in Malaysia would have been desirable but barriers included embarrassment, fear of results, concerns relating to hygiene and contamination, discretion and privacy are difficult to overcome. Personal gain must be highlighted as the main incentive for sampling and returning a stool sample (Lecky *et al.*, 2014) together with the provision of an information leaflet on stool collection.

CONCLUSION

Overall prevalences of infection amongst urban poor communities in parts of Kuala Lumpur, Selangor and Malacca mainly fluctuate in line with both the downward trend of poverty and acceleration of urbanization. Infection values recorded in the present investigation are indicative of the Malaysian Government's successful efforts post-MDA to improve health through the provision of clean water supplies and good sanitation facilities to the general public. However, intestinal parasitic infections continue to persist particularly amongst occupants of low

cost PPR flats (22.5%) and according to World Health Organization (2018), deworming treatment should be given once a year when the baseline prevalence of soil-transmitted helminth infections in the community is over 20%. This intervention should be included among the study cohort in addition to programs encouraging healthy behaviors. In addition, overall improvements are still required for better public services such as regular rubbish collection and maintenance of lifts in these developments.

Acknowledgments. The authors wish to extend their grateful thanks to the Ministry of Health, Malaysia for their co-operation and support in this study. Special thanks are also extended to all volunteers to which this study could not be possible, medical staff from the University Malaya Medical Centre for their technical assistance. This research work was funded by University of Malaya (GPF 012B-2018).

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