CHAPTER 3

Epidemiology of Human Soil-Transmitted Helminthiasis among Five Subgroups of Orang Asli Living in Remote and Semi-Remote Areas in Peninsular Malaysia

3.1 INTRODUCTION

Malaysia has witnessed rapid growth in their socioeconomic and infrastructure development since gaining her independence almost 58 years ago. Nevertheless, the country is still plagued with many parasitic diseases notably the perpetual soil-transmitted helminth (STH) infections especially among poor and socioeconomically deprived communities living in rural and remote areas (Lim et al, 2009). While vector-borne diseases such as malaria and filariasis have decreased significantly over the years in rural areas (Anon, 2003), STH infections which are closely associated with poor environmental and personal hygiene practices still cause major health problems among these deprived communities. Although the prevalence rates of STH infections have been significantly reduced among the general population in urban areas (Jamaiah & Rohela, 2007), this reduction trend remains significantly unchanged and the prevalence rate is still high with prominent morbidity among rural dwellers especially Orang Asli communities (Al-Mekhlafi et al, 2005; 2007; Ahmed et al, 2011; Nasr et al, 2013).

Although the Orang Asli is the original people of Malaysia, they have been sidelined from the country's rapid pace of development. Comprising less than 1% of the total population in Malaysia, the marginalized Orang Asli remains one of the poorest ethnic groups in the country (Anon, 2001). While the national statistics for poverty and hardcore poverty are at the rates of 7.5% and 1.4%, the poverty rate among the Orang Asli is high (76.9%) with 50.9% of the population being considered as poor and 35.2%

as hardcore poor, respectively (Anon, 2001). The high rate of poverty in these communities has been identified as one of the major factors contributing to their poor nutritional status and high incidence of infectious diseases including malaria, tuberculosis as well as the perpetual STH infections (Al-Mekhlafi et al, 2005; 2007; Khor & Zalihah, 2008; Lim et al, 2009; Ahmed et al, 2011; Nasr et al, 2013).

Since the colonial era, many studies have been documented on the medical and health aspects of the Orang Asli particularly on infectious diseases, more often than not the malaria and STH infections as they are deemed to be of great medical importance. According to the available literature, the earliest study of STH infections among Orang Asli was recorded in 1938 (Nevin, 1938). Up to 2013, more than 30 studies on STH infections have been conducted among Orang Asli communities. Lim et al. (2009) reviewed and summarized studies that have been conducted since 1930 and found that the prevalence rate of STH infections remains largely unchanged with alarming high prevalence especially among school-age children. Between the years of 2010 to 2013, several studies have been conducted in these communities reporting an overall prevalence of more than 50%, ranging from 52.4% to 92.2% (Ahmed et al, 2011; Nasr et al, 2013). Therefore, STH infections continue to have negative impact on the nutrition, growth and development of these disadvantaged communities. Several studies have demonstrated that STH infections are significant predictor factors and leading cause of protein-energy malnutrition including anaemia, iron deficiency anaemia (IDA) and vitamin A deficiency, growth stunting, cognitive and educational deficits among Orang Asli communities (Norhayati et al, 1995; Osman & Zaleha, 1995; Rahmah et al, 1997; Zulkifli et al, 1999; Nor Aini et al, 2007; Al-Mekhlafi et al, 2005).

With the exception of study carried out by Dunn in 1972 (Dunn, 1972), almost all of these studies failed to take into consideration the differences in the respective

subgroups, culture and environment of the Orang Asli communities. This is highly regrettable because Orang Asli is not a homogenous group as they are divided into 18 distinct ethno-linguistic subgroups. The various subgroups of Orang Asli live in diverse ecosystems and have different cultural practices and approaches in managing illness. As Lim et al (2009) have highlighted, although implementation of socioeconomic development programs did have some positive impacts on STH infections in certain subgroups, these outcomes were not noticeable in many other subgroups as STH infections were still highly prevalent in these communities. Therefore, the disease dynamics in each subgroup need to be re-looked and re-evaluated as the findings will provide beneficial information for the formulation of highly effective control strategies and policies relevant to each subgroup. Thus, it is timely that a comprehensive study assessing STH infections in the various subgroups is given due consideration. Together with the diversity in their habitats, cultural as well as socioeconomic background and sanitary behavior, we conducted this study to provide a comprehensive data on the current status of STH infections among five Orang Asli subgroups living in rural and remote areas of Peninsular Malaysia.

3.1.1 Objectives of the study

General objectives

To determine the epidemiology of human soil-transmitted helminthiasis among five subgroups of Orang Asli living in remote and semi-remote areas in Peninsular Malaysia.

Specific objectives

1. To determine the current prevalence of STH infections among five subgroups of Orang Asli.

2. To examine the distribution patterns of STH infections among these five subgroups of Orang Asli.

3. To identify the possible significant associated predisposing factors of STH infections among these five subgroups of Orang Asli.

3.1.2 Research hypotheses

1. The socioeconomic, environmental sanitation and personal hygiene characteristics are generally poor among the survey population.

2. The prevalence of all three STH infections (i.e., *Trichuris trichiura*, *Ascaris lumbricoides* and hookworm) are high among the surveyed populations.

3. The distribution patterns of STH infections are significantly different among different Orang Asli subgroups.

4. The prevalence of STH infections are significantly higher among vulnerable group such as children compared to adults.

5. The prevalence of STH infections is significantly higher among those with low socioeconomic background, poor sanitation, environmental and personnel hygiene among the surveyed populations.

3.1.3 Significance of the study

1. A comprehensive data on the current status of STH infections among the five subgroups of Orang Asli as reported in this study will fill vital gaps and provide beneficial insight and information on the epidemiology and disease dynamics of STH infections for the establishment of efficient, integrated control measures and policies relevant to these subgroups.

2. The establishment of such data will also be valuable for the public health authorities to justify and facilitate the reassessment of the existing control measures to reduce the prevalence of STH infections in these rural communities. With effective control measures in place, these communities especially children will have a greater opportunity for a better future in terms of health and educational attainment, which will eventually put them on par socially and economically with other communities in Malaysia.

3.2 MATERIALS AND METHODS

3.2.1 Ethical approval

The study protocol was approved by the National Institutes of Health, Ministry of Health (MoH) Malaysia (Reference Number: NMRR-10-801-6816) and the Ethics Committee of the University Malaya Medical Centre (UMMC) Malaysia (Reference Number: 824.11).

3.2.2 Study population

The 'Orang Asli' translated as 'original peoples' or 'first people' are the indigenous minority peoples of Peninsular Malaysia. The term 'Orang Asli' is a collective term introduced by the anthropologists and government officials for the administration and official purposes. According to the latest available records from the Department of Orang Asli Development, their population is approximately 149,723, contributing 0.7% of the total population in Malaysia (Anon, 2006). Officially, the Orang Asli is classified into three major ethno-linguistic groups, namely the Senoi, Proto-Malays (Aboriginal Malays) and Negritos. Each group is then further divided into 6 subgroups, bringing to a total of 18 different cultural linguistic subgroups. The Senoi are the largest group forming about 54% of the total Orang Asli population, followed by Proto-Malays (43%) whilst the Negritos are the smallest Orang Asli group which constituted only 3% of the total Orang Asli population (Anon, 2006).

The Orang Asli is not homogenous group as each group has its own language and custom, most importantly, perceiving themselves as different from their counterpart. They live in the closest possible association with the nature of the coastal mangrove swamps to the tropical forest valleys and mountains throughout the Peninsular Malaysia. Today majority of them live outside the primary forest, however most of their villages are still located close to the jungle fringe including the scrub vegetation areas typically near a rubber estate, palm oil plantation, tin-mining pool and even a town. While majority of the Orang Asli are still bonded to their cultural and belief in their daily activities particularly related to family relationships, medicine, economic and food, much of the basis of their culture and spirituality are derived from this close relationship with the particular environment (Nicholas, 2000).

In general, majority of Orang Asli are engaged in agriculture, forestry and fishing that mainly require physical labor and manual skills. Those live in or close to the forest areas are engaged in a variety of occupation related to agriculture or forest resources such as hunting and gathering jungle products including *petai*, *durian*, *gaharu*, rattan and resin to be exchanged for cash. Some of them have taken permanent agriculture, such as managing their own rubber or oil palm and partake in the wage sector including both unskilled and skilled jobs in factory and construction site. Slash and burn agriculture is still widely practiced especially for hill rice cultivation (swiddening). Those living close to the coastal and riverine areas mainly engage traditional fishing and vegetables cultivation for their own consumption. Small numbers of them especially the Negritos are still living as semi-nomadic hunters or jungle product gatherers in northern interior of Peninsular Malaysia and southernmost Thailand which prefers to take advantage of the seasonal bounties. There are only small numbers of them involved in professional and technical jobs.

3.2.3 Study areas

A cross-sectional study was carried out for a period of two years (i.e., April 2009 to April 2011) amongst various Orang Asli villages located in remote and semi-remote areas of Peninsular Malaysia. This study was conducted with the collaboration of Department of Orang Asli Development (*Jabatan Kemanjuan Orang Asli*, *JAKOA*), Ministry of Rural and Regional Development, Malaysia. The villages were selected based on the suggestion and approval by the Department of Orang Asli Development, villager willingness to take part and also its accessibility by road for rapid transfer of samples to the laboratory. Throughout this study, eight villages were randomly selected

from official listing provided by the department. The villages were Pos Iskandar (102.65^{o}E longitude, 3.06^{o}N latitude), Sungai Layau (104.10^{o}E longitude, 1.53^{o}N latitude), Bukit Serok (102.82^{o}E longitude, 2.91^{o}N latitude), Gurney (101.44^{o}E longitude, 3.43^{o}N latitude), Sungai Bumbun (101.42^{o}E longitude, 2.85^{o}N latitude), Kuala Pangsun (101.88 ^{o}E longitude, 3.21^{o}N latitude), Sungai Miak (101.90^{o}E longitude, 3.52^{o}N latitude), and Kemensah (101.77^{o}E longitude, 3.21^{o}N latitude) representing five different Orang Asli subgroups (i.e., Temuan, Semelai, Jakun, Mah Meri and Orang Kuala) (Figure 3.1).

Briefly, each village had a small population and the number of residents in each village was estimated to be 80 to 100 inhabitants. Villages such as RPS Pos Iskandar, RPS Bukit Serok and RPS Sungai Layau under the resettlement scheme (*Rancangan Penempatan Semula*) initiated by the government to improve the quality of lives. Under this relocation scheme or 'regroupment schemes', the Orang Asli communities living in the jungle area are resettled to new areas where a house is provided per family as well as provision of basic amenities such as school, clean water supply, electricity, accessible by tar road, clinic, shop and community hall. The schemes also provided land and subsidies to the settler for them to participate in cash economy activities such as growing cash crops including rubber, palm oil and fruit trees and also small scale of animal husbandry practices and vegetables cultivation for their own consumption. For example, resettlement villages such as Pos Iskandar and Bukit Serok are involved in rubber plantation whilst Sungai Layau is active in oil palm plantation.

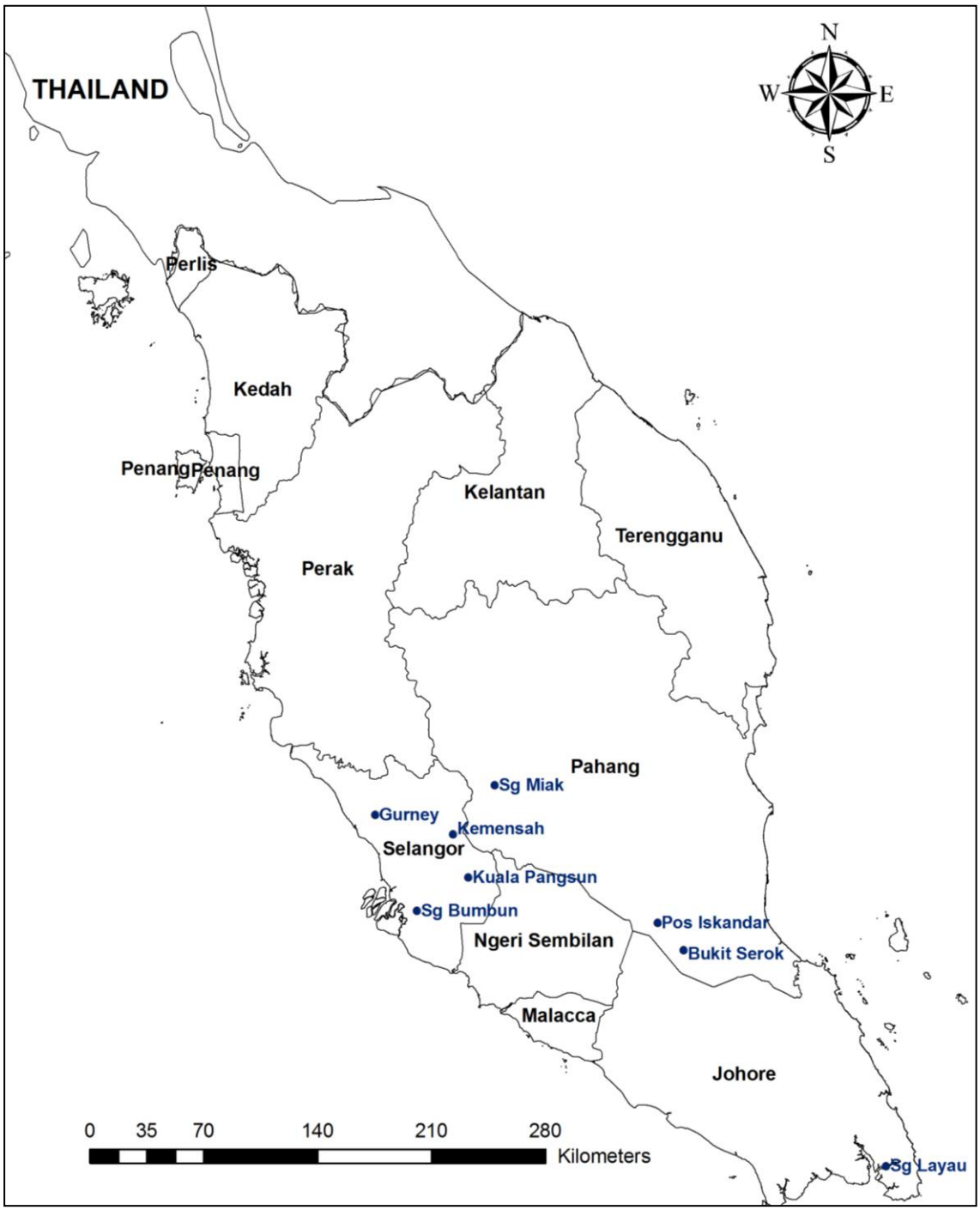

Figure 3.1: Location of the study areas in Peninsular Malaysia

Those who live in small traditional villages such as Gurney, Sungai Bumbun, Kemensah, Kuala Pangsun and Sungai Miak were also provided with the basic facilities however, these basic facilities were unevenly distributed. For example, some villagers have concrete houses constructed by government while others still live in traditional structures made of bamboo, wood, brick or a mixture of both built by themselves. Generally, a majority of them lived in deprived and socioeconomically disadvantaged conditions where overcrowding, poor environmental sanitation, lack of educational attainment and poor provision of clean water are common of resettlement or traditional villages. As not all houses have treated water supply, some rely on river water adjacent to their village for their daily chores. Even if this provision were provided, a majority could not afford the monthly bills leading to the termination of water supply. As a result, rivers located nearby to the village remain the main source of water supply for their domestic needs including drinking, cooking, bathing and washing.

Household-based sanitation facilities are almost non existing in these communities. A single latrine usually serves few families, but it is not frequently used due to poor maintenance (e.g., dirty and smelly) which encouraged indiscriminate defecation in bushes or river. Children were allowed to defecate indiscriminately in their houses vicinity without parental supervision. Dogs and cats are the most common domestic animal, other animals include poultry, monkeys, rabbits and birds. These animals are usually left to roam freely. Sometimes dogs could be observed following their owners into the jungle to hunt. The villagers have very close contact with dogs and cats. Occasionally, dogs and cats were observed sharing food from the same plate with their owners and sleeping on the clothing racks. They defecate outdoor promiscuously and some cats also defecate indoor especially near the fire wood in the kitchen area.

3.2.4 Sample size estimation

The sample size required for this study was calculated according to the anticipated prevalence of STH infections in the Orang Asli. The sample size calculation made based on overall prevalence of 59.5% (Hakim et al, 2007) according to the following formula (Leedy, 1993):

$$\mathbf{n \geq \left(\frac{z}{m}\right)^2 x\ p\ (1 - p)}$$

n = sample size

z = standard score (1.96)

m = rate of sampling error (5%)

p = estimated rate or case which happened in the population

$$\mathbf{n = \left(\frac{z}{m}\right)^2 x\ p\ (1 - p)}$$

$$\mathbf{= (1.96/0.05)^2 x\ 0.595\ (1 - 0.595)}$$

$$\mathbf{\approx 370.29}$$

Hence, by using significance level of 5% and confidence level of 95%, a minimum sample size of 370 was required for this study. However, every member of the villages was approached and a total of 634 eligible individuals who had given informed consent voluntarily participated in this study.

3.2.5 Data collection

3.2.5.1 Consent and structured questionnaire

Prior to the sample collection, a small community meeting was held with the villagers together with their village headman. Before participating in the study, parents and their children were given an oral briefing by the investigator on the objective and methodology of the study. During the meetings, they were informed that their participation was voluntary and therefore they could withdraw from the study at any time without giving any reason. They were also informed that their identities and personal particulars will be kept strictly confidential and the procedure used will not pose any risk. If they agree to participate, the consent sheet was signed (i.e., written form) for literate participant whilst those who are illiterate, a verbal consent followed by thumb prints were taken from them. For children and very old participants especially in the case of ill adults, the consent was completed by their parents and guardians or relevant adults who are usually head of the family.

After they had completed their consent form, the participants was then asked to answer a structured questionnaire by field workers. The questionnaire was administered to get information on their demographic (i.e., age, gender, education achievement), socioeconomic (i.e., occupation, household income), behavioral (i.e., personal hygiene such as wearing shoe, food consumption, defecation practices), sanitation infrastructure as well as living condition characteristics including water supply, latrine system and domestic animals ownership or contact. Initially, the questionnaire was constructed in the English language. Then, the questionnaire was translated to Bahasa Malaysia, which is the national language for Malaysia and well understood by the participants. The

questionnaire was completed by interviewing the head of the household or any designated substitute for children and elderly participants (Appendix Ai and Aii).

3.2.5.2 Fecal sample collection and parasitological analysis

Following completion of the questionnaire, a dry, clean and leak proof screw capped pre-labeled fecal container with the individual's name and code was distributed to the participants. Their ability to identify their names was also checked. They were guided on how to collect the sample and advised to scoop a thumb-size fecal sample by using a provided scoop into the containers. Parents and guardians were instructed to monitor their children to make sure that they placed their fecal sample into the designated container. Then, the filled containers with fecal sample were collected on the next day. This collection step was repeated for two consecutive days. Participants who were not able to provide their fecal sample on the first day were then asked to do so during the second collection. However, due to cultural sensitivity and personal request, some participants were reluctant and ashamed to give their fecal sample, thus were excluded from this study. Participants who complete their questionnaire and provide fecal samples were honored with a small token of appreciation.

The fresh fecal samples were stored at ambient temperature and transported back to the Department of Parasitology, Faculty of Medicine, University of Malaya on the same day of collection. Upon reaching the laboratory, the sample were preserved in 2.5% potassium dichromate and refrigerated at 4 °C until further analysis. All samples were tested using standard operating procedures and performed within 24 hours after collection. The fecal samples were processed by the wet smear and formalin ethyl acetate concentration technique (Cheesbrough, 1998). In brief, 1 to 2 g of fecal sample

was mixed with 7 ml of formalin and 3 ml ethyl acetate, centrifuged, stained with 0.85% iodine followed by microscopic examination using 10 x magnifications and 400 x magnifications using light microscope (Olympus CX40, USA) (Appendix B). Detection of STH species was determined on the basis of morphological characteristic of specific species under microscopic examination. One of each sample was examined and the result was considered as positive when at least one parasite egg was observed in one of each employed technique.

3.2.6 Statistical analysis

Questionnaire data and laboratory test results were entered and analyzed using the SPSS software (Statistical Package for the Social Sciences) program for Window version 17 (SPSS Inc, Chicago, USA). Prior to each analysis, initial data entry was cross-checked regularly in order to be sure that data were entered correctly and consistently. Quantitative or continuous variables were expressed as median and ranges whilst qualitative or categorical data were calculated and presented as frequencies and percentages (rates) with 95% c(95% CI) confidence interval for proportion. A Pearson's Chi-square (χ^2) test on proportion was used to examine the crude associations between binary and independent variables. In addition, a univariate analysis was used to test the possible associations between the infection status and potential associated key factors. In univariate model, the outcome of interest or dependent variables was infection status while the independent variables were subgroups, socio-demographic, environmental and sanitary behavior and living condition characteristics. A significant level was set as $p<0.05$ and odd ratios (OR) and 95% CI was computed for all tests to explore the association between each variables. All explanatory variables that was significant at

level of $p<0.05$ in the univariate analysis were included in a multiple logistic regression analysis. In addition, all variables with the borderline significance level of 0.10 to 0.25 were also included in the multivariable analysis to ensure that any potentially important predictors are not excluded and also due to a low number of predictor variables (Bendel & Afifi, 1977). The subset for final model was then analyzed with multiple logistic regression model to determine which factors could be dropped from the multivariable model and finally determine the significant associated key factors for STH infections.

3.3 RESULTS

3.3.1 Survey population characteristics

3.3.1.1 Demographic characteristics

A total of 634 participants from 5 Orang Asli subgroups (i.e., Temuan, Semelai, Jakun, Mah Meri and Orang Kuala) were eligible to participate in this study (Table 3.1). Of these subgroups, Temuan subgroup had the highest proportion of participation with 44.0% (279/634), followed by Semelai (17.8%; 113/634), Jakun (15.6%; 99/634), Orang Kuala (14.0%; 89/634) whilst Mah Meri subgroup had the least (8.5%; 54/634) (Table 3.2). The overall ages ranged from 1 to 80 years with median age of 11.0 years. According to subgroup, the median ages were 11.0 (range: 1 to 80), 10.0 (range: 8-68), 11.0 (range: 7 to 58), 11.0 (range: 7 to 65), and 13.0 years (range: 1 to 80) for Temuan, Semelai, Jakun, Orang Kuala and Mah Meri, respectively (X^2 = 45.6, $p<0.001$). With regards to gender, a total of 276 (43.5%) male and 358 (56.5%) female consisted of 392 (61.8%) children and 242 (38.2%) adults were participated in this study. Generally, the

age category of 7 to 12 and above 18 years had the highest number of participants with proportions of 1.7%, 8.8%, 3.9%, 41.3%, 5.2% and 39.0% for age less than 1, 1 to 4, 5 to 6, 7 to 12, 13 to 17 and above 18 years, respectively.

3.3.1.2 Socioeconomic, environmental sanitation and personal hygiene characteristics

The socioeconomic, environmental sanitation and personal hygiene characteristics were generally poor and appears to be similar in all communities with the exception of Orang Kuala (Table 3.3). With the exemption of Temuan, all other subgroups such as Semelai (72.6%), Jakun (79.8%), Orang Kuala (80.9%) and Mah Meri (66.7%) were significantly more likely to receive some form of formal education at least up to primary level. Detailed analysis demonstrated that a majority of the Orang Asli children (76.3%) had received some form of formal education such as primary, secondary or tertiary level while only 23.7% of them never went to school. In contrast, there were high numbers of illiteracy in adults (63.6%) leaving only 36.4% who had obtained educational attainment. This showed that younger generation has more education opportunities compared to older generation or their parents.

With regards to their occupational status, there was significantly high number of unemployed among survey population across all subgroups. More than half of the overall survey population was unemployed. However, it was also noted that most of the housewife normally helped their husband in the oil palm or rubber plantations or go into the jungle to collect jungle product to supplement their family income. As for the employed participant, majority of them were engaged with odd jobs such as jungle product collector (8.8%) who often entered forest for varying length of time without

permanent income. There were 6.3% who were working as unskilled laborers in palm oil plantation, factory and construction site with daily income. Of the entire survey population, only one (0.2%) was a government employee as a field worker under the Malaria Control Program. In addition, some of the participants from Mah Meri subgroup are wood sculptors and carvers while a few of them are well known in the international arena for their intricate work of arts.

With the exception of Orang Kuala subgroup, Semelai and Jakun subgroups were predominantly poor with 88.5% and 86.9% of them having monthly household income less than RM 500 (Ringgit Malaysia) (US$ 1≈RM 3.15) followed by Mah Meri subgroup (59.3%) and Temuan (56.6%). As for Orang Kuala subgroup, all of the participants had their monthly household income more than RM 500. Although more than half of the overall survey population had treated water supply (54.4%) at home, it was not fully utilized by the family. From our personal communication with them, most of their water supply had been terminated due to outstanding bills. It was also observed that river adjacent to their village remains the major source of water supply for their daily chores such as drinking, cooking, bathing and washing. Of these five subgroups, household in Temuan (68.5%) and Semelai (79.5%) subgroups had the least number of treated water supplies at their homes. As for Orang Kuala subgroup, all family had treated water supply at homes for their domestic needs.

The Mah Meri subgroup (77.8%) had the highest rates of no toilet facilities at home, followed by Semelai (67.3%) and Temuan (62.7%) while 51.5% family of Jakun subgroup had toilet at home. Again, each household of Orang Kuala had proper toilet facility at their home. Those without proper toilet facilities were more likely to defecate in river, pit latrines, bushes while children usually defecated indiscriminately around the housing areas. The highest rates of open or indiscriminate defecation were observed

among the Temuan, Semelai, Jakun, and Mah Meri subgroups. Likewise, participants from Temuan, Semelai, Jakun, and Mah Meri subgroups were unlikely to wear shoes or sandal outside the house. Eating with hand without proper washing was observed as routine practices among Orang Asli communities. A close contact and relationship with dogs and cats were also noted as a general practice in these communities. Although the proportion of collected garbage in a designated area surrounding their house compound was slightly lower than indiscriminate disposal, central garbage disposal facilities were not available in all communities. Thus, it can be summarized that the socioeconomic, environmental and sanitary behavior of the Orang Asli communities were poor and appeared to be similar across the Temuan, Semelai, Jakun, and Mah Meri subgroups with the exception of Orang Kuala subgroup.

3.3.2 Prevalence of STH infections stratified by participant characteristics

The overall prevalence of infection with any STH species among 634 participants was 59.9% (380/634; 95% CI = 56.1-63.7%) with *Trichuris trichiura* (344/634; 54.3%; 95% CI = 50.4-58.2%) being the predominant species recorded followed by *Ascaris lumbricoides* (169/634; 26.7%; 95% CI = 23.3-30.1%) while hookworm (58/634; 9.1%; 95% CI = 6.9-11.3%) had the least infection rates (Table 3.4). There was a significant difference in village-specific prevalence either infections with individual or any STH species in the surveyed population. With the exception of *A. lumbricoides*, it was observed that *T. trichiura* (79.4%; 95% CI = 72.7-86.1%), hookworm (19.1%; 95% CI = 16.6-25.6%) and any STH infections (84.4%; 95% CI = 78.4-90.4%) were significantly higher in Gurney village compared to other villages. Sungai Layau had significantly lower prevalence of *T. trichiura* (3.4%; 95% CI = -0.4-7.2%) and any STH

infections (4.5%; 95% CI = -0.2-8.8%). Meanwhile, the prevalence of *A. lumbricoides* (46.3%; 95% CI = 33.0-59.5%) was significantly higher in Kemensah village compared to other villages. Prevalence of other intestinal parasites detected in this study were 9.5% (60/634) for *Giardia* spp., and 9.1% (58/634) for *Entamoeba histolytica/dispar* (data not shown).

The species-specific distribution of STH infections were further analyzed according to the subgroups. There was a significant difference in prevalence of STH infections between subgroups for all type of infections (i.e., individual or any STH species). Mah Meri subgroup had significantly highest prevalence for all species with the exemption of hookworm infection which include *T. trichiura* (66.7%; 95 CI% = 54.1-79.3%), *A. lumbricoides* (40.7%; 95 CI% = 27.6-53.8%) and any STH species (75.9%; 95 CI% = 64.5-87.3%). Meanwhile, Semelai subgroup had the significantly higher prevalence of hookworm infection (12.4%; 95 CI% = 6.3-18.5%). Interestingly, it was observed that Orang Kuala subgroup had significantly lowest prevalence for all type of STH infections, i.e., *T. trichiura* (3.4%; 95 CI% = -0.4-7.2%), *A. lumbricoides* (0%), hookworm (1.1%; 95 CI% = -1.1-3.3%) and any STH species (4.5%; 95 CI% = 0.2-8.8%).

There was no significant difference ($p>0.05$) in prevalence of STH infections between male and female for any STH species, although female had slightly higher overall and individual species of STH infections. Likewise, there was no significant difference in the prevalence of all STH infections between children and adults with the exception of *A. lumbricoides* although the prevalence was higher in children. For *A. lumbricoides*, the prevalence was significantly higher in children (30.6%; 95% CI = 26.0-35.2%) as compared to adults (20.2%; 95% CI = 15.1-25.3%). Given the important association between STH infections and different age groups, the prevalence of STH

infections was further analyzed according to six age groups, i.e., infants (less than 1 year), toddlers (1 to 4 years), pre-school children (5 to 6 years), primary school children (7 to 12 years), teenagers (13 to 17years) and adults (more than 18 years). In general, there was a significant difference between age groups and all type of STH infections. With the exception of *A. lumbricoides*, the prevalence of *T. trichiura* (72.0%; 95% CI = 54.4-89.6%), hookworm (24.0%; 95% CI = 7.3-40.7%) and any STH infections (76.0%; 95 CI% = 59.3-92.7%) were significantly higher in pre-school children age of 5 to 6 years. As for *A. lumbricoides* infection, it appears to decrease significantly with the increase in age. Although, the peak prevalence was recorded in persons aged 7 to 12 years (33.6%; 95% CI = 27.9-39.3%), the prevalence rates continued to decline after this age range.

Although the prevalence of infections with all STH species was slightly higher in working persons, there was no significant difference in the prevalence between employed and unemployed persons for all STH species. With the exception of hookworm infection, persons from low household income family that earned cumulative monthly income less than RM 500 were significantly more likely to be infected with *T. trichiura* (64.9%; 95% CI = 60.1-69.7%), *A. lumbricoides* (32.7%; 95% CI = 28.0-37.4%) and any STH infections (71.3%; 95% CI = 66.7-75.9%). The prevalence of all type of STH infections, i.e., *T. trichiura* (65.4%; 95% CI = 59.9-70.9%), *A. lumbricoides* (31.5%; 95% CI = 26.1-36.9%), hookworm (12.5%; 8.7-16.3%) and any STH infections (70.6%; 95 %CI = 65.4-75.9%) were significantly higher in participants who were using untreated water supply for domestic needs. Likewise, *T. trichiura* (65.1%; 95% CI = 60.0-70.2%), hookworm (11.7%; 95% CI = 8.3-15.1%) and any STH infections (71.6%; 95 %CI = 66.8-76.4%) were significantly greater in household with no toilet facilities at home. In addition, the prevalence of infections with *T. trichiura*

(63.1%; 95% CI = 59.4-67.8%), *A. lumbricoides* (31.2%; 95% CI = 26.7-35.7%), hookworm (11.8%; 95% CI = 8.7-14.9%) and any STH infections (68.8%; 95% CI = 64.3-73.3%) were significantly higher in persons who defecated openly or indiscriminately.

Likewise, the prevalence of STH infections either infection with individual or any species were also significantly higher among persons who walked barefooted for *T. trichiura* (68.2%; 95% CI = 62.4-74.0%), *A. lumbricoides* (39.2%; 95% CI = 33.1-45.3%), hookworm (18.4%; 95% CI = 13.6-23.3%) and any STH species (76.3%; 95 CI% = 71.0-81.6%). There was also significant difference in the prevalence of *T. trichiura* (60.5%; 95% CI = 56.3-64.7%), *A. lumbricoides* (29.6%; 95% CI = 25.7-33.5%), hookworm (10.2%; 95% CI = 7.6-12.8%) and any STH infections (66.9%; 95 CI% = 62.9-70.9%) among those who were eating with hand without prior proper washing. With the exception of *T. trichiura* and *A. lumbricoides* infections, the prevalence hookworm (10.6%; 95% CI = 8.0-13.3%) and infection with any STH species (61.9%; 95 %CI = 57.7-66.1%) were significantly higher in household with the close contact with domestic animals particularly dogs and cats. There was no significant difference in the prevalence of STH infections between proper and indiscriminate garbage disposal.

3.3.3 Polyparasitisim of STH infections

Based on the total sample size of 634 participants, overall prevalence of single infection with only one STH species (202/634; 31.9%; 95% CI = 28.3-35.5%) was the most common followed by double infections (149/634; 23.5%; 95% CI = 20.2-26.8%) whilst triple infections with any STH species (24/634; 2.8%; 95% CI = 1.5-4.1%) had the

least. Of the single infection with individual species, single infection of *T. trichiura* (176/634; 27.8%; 95% CI = 24.3-31.3%) was the most predominant followed by *A. lumbricoides* (22/634; 3.5%; 95% CI = 2.1-4.9%) while single infection with hookworm accounted for 0.6% (4/634; 95% CI = 0-1.2%) (Table 3.5). As for double infections, overall prevalence of co-infections with *T. trichiura* and *A. lumbricoides* (120/634; 18.9%; 95% CI = 15.9-22.0%) was the most common followed by combination of *T. trichiura* and hookworm (25/634; 3.9%; 95% CI = 2.4-5.4%) and lastly co-infections with *A. lumbricoides* and hookworm (4/634; 0.6%; 95% CI = 0-1.2%). The overall prevalence of co-infections with all three STH species (i.e., *T. trichiura, A. lumbricoides* and hookworm) was 3.8% (24/634; 95% CI = 2.3-5.3%). Further analysis based on subgroups demonstrated that the prevalence of single infection with *T. trichiura* (3.4%; 95% CI = -0.4-3.7%) was significantly lower in Orang Kuala than in other subgroups. Likewise, co-infections with *T. trichiura* and *A. lumbricoides* (12.4%; 95% CI = 8.2-16.6%) was significantly lower in adults compared to children.

3.3.4 Risk factors of STH infections based on subgroup

Twelve potential risk factors including socio-demographic, environmental sanitation and lifestyle characteristics of the survey populations were included and examined for the possible associations between STH infections and associated key factors among five Orang Asli subgroups. In Temuan subgroup, five potential key factors were significantly associated with STH infections includes low household income family (OR = 1.68; 95% CI = 1.32-2.84; p=0.045), persons who defecated openly or indiscriminately (OR = 1.24; 95% CI = 1.02-1.50; p=0.015), walking barefooted outside the house (OR = 1.37; 95% CI = 1.10-1.87; p=0.032), eating with hand without prior

proper washing (OR =3.10; 95% CI = 1.73-13.19; p=0.010) and close contact with domestic animals particularly dogs and cats (OR = 2.23; 95% CI = 1.30-3.82; p=0.003) (Table 3.6). The final multiple logistic regression analysis confirmed that low family income were at 1.6 times higher odds of having STH infections (95% CI = 1.34-2.03; p=0.050). Additionally, household with no toilet facility available at home and persons who walked barefooted were also at 2 times (95% CI = 1.13-3.62; p=0.018) and 1.8 times (95% CI = 1.01-3.06; p=0.047) greater odds to be infected with STH infections, respectively. Similarly, close contact with domestic animals particularly dogs and cats were also at 1.4 times higher odds (95% CI = 1.24-1.74; p=0.002) to get STH infections.

In Semelai subgroup, the univariate analysis showed that children less that 12 years old (OR = 19.91; 95% CI = 7.00-56.66; p<0.001), those with no formal education (OR = 2.35; 95% CI = 1.61-3.42; p<0.001), non working parents (OR = 1.40; 95% CI = 1.13-1.73; p<0.001), low household income family (OR = 4.37; 95% CI = 71.25-15.22; p<0.001) and eating with hand without prior washing properly (OR = 3.07; 95% CI = 1.37-25.41; p=0.020) were significantly associated with the STH infections in these communities (Table 3.7). Further multiple logistic regression model found that survey participants who were less than 12 years of age, i.e., children were at 22.4 times (95% CI = 7.56-66.16; p<0.001) greater odds of having STH infections. Likewise, participants using untreated water supply for their daily chores were at 3 times (95% CI = 1.96-9.41; p<0.049) higher odds more likely to suffer from STH infections as compared to those who used clean and treated water supply.

In Jakun subgroup, being children aged less than 12 years (OR = 1.28; 95% CI = 1.07-3.52; p=0.027), persons who do not wear shoes or sandal outside the house (OR = 2.05; 95% CI = 1.06-3.98; p=0.019) and close contact with domestic animals especially

dogs and cats (OR = 1.06; 95% CI = 1.01-1.15; p=0.048) were significantly associated with the odds of STH infections (Table 3.8). The final multiple logistic regression model indicated that persons who walked barefooted outside the house had increased odds for STH infections by 3 times (95% CI = 1.78-7.54; p = 0.021) than those who protected their foot with shoes or sandal.

As for Orang Kuala subgroup, none of the potential key factors were significantly associated with STH infections in these communities (Table 3.9). In Mah Meri subgroup, six potential key factors were significantly associated with STH infections. These included age group less than 12 years (OR = 4.71; 95% CI = 1.12-19.70; p=0.026), non working parents (OR = 1.54; 95% CI = 1.19-2.60; p=0.033), low household income (OR = 3.09; 95% CI = 1.85-11.21; p=0.030), defecated openly and indiscriminately (OR = 5.69; 95% CI = 1.49-21.72; p=0.007), walking barefooted when outside the house (OR = 2.43; 95% CI = 1.87-6.80; p=0.038) and close contact with domestic animals particularly dogs and cats (OR = 4.23; 95% CI = 1.57-11.42; p<0.001) (Table 3.10). Of these six associated key factors, only two were retained in the multiple logistic regression model. The final model indicated that unemployed parents were at 10.4 times greater odds (95% CI = 1.89-121.97; p=0.050) of having STH infections. Likewise, persons that had close contact with domestic animals such as dogs and cats were also at higher odds of having STH infections by 2.1 times (95% CI = 2.14-2.73; p<0.001).

Table 3.1: Geographical distribution of the Orang Asli subgroups participated in this study stratified by location

Village	District	States	Subgroup	Geographic coordinates		Habitat
				Longitude (°E)	Latitude (°N)	
Gurney	Hulu Selangor	Selangor	Temuan	101.653	3.430	Lowland forest fringe, near town and Chinese village
Pos Iskandar *	Bera	Pahang	Semelai	102.650	3.060	Secondary lowland forest and swampy lakeside
Bukit Serok *	Rompin	Pahang	Jakun	102.820	2.910	Secondary lowland forest
Sungai Layau *	Kota Tinggi	Johor	Orang Kuala	104.100	1.530	Swampy mangrove of a river delta
Sungai Bumbun	Kuala Langat	Selangor	Mah Meri	101.420	2.850	Coastline or seashore areas
Kemensah	Hulu Klang	Selangor	Temuan	101.770	3.210	Surrounded by major urban areas
Kuala Pangsun	Hulu Langat	Selangor	Temuan	101.878	3.209	Lowland forest fringe, near town and Malay village
Sungai Miak	Bentong	Pahang	Temuan	101.900	3.520	Secondary hill land forest

N: Number of participant; * Resettlement scheme (*RPS: Rancangan Penempatan Semula*)

Table 3.2: Distribution demographic characteristics of survey population stratified by subgroup

Characteristic	Temuan (N=279)		Semelai (113)		Jakun (N=99)		Orang Kuala (N=89)		Mah Meri (N=54)		Total (N=634)		*X^2	p
	n	%	n	%	n	%	n	%	n	%	n	%		
Age (years)														
Range	1-80		8-68		7-58		7-65		1-80		1-80			
Median	11.0		10.0		11.0		11.0		13.0		11.0		**45.8	<0.001
Gender														
Male	133	47.7	42	37.2	41	41.4	42	47.2	18	33.3	276	43.5		
Female	146	52.3	71	62.8	58	58.6	47	52.8	36	66.7	358	56.5	6.8	0.149
Age group (Years)														
Children (≤ 12)	135	48.4	79	69.9	79	79.8	72	80.9	27	50.0	392	61.8		
Adults (≥13)	144	51.6	34	30.1	20	20.2	17	19.1	27	50.0	242	38.2	54.9	<0.001
Age stratify (Years)														
< 1	6	2.2	0	0	3	3.0	0	0	2	3.7	11	1.7		
1-4	46	16.5	0	0	6	6.1	0	0	4	7.4	56	8.8		
5-6	20	7.2	0	0	1	1.0	0	0	4	7.4	25	3.9		
7-12	58	20.8	79	69.9	36	36.4	72	80.9	17	31.5	262	41.3		
13-17	21	7.5	0	0	11	11.1	0	0	1	1.9	33	5.2		
18 and above	128	45.9	34	30.1	42	42.4	17	19.1	26	48.1	247	39.0	186.1	<0.001

***** Pearson Chi Square (X^2) test (calculated across all subgroups); ****** Kruskal-Wallis test; Significant difference (p<0.05)

Table 3.3: Distribution socioeconomic, environmental sanitation and personal hygiene characteristics of survey population stratified by subgroup

Characteristic	Temuan (N=279)		Semelai (113)		Jakun (N=99)		Orang Kuala (N=89)		Mah Meri (N=54)		Total (N=634)		*X^2	p
	n	%	n	%	n	%	n	%	n	%	n	%		
Educational attainment														
No formal	160	57.3	31	27.4	20	20.2	17	19.1	18	33.3	246	38.8		
Formal education (at least primary level)	119	42.7	82	72.6	79	79.8	72	80.9	36	66.7	388	61.2	76.2	<0.001
Occupational status														
Working	92	33.0	18	15.9	9	9.1	7	7.9	13	24.1	139	21.9		
Not working	187	67.0	95	84.1	90	90.9	82	92.1	41	75.9	495	78.1	42.2	<0.001
Occupational category														
Not working (housewife / student)	185	66.3	95	84.1	92	92.9	82	92.1	41	75.9	495	78.1		
Jungle product gatherers	30	10.8	7	6.2	7	7.1	0	0	12	22.2	56	8.8		
Palm oil / rubber plantation	31	11.1	7	6.2	2	0.7	0	0	0	0	40	6.3		
Labor (factory / construction sites)	28	10.0	4	3.5	0	0	7	8.5	1	1.9	40	6.3		
Small business (mini sundry shop)	2	0.7	0	0	0	0	0	0	0	0	2	3.2		
Government employee	1	0.4	0	0	0	0	0	0	0	0	0	0.2		
Others (driver etc.)	2	0.7	0	0	0	0	0	0	0	0	2	3.2	140.4	<0.001
Household income (RM/month)														
< RM 500 (< US$ 166.7)	152	56.6	100	88.5	86	86.9	0	0	32	59.3	376	59.3		
> RM 500 (> US$ 166.7)	121	43.4	13	11.5	13	13.1	89	100	22	40.7	258	40.7	201.6	<0.001
Source of water supply														
Untreated (River, mountain water, etc.)	191	68.5	90	79.6	8	8.1	0	0	0	0	289	45.6		
Treated (Government pipe water)	88	31.5	23	20.4	91	91.9	89	100	54	100	345	54.4	287.6	<0.001

***** Pearson Chi Square (X^2) test (calculated across all subgroups); Significant difference (p<0.05)

Table 3.3 (continued)

Characteristic	Temuan (N=279)		Semelai (113)		Jakun (N=99)		Orang Kuala (N=89)		Mah Meri (N=54)		Total (N=634)		*X^2	p
	n	%	n	%	n	%	n	%		n	%	n		
Presence of toilet														
No	175	62.7	76	67.3	48	48.5	0	0	42	77.8	341	53.8		
Yes	104	37.3	37	32.7	51	51.5	89	100	12	22.2	293	46.2	134.4	<0.001
Type of toilet facilities														
Pour flush toilet	94	33.7	2	1.8	20	20.2	89	100	24	44.4	229	36.1		
Pit latrine/Non pour flush toilet	51	18.3	50	44.2	48	48.5	0	0	1	1.9	150	23.7		
Bush	100	35.8	23	20.4	25	25.3	0	0	28	51.9	176	27.8		
River	34	12.2	38	33.8	6	6.1	0	0	1	1.9	79	12.5	332.1	<0.001
Defecation sites														
Open/Indiscriminate	201	72.0	113	100	76	76.8	0	0	17	31.5	407	64.2		
Latrine	78	28.0	0	0	23	23.2	89	100	37	68.5	227	35.8	262.0	<0.001
Wear shoes/sandals outside the house														
No	136	48.7	45	39.8	38	38.4	0	0	26	48.1	245	38.6		
Yes	143	51.3	68	60.2	61	61.6	89	100	28	51.9	389	61.4	70.0	<0.001
Eat with hand without prior washing														
Yes	261	93.5	107	94.7	99	100.0	10	11.2	54	100	531	83.8		
No	18	6.5	6	5.3	0	0	79	88.8	0	0	103	16.2	403.2	<0.001
Presence/close contact with dogs/cats														
Yes	184	65.9	113	100	97	98.0	80	89.9	43	79.6	517	81.5		
No	95	34.1	0	0	2	2.0	9	10.1	11	20.4	117	18.5	92.7	<0.001
Garbage disposal														
Indiscriminate	145	52.0	55	48.7	45	45.4	57	64.0	28	51.9	330	52.1		
Collected	134	48.0	58	51.3	54	54.4	32	36.0	26	48.1	304	47.9	7.4	0.017

Table 3.4: Prevalence of soil-transmitted helminth (STH) infections according to population characteristic

Characteristic		*Trichuris trichiura*		*Ascaris lumbricoides*		Hookworm		Any STH (Overall)	
	N	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Survey population	634	54.3	50.4-58.2	26.7	23.3-30.1	9.1	6.9-11.3	59.9	56.1-63.7
Village									
Gurney	141	79.4	72.7-86.1	29.1	21.6-36.6	19.1	16.6-25.6	84.4	78.4-90.4
Pos Iskandar	113	54.9	45.7-64.1	36.3	27.4-45.2	12.4	6.3-18.5	61.9	53.0-70.1
Bukit Serok	99	59.6	49.9-69.3	26.3	17.6-35.0	8.1	2.7-13.5	64.6	55.2-74.0
Sungai Layau	89	3.4	-0.4-7.2	0	0	1.1	-1.1-3.3	4.5	0.2-8.8
Sungai Bumbun	54	66.7	54.1-79.3	40.7	27.6-53.8	3.7	-1.3-8.7	75.9	64.5-87.3
Kemensah	54	74.1	62.4-85.8	46.3	33.0-59.6	0	0	77.8	66.7-88.9
Kuala Pangsun	54	53.7	40.4-67.0	25.9	14.2-37.6	11.1	2.7-19.5	68.5	56.1-80.9
Sungai Miak	30	10.0	-0.7-20.7	0	0	0	0	10.0	-0.7-20.7
X^2		165.6		65.2		36.1		195.7	
p		<0.001		<0.001		<0.001		<0.001	
Subgroup									
Temuan	279	65.9	60.3-71.5	28.7	23.4-34.0	11.8	8.0-15.6	72.0	66.7-77.3
Semelai	113	54.9	45.7-64.1	36.3	27.4-45.2	12.4	6.3-18.5	61.9	56.2-67.6
Jakun	99	59.6	49.9-69.3	26.3	17.6-35.0	8.1	2.7-13.5	64.6	52.9-70.9
Orang Kuala	89	3.4	-0.4-7.2	0	0	1.1	-1.1-3.3	4.5	0.2-8.8
Mah Meri	54	66.7	54.1-79.3	40.7	27.6-53.8	3.7	-1.3-8.7	75.9	64.5-87.3
X^2		112.7		43.7		12.8		140.8	
p		<0.001		<0.001		0.012		<0.001	

Pearson Chi Square (X^2) test; CI = confidence interval; Significant difference (p<0.05)

Table 3.4 (continued)

Characteristic		*Trichuris trichiura*		*Ascaris lumbricoides*		Hookworm		Any STH (Overall)	
	N	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Gender									
Male	276	54.3	48.4-60.2	26.1	20.9-31.3	8.7	5.7-12.7	58.3	52.5-64.1
Female	358	54.2	49.0-59.4	27.1	22.5-31.7	9.5	6.7-13.0	61.2	55.5-67.0
X^2		0.02		0.1		0.1		0.5	
p		0.968		0.776		0.729		0.456	
Age group (Years)									
Children (≤ 12)	392	56.4	51.5-61.3	30.6	26.0-35.2	9.2	6.5-12.5	61.7	56.9-66.5
Adults (≥13)	242	50.8	44.5-57.1	20.2	15.1-25.3	9.1	5.8-13.4	57.0	50.8-63.2
X^2		1.9		8.2		0.01		1.4	
p		0.173		0.004		0.969		0.240	
Age stratify (Years)									
< 1	11	18.2	-4.6-41.0	0	0	0	0	27.3	10.0-53.6
1-4	56	60.7	47.9-73.5	26.8	15.2-38.4	5.4	-0.5-11.3	67.9	55.7-80.2
5-6	25	72.0	54.4-89.6	24.0	7.3-40.7	24.0	7.3-40.7	76.0	59.3-92.7
7-12	262	54.6	48.5-60.5	33.6	27.9-39.3	8.8	5.4-12.2	59.2	53.3-65.2
13-17	33	69.7	54.0-85.4	24.2	9.6-38.8	3.0	-2.8-8.8	72.7	57.5-87.9
18 and above	247	50.2	44.0-56.4	21.1	16.0-26.2	10.1	6.3-13.9	57.1	50.9-63.4
X^2		14.7		14.6		10.5		12.2	
p		0.012		0.012		0.050		0.032	
Educational attainment									
No formal	246	51.6	45.4-57.8	23.6	18.3-28.9	7.8	4.5-11.2	58.5	52.3-64.7
Formal education (at least primary level)	388	55.9	51.0-60.8	28.6	24.1-33.1	10.0	7.0-13.0	60.8	55.9-65.7
X^2		1.1		1.9		0.8		0.3	
p		0.289		0.163		0.347		0.567	

Table 3.4 (continued)

Characteristic		*Trichuris trichiura*		*Ascaris lumbricoides*		Hookworm		Any STH (Overall)	
	N	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Occupational status									
Working	139	51.1	42.8-59.4	22.3	15.4-29.2	10.1	5.1-15.1	57.6	49.4-65.8
Not working	495	55.2	50.8-59.6	27.9	24.0-31.9	8.9	6.4-11.4	60.6	56.3-64.9
X^2		0.7		1.7		0.03		0.4	
p		0.394		0.189		0.669		0.516	
Household income (RM/month)									
< RM 500 (< US$ 166.7)	376	64.9	60.1-69.7	32.7	28.0-37.4	10.1	7.1-13.2	71.3	66.7-75.9
> RM 500 (> US$ 166.7)	258	38.8	32.9-44.8	17.8	13.1-22.5	7.8	4.5-11.2	43.3	37.3-49.4
X^2		42.1		17.3		0.8		49.5	
p		<0.001		<0.001		0.312		<0.001	
Source of water supply									
Untreated (River, mountain water, etc.)	289	65.4	59.9-70.9	31.5	26.1-36.9	12.5	8.7-16.3	70.6	65.4-75.9
Treated (Government pipe water)	345	44.9	39.7-50.2	22.6	18.2-27.0	6.4	3.8-9.0	51.0	45.7-56.3
X^2		26.6		6.3		6.3		25.1	
p		<0.001		0.012		0.008		<0.001	
Presence of toilet									
No	341	65.1	60.0-70.2	29.6	24.8-34.5	11.7	8.3-15.1	71.6	66.8-76.4
Yes	293	41.6	36.0-47.2	23.2	18.4-28.0	6.1	3.4-8.8	46.4	40.7-52.1
X^2		35.0		3.3		6.8		41.4	
p		<0.001		0.069		0.015		<0.001	
Defecation sites									
Open/Indiscriminate	407	63.1	59.4-67.8	31.2	26.7-35.7	11.8	8.7-14.9	68.8	64.3-73.3
Latrine	227	38.3	32.0-44.6	18.5	13.5-23.6	4.1	1.5-6.7	44.1	37.6-50.6
X^2		36.2		12.0		15.6		37.2	
p		<0.001		0.001		0.002		<0.001	

Table 3.4 (continued)

Characteristic		*Trichuris trichiura*		*Ascaris lumbricoides*		Hookworm		Any STH (Overall)	
	N	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Wear shoes/sandals outside the house									
No	245	68.2	62.4-74.0	39.2	33.1-45.3	18.4	13.6-23.3	76.3	71.0-81.6
Yes	389	45.5	40.6-50.5	18.8	14.9-22.7	3.3	1.5-5.1	49.6	44.6-54.6
X^2		31.1		32.1		30.7		44.7	
p		<0.001		<0.001		<0.001		<0.001	
Eat with hand without prior washing									
Yes	531	60.5	56.3-64.7	29.6	25.7-33.5	10.2	7.6-12.8	66.9	62.9-70.9
No	103	22.3	14.3-30.3	11.7	5.5-17.9	2.9	-0.3-6.1	24.3	16.0-32.6
X^2		50.2		14.2		2.7		65.1	
p		<0.001		<0.001		0.043		<0.001	
Presence/close contact with dogs/cats									
Yes	517	56.1	51.8-60.4	28.0	24.1-31.9	10.6	8.0-13.3	61.9	57.7-66.1
No	117	46.2	37.2-55.2	20.5	13.2-27.9	2.6	-0.3-5.5	51.3	42.2-60.4
X^2		3.8		2.8		5.7		4.5	
p		0.061		0.096		0.006		0.034	
Garbage disposal									
Indiscriminate	330	55.2	49.8-60.6	28.5	23.6-33.3	9.1	6.0-12.2	60.0	54.7-65.3
Collected	304	53.3	47.7-58.9	24.7	19.9-29.6	9.2	6.0-12.5	59.9	54.4-65.4
X^2		0.2		1.2		0.1		0.01	
p		0.638		0.278		0.958		0.973	

Table 3.5: Prevalence of single, double and triple infection of soil-transmitted helminth (STH) stratified by subgroup and age group

Characteristic		Type of soil-transmitted helminth (STH) infections													
		Single infections						Dual infections						Triple infections	
		Tri		*Asc*		Hkw		*Tri* + *Asc*		*Tri* + Hkw		Hkw + *Asc*		*Tri* + *Asc* + Hkw	
	N	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Subgroup															
Temuan	279	35.5	29.9-41.1	4.7	2.2-7.2	0.4	-0.34-1.1	19.4	14.8-24.0	6.8	3.9-9.8	0	0	4.3	1.9-6.7
Semelai	113	20.4	13.0-27.8	1.8	-0.7-4.3	1.8	-0.7-4.3	27.4	19.2-35.6	3.5	0.1-6.9	2.7	-0.3-5.7	4.4	0.6-8.2
Jakun	99	34.5	25.1-43.9	3.0	-0.4-6.4	0	0	18.2	10.6-25.8	1.0	1.0-3.0	1.0	1.0-3.0	6.1	1.4-10.8
OrangKuala	89	3.4	-0.4-3.7	0	0	1.1	-1.1-3.3	0	0	0	0	0	0	0	0
Mah Meri	54	31.5	19.1-43.9	7.4	0.4-14.4	0	0	31.5	19.1-43.9	1.9	-1.8-5.5	0	0	1.9	-1.8-5.5
X^2		40.3		7.9		4.0		31.7		12.6		10.3		5.8	
p		<0.001		0.095		0.408		<0.001		0.013		0.360		0.215	
Age (years)															
Children (≤ 12)	392	25.8	21.5-30.1	3.1	1.4-4.8	0.5	-0.2-1.2	23.0	18.8-27.2	3.6	1.8-5.4	0.8	-0.1-1.7	4.3	2.3-6.3
Adults (≥13)	242	31.0	25.2-36.8	4.1	1.6-6.6	0.8	-0.3-1.9	12.4	8.2-16.6	4.5	1.9-7.1	0.4	-0.4-1.2	2.9	0.8-5.0
X^2		2.0		0.5		0.2		10.9		0.4		0.3		0.9	
p		0.153		0.474		0.625		<0.001		0.540		0.586		0.355	
Total	**634**	**27.8**	**24.3-31.3**	**3.5**	**2.1-4.9**	**0.6**	**0-1.2**	**18.9**	**15.9-22.0**	**3.9**	**2.4-5.4**	**0.6**	**0-1.2**	**3.8**	**2.3-5.3**

Tri = Trichuris trichiura; *Asc = Ascaris lumbricoides*; Hkw = Hookworm

Pearson Chi Square (X^2) test; CI = confidence interval; Significant difference (p<0.05)

Table 3.6: Odd ratios of the potential risk factor associated with soil-transmitted helminth (STH) infections in Temuan subgroup [a]

Potential risk factor [b]	Temuan			
	Crude		Adjusted	
	OR (95 % CI)	p	OR [c] (95 % CI)	p
Male	1.07 (0.82-1.38)	0.627		
Children (< 12 years)	1.05 (0.63-1.78)	0.843		
Low parent's educational attainment	1.06 (0.62-1.79)	0.844		
Non working parents	1.06 (0.88-1.29)	0.518		
Low household income (RM < 500 per month) [d] *	1.68 (1.32-2.84)	0.045	1.60 (1.34-2.03)	0.049
Untreated water supply for daily chores	1.04 (0.87-1.24)	0.688		
No toilet at home *	1.16 (1.03-1.44)	0.174	2.02 (1.13-3.62)	0.018
Open/indiscriminate defecation [d] *	1.24 (1.02-1.50)	0.015		
Do not wear shoes/sandal outside the house [d] *	1.37 (1.10-1.87)	0.032	1.76 (1.01-3.06)	0.047
Eat with hand without prior washing [d] *	3.10 (1.73-13.19)	0.010		
Close contact with dogs or cats [d] *	2.23 (1.30-3.82)	0.003	1.42 (1.24-1.74)	0.002
Indiscriminate garbage disposal *	1.18 (0.90-1.54)	0.226		

[a] Odds ratios of the potential factors for STH infections with corresponding 95% confidence intervals (95% CI) and p values resulting from logistic univariate and multivariate stepwise regression.

[b] Reference groups: Female; adults (> 13 years); parent's educational attainment (at least primary school); working parents; high household income (>RM 500 per month); treated/government water supply; presence of toilet at home; proper latrine system; wear shoes/sandal; wash hand properly before eating; absence/no contact with dogs or cats; proper garbage collection.

[c] OR adjusted for household income; presence of toilet; defecation sites; wear shoes/sandal; eat with hand without prior washing; presence/close contact with dogs or cats; garbage disposal.

[d] Significant associated risk factors in the univariate analysis.

* Variables were included in the logistic multivariate analysis.

OR = odd ratio; CI = confidence interval; significant association ($p<0.05$).

Table 3.7: Odd ratios of the potential risk factor associated with soil-transmitted helminth (STH) infections in Semelai subgroup [a]

Potential risk factor [b]	Semelai			
	Crude		Adjusted	
	OR (95 % CI)	p	OR [c] (95 % CI)	p
Male	1.17 (0.53-2.58)	0.694		
Children (< 12 years) [d] *	19.91 (7.00-56.66)	<0.001	22.36 (7.56-66.16)	<0.001
No formal education [d] *	2.35 (1.61-3.42)	<0.001		
Non working parents [d] *	1.40 (1.13-1.73)	<0.001		
Low household income (RM < 500 per month) [d] *	4.37 (1.25-15.22)	0.014		
Untreated water supply for daily chores *	1.17 (0.95-1.45)	0.118	3.00 (1.96-9.41)	0.049
No toilet at home	1.12 (0.85-1.47)	0.428		
Defecated openly/indiscriminately	**	-		
Do not wear shoes or/sandal outside the house	1.01 (0.63-1.62)	0.916		
Eat with hand without prior washing [d] *	3.07 (1.37-25.41)	0.020		
Close contact with dogs and cats	**	-		
Indiscriminate garbage disposal	1.16 (0.78-1.75)	0.455		

[a] Odds ratios of the potential factors for STH infections with corresponding 95% confidence intervals (95% CI) and p values resulting from logistic univariate and multivariate stepwise regression.

[b] Reference groups: female; adults (> 13 years); parent's educational attainment (at least primary school); working parents; high household income (>RM 500 per month); treated/government water supply; presence of toilet at home; proper latrine system; wear shoes/sandal; wash hand properly before eating; absence/no contact with dogs or cats; proper garbage collection.

[c] OR adjusted for age group; educational attainment; occupational status; household income; source of water supply; eat with hand without prior washing.

[d] Significant associated risk factors in the univariate analysis.

* Variables were included in the logistic multivariate analysis.

** No statistic are computed because variable is a constant (i.e., all the surveyed participants were defecated openly/indiscriminately and close contact with dogs/cats).

OR = odd ratio; CI = confidence interval; significant association ($p<0.05$).

Table 3.8: Odd ratios of the potential risk factor associated with soil-transmitted helminth (STH) infections in Jakun subgroup [a]

Potential risk factor [b]	Jakun			
	Crude		Adjusted	
	OR (95 % CI)	p	OR [c] (95 % CI)	p
Male *	1.22 (0.84-1.78)	0.205		
Children (< 12 years) [d] *	1.28 (1.07-3.52)	0.027		
No formal education	1.12 (0.89-1.40)	0.312		
Non working parents	1.04 (0.91-1.20)	0.550		
Low household income (RM < 500 per month)	1.82 (0.54-6.20)	0.321		
Untreated water supply for daily chores	1.64 (0.35-7.70)	0.523		
No toilet at home	1.09 (0.71-1.70)	0.683		
Defecated openly/indiscriminately	1.33 (0.49-3.64)	0.573		
Do not wear shoes or/sandal outside the house [d] *	2.05 (1.06-3.98)	0.019	2.98 (1.78-7.54)	0.021
Eat with hand without prior washing	**	-		
Close contact with dogs and cats [d] *	1.06 (1.01-1.15)	0.048		
Indiscriminate garbage disposal	1.02 (0.44-2.33)	0.969		

[a] Odds ratios of the potential factors for STH infections with corresponding 95% confidence intervals (95% CI) and p values resulting from logistic univariate and multivariate stepwise regression.

[b] Reference groups: female; adults (> 13 years); parent's educational attainment (at least primary school); working parents; high household income (>RM 500 per month); treated/government water supply; presence of toilet at home; proper latrine system; wear shoes/sandal; wash hand properly before eating; absence/no contact with dogs or cats; proper garbage collection.

[c] OR adjusted for gender; age group; wear shoes/sandal; presence/close contact with dogs or cats.

[d] Significant associated risk factors in the univariate analysis.

* Variables were included in the logistic multivariate analysis.

** No statistics are computed because variable is a constant (i.e., all the surveyed participants were eating with hand without washing).

OR = odd ratio; CI = confidence interval; significant association ($p<0.05$).

Table 3.9: Odd ratios of the potential risk factor associated with soil-transmitted helminth (STH) infections in Orang Kuala subgroup [a]

Potential risk factor [b]	Orang Kuala			
	Crude		Adjusted **	
	OR (95 % CI)	p	OR (95 % CI)	p
Male	1.54 (0.35-5.40)	0.354		
Children (< 12 years)	1.25 (1.12-1.39)	0.320		
No formal education	1.25 (1.12-1.39)	0.320		
Non working parents	1.09 (1.02-1.16)	0.550		
Low household income (RM < 500 per month)	*			
Untreated water supply for daily chores	*			
No toilet at home	*			
Defecated openly/indiscriminately	*			
Do not wear shoes or/sandal outside the house	*			
Eat with hand without prior washing	1.13 (1.05-1.23)	0.467		
Close contact with dogs and cats	2.66 (0.43-6.11)	0.315		
Indiscriminate garbage disposal	1.18 (0.66-2.13)	0.640		

[a] Odds ratios of the potential factors for STH infections with corresponding 95% confidence intervals (95% CI) and p values resulting from logistic univariate and multivariate stepwise regression

[b] Reference groups: female; adults (> 13 years); parent's educational attainment (at least primary school); working parents; high household income (>RM 500 per month); treated/government water supply; presence of toilet at home; proper latrine system; wear shoes/sandal; wash hand properly before eating; absence/no contact with dogs or cats; proper garbage collection.

* No statistics are computed because variable is a constant (i.e., all the surveyed participant have high household income (>RM 500), using treated government water supply, presence of toilet at home, using proper latrine for defecation and wear shoes/sandal outside the house).

** No multivariate analysis is examined because none of the variables (potential risk factors) were significant at univariate level.

OR = odd ratio; CI = confidence interval; significant association ($p<0.05$).

Table 3.10: Odd ratios of the potential risk factor associated with soil-transmitted helminth (STH) infections in Mah Meri subgroup [a]

Potential risk factor [b]	Mah Meri			
	Crude		Adjusted	
	OR (95 % CI)	p	OR [c] (95 % CI)	p
Male	1.11 (0.69-1.79)	0.653		
Children (< 12 years) [d] *	4.71 (1.12-19.70)	0.026		
No formal education *	1.31 (1.07-2.26)	0.230		
Non working parents [d] *	1.54 (1.19-2.60)	0.033	10.42 (1.89-121.97)	0.050
Low household income (RM < 500 per month) [d] *	3.09 (1.85-11.21)	0.030		
Untreated water supply for daily chores	**			
No toilet at home	1.02 (0.72-1.42)	0.932		
Defecated openly/indiscriminately [d] *	5.69 (1.49-21.72)	0.007		
Do not wear shoes or/sandal outside the house [d] *	2.43 (1.87-6.80)	0.038		
Eat with hand without prior washing	**			
Close contact with dogs and cats [d] *	4.23 (1.57-11.42)	<0.001	2.10 (1.14-1.73)	<0.001
Indiscriminate garbage disposal	1.11 (0.32-3.88)	0.869		

[a] Odds ratios of the potential factors for STH infections with corresponding 95% confidence intervals (95% CI) and p values resulting from logistic univariate and multivariate stepwise regression.

[b] Reference groups: female; adults (> 13 years); parent's educational attainment (at least primary school); working parents; high household income (>RM 500 per month); treated/government water supply; presence of toilet at home; proper latrine system; wear shoes/sandal; wash hand properly before eating; absence/no contact with dogs or cats; proper garbage collection.

[c] OR adjusted for age group; educational attainment; occupational status; household income; defecation sites; wear shoes/sandal; presence/close contact with dogs or cats.

[d] Significant associated risk factors in the univariate analysis.

* Variables were included in the logistic multivariate analysis.

** No statistics are computed because variable is a constant (i.e., all the surveyed participants were using untreated water supply and eating with hand without washing).

OR = odd ratio; CI = confidence interval; significant association ($p<0.05$).

3.4 DISCUSSION

In the present study, we have been able to provide the comprehensive analysis of the soil-transmitted helminth (STH) infections and their associated factors among various subgroups of Orang Asli living in rural and remote areas of Peninsular Malaysia taking into consideration the diversity in their habitat, cultural, socioeconomic and sanitary behavior. As illustrated in this study, soil-transmitted helmithiasis are still highly prevalent and continuous to be major public health problems in this socially and economically deprived communities. The results of the present study reported that STH infections are still endemic with 59.9% of the survey participants infected with at least one STH species. The high prevalence of STH infections as reported here were consistent with previous studies conducted among Orang Asli communities wherein merely more than 90% of studies conducted in the past had reported that prevalence rates were more than 50% (Nevin, 1938; Polunin, 1953; Sandodsham, 1953; Bisseru & Abdul Aziz, 1970; Dunn, 1972; Dissanaike et al, 1977; Bundy et al, 1988; Che Ghani & Oothuman, 1991; Rajeswari et al, 1994; Karim et al, 1995; Mohd Sham, 1996; Rahmah et al, 1997; Ghani et al, 2002; Hakim et al, 2007; Ahmed et al, 2011). Moreover, recent study conducted by Nasr and co-workers (2013) among Orang Asli communities also reported similar findings with prevalence rates of 78.0%. In fact, few studies that were conducted in recent years still reported high infection rates, i.e., ranging from 90% and up to 100% (Norhayati et al, 1997; Al-Mekhlafi et al, 2005; 2007).

Issues such as poverty, education and health are the national issues closely related to the Orang Asli communities. In response to such issues, the Malaysian Government through the Department of Orang Asli Development (*Jabatan Kemajuan Orang Asli*, (*JAKOA*) has been consistently proactive in ensuring that the Orang Asli

communities become involved in the mainstream of the national development process by upgrading their quality of life through various comprehensive programs including land development, economic, social, provision of basic infrastructure and educational as well as human capital development. Over the years, numerous socioeconomic development programs have been carried out for the Orang Asli communities in order to alleviate the poverty level in these communities. For instance, throughout the year 2011, the government has allocated a total of 100 million Malaysian Ringgit for the implementation of several development programs focusing on the socio-economic, education, health and medical aspects (Anon, 2011).

The government also realizes that another problem hindering the progress of the Orang Asli communities is that their villages are generally scattered in the jungle with poor accessibility (Nicholas, 2000). The government's solution to these problems has been to resettle them in small agricultural schemes under Resettlement Scheme *(Rancangan Penepatan Semula)* by resettling the small villagers from the jungle into larger resettlement area at jungle fringes with the basic facilities such as health clinic, main road and boarding school (Nicholas, 2000). Unfortunately, such programs have not been successful in reducing the STH infections in these communities. Factors such as poor planning and implementation of these programmes have been cited as the main reasons for failure of this program among the Orang Asli (Mohd Tap, 1990). In addition, these programmes have poor follow-up support. There has been very little significant adjustment made to adapt the national development policies to the current needs of the respective Orang Asli subgroups (Mohd Tap, 1990; Nicholas, 2000).

To date, many of these promised infrastructural developments, such as clean water supplies, electricity, rubber plantation smallholdings and houses remain to be delivered or even when delivered, it takes several years to be delivered and often

insufficient for all members of the community due to the highly centralised planning system of *JAKOA*. In addition, there have been some evidences that distribution of amenities were disproportionate (Nicholas, 2000). For instance, amongst the three resettlement villages participated in this study, it was observed that only RPS Sungai Layau benefited the most from such the promised infrastructure. In contrast, other resettlement villages such as RPS Pos Iskandar and RPS Bukit Serok did not obtain similar privileges compared to RPS Sungai Layau. One of the clear examples was observed in the RPS Pos Iskandar where houses wooden stilt houses are poorly and traditionally constructed with walls made of tree bark, bamboo or wooden floor along with no proper basic infrastructures.

Those who live in small traditional villages such as Gurney, Sungai Bumbun, Kemensah, Kuala Pangsun and Sungai Miak were also provided with the basic facilities however, these basic facilities were unevenly distributed. For instance, some family in Gurney village have concrete houses constructed by government while others still live in traditional structures of bamboo, wood, brick or a mixture of both materials. Similarly, not all houses were provided with treated water supply, electricity and toilet facility. Thus, with such inconsistent delivering system of the socioeconomic development programs, it was not surprising that STH infections are still highly prevalent (i.e., more than 50%) among various Orang Asli subgroups with the exception of Orang Kuala subgroup in RPS Sungai Layau as reported in the present study. It was evident that Orang Kuala in RPS Sungai Layau who generally were well developed and led better quality of life had significantly least rate of STH infections compared to their other counterparts. Essentially, finding of the current study emphasized that with proper provision of basic amenities to each member of the Orang Asli communities along with knowledge and good practice on how to use of these amenities properly, the national

goal of reducing poverty-associated diseases such as STH infections can be achieved and reduced to significant levels.

Of the three STH species, *Trichuris trichiura* infection was most predominant, followed by *Ascaris lumbricoides* infection and hookworm infection had the least. The findings of *T. trichiura* infection being the most common among the three STH species while hookworm infection had the least have also been reported in other previous local studies conducted among Orang Asli in Peninsular Malaysia (Bisseru & Abdul Aziz, 1970; Dissanaike et al, 1977; Bundy et al, 1988; Che Ghani & Oothuman, 1991; Rajeswari et al, 1994; Karim et al, 1995; Norhayati et al, 1997; Ghani et al, 2002; Al-Mekhlafi et al, 2005; 2007; Hakim et al, 2007; Ahmed et al, 2011; Nasr et al, 2013). As summarized by Lim et al (2009), previous studies among other communities in Malaysia also observed similar outcomes with high prevalence of *T. trichiura* infection compared to *A. lumbricoides* and hookworm infection. It was also noted that *T. trichiura* infection frequently reported either as a single infection or mixed with *A. lumbricoides* species. Thus, the current findings was not only show that the prevalence of STH remains high but the distribution pattern of STH also remains unchanged among the Orang Asli communities. However, our finding was contrary to a recent community study in STH endemic areas in four provinces in northern Laos which reported that hookworm was the most prevalent species, followed by *T. trichiura* and *A. lumbricoides* (Conlan et al, 2012).

As both species have similar mode of transmission which is through the ingestion of infective egg, this could be a reason for the high prevalence of these two species. Moreover, the biological make-up of *T. trichiura* could also be a reason for the high prevalence of *T. trichiura* infection. The attenuated anterior end of adult is embedded in epithelial tunnels while the larger posterior end extrudes into the lumen

(Drake et al, 1994), therefore difficult to expelled by single dose of anthelminthic drug and may required multiple dosages for removal or killing of the worm (Kamath, 1973). Another important problem encountered in treatment management is the low efficacy or choice of anthelminthic drugs against this worm as reported previously (Bennett & Guyatt, 2000; Albonico et al, 2003). Currently, the recommended anthelminthic drug is benzimidazole family including albendazole and mebendazole. Although both drugs are considered broad spectrum anthelminthic agents, important therapeutic differences do exist which affect their uses in clinical practice (Albonico et al, 2002; Adams et al, 2004). For instance, single dose of both drugs have been proven to be effective against *A. lumbricoides* infections. Contrary, only albendazole is more effective against hookworm infection while single dose of mebendazole have been reported to have low cure rate (Albonico et al, 2002). Likewise, single doses of both drugs are not effective in many cases of in *T. trichiura* infection (Adams et al, 2004). Thus, combination of more than one drug with different modes of action as an alternative therapy to improve drug efficacy is highly recommended. For instance, study has proved that combination of levamisole with mebendazole or pyrantel with oxantel are more effective against STH infections than any single drug (Albonico et al, 2003).

However, the use of combinational drug as therapeutic agents against STH infection is most unlikely in these communities. From personal communication with local nurses during each visit to the rural clinic in the Orang Asli villages, only either albendazole or mebendazole and not both drugs are available at any one time. In 2011, the Department of Orang Asli Development launched a deworming program among Orang Asli communities. Although this is proactive initiatives in term of reducing the STH infections among these communities, only single dose of albendazole were used as a treatment regime in this program (Anon, 2011). The Orang Asli is exposed to single

drug for long periods which will eventually cause the ineffectiveness of treatment and indirectly generating drug resistance (Chan et al, 1992). Drug resistance against *T. trichiura* has been proven in previous local studies (Rajeswari et al, 1994; Norhayati et al, 1998).

This condition was further aggravated by the common practice of unscheduled deworming time or poor monitoring system of the treatment itself among Orang Asli communities. Based on our conversation with the villagers, it was found that some of the Orang Asli children may have received anthelminthic drug from local health authorities during their visits to the rural clinic or nearby health clinic upon request for the drug by their parents. Some parents may have also purchased the anthelminthic drug for their children from private pharmacy without following the recommended treatment intervals. The high re-infection rates particularly in highly endemic areas are one of the crucial elements to consider in formulating effective control programs for treatment management (Albonico et al, 1995). Local studies among Orang Asli have reported that re-infection can occur as early as 2 months after treatment while, nearly half of the treated population had been re-infected after 4 months post-treatment (Norhayati et al, 1998). Previous local study also reported that after 6 months of treatment, the intensity of STH infections returned to its pre-treatment levels (Al-Mekhlafi et al, 2008). Thus, the relevant authorities need to recognize that providing treatment alone will not solve the problem. Re-infection rates will continue to remain high unless the source of contamination as well as the high level of environmental contamination are tackled and eradicated simultaneously.

As illustrated in the present study, the prevalence of STH infections was significantly higher among the school-age children (i.e., ages of 5 to 12 years old) compared to other cohorts. This showed that our finding was in agreement with the

global distribution of STH infections which indicated age dependency relationship (Chan et al, 1994b). The prevalence of STH infections increase rapidly and reached peaks during childhood (Chan et al, 1994b; Gilles, 1996; Crompton, 2000). In addition, the present findings also showed that Orang Asli children have been infected with STH species as early as infant with the youngest age of infant harboring STH infections being 6 months. The high prevalence of STH infections among children might be due to several factors which directly related to the particular age group. For instance, infants and toddlers are more likely to get infections from the unhygienic habits such as putting contaminated hands into their mouth or drinking contamination milk due to unclean preparation. As for school-age children aged 5 to 12 years, infections maybe acquired within the vicinity of their home. They are more independent, active, curious or interested in learning new things and at the same time not fully aware of their personal hygiene and cleanliness practice and realize the importance of exposing themselves to pathogenic organisms. From our personal observation during each visit, playing or moving around without any footwear were universal practices among the children including adults, thus increasing the risks to get infections particularly hookworm infection. The lack of parental supervision and some degree of negligence in personal hygiene and cleanliness also make them more exposed to infection.

The present study has also collected an extensive set of data on the demographic, socioeconomic environmental and sanitary behavior of the five Orang Asli subgroups. Generally, the socio-economic, environmental and sanitary behavior appears to be similar in each subgroup with the exception of Orang Kuala subgroup in RPS Sungai Layau. The present study identified that associated key factors which closely related with poverty, poor environmental and sanitary behavior and impoverished health services were recognized and remain unchanged as an important

determinate contributing factors of STH infections among these communities. This findings were in accordance with previous local studies carried out among these communities highlighted that there is a web of risk factors associated with the high prevalence of STH infections which includes poverty, inadequate sanitation, untreated water supply, low level of parental education, presence and close contact with animals and poor sanitary behavior (Rajeswari et al, 1994; Rahmah et al, 1997; Zulklifli et al, 1999; Al-Mekhlafi et al, 2005; 2007; Ahmed et al, 2011; Nasr et al, 2013).

It was also noted that defecation habits among young children in all surveyed communities, except for Orang Kuala subgroup in RPS Sungai Layau were relatively promiscuous. Children were allowed to defecate indiscriminately close to their houses or at least within the village confines. Although, some parents may also advised and discouraged their children are not to defecating in river, yet this instruction does not prevent the water contamination with fecal material as children usually cleanse themselves in the streams after defecation, thus indirectly contaminate the water while playing in river. As majority of the Orang Asli communities still relies on the streams located adjacent to their village as the major source of water supply for their daily chores such as drinking, bathing and washing, contaminated water could increases the likelihood of STH infections. Thus, it was not surprising that the prevalence of STH infections was significantly higher in persons who using untreated river water supply for their domestic needs. Moreover, using untreated river water supply for their daily chores was identified as a significant predisposing factor for STH infections among Semelai subgroup in RPS Pos Iskandar. Similar findings have also been reported indicating that using untreated river water as significant predictor for acquiring STH infection among Orang Asli communities (Ahmed et al, 2011; Nasr et al, 2013).

The unsupervised or indiscriminate defecation habits of the communities can also lead to the environmental contamination with the fecal materials which eventually become sources of infection to others. The damp soil and lush vegetations makes conditions ideal for the development, survival and transmission of STH infections. The environmental contamination areas with fecal material by indiscriminate defecation practices among Orang Asli communities can be generalized by a series of concentric zone based on the differences in their defecation places as described by Dunn (1972). For example, as the toddler or young children usually defecate near or under the surrounding area of their homes, the contamination of this zone is largely caused by these particular groups. The second zone including their village orchards or cultivated areas are the favored defecation places for adolescents including adults female. For adult especially males, their defecation practices are more secretive and usually defecated at the jungle fridge outside the vicinity area of their homes. Therefore, the environmental contamination zone with human fecal materials occurs according to the age and gender. The contamination is usually prominent at the centre (i.e., around the vicinity of their homes) where young children are concentrated in a relatively small area. However, the degree of contamination becomes lesser than in the central zone in the wider peripheral zones especially in the forest areas including the farming areas or gardens. Individuals particularly adults who defecated these areas usually disperse their fecal, therefore indirectly minimizing the transmission chances of STH parasites that may be expelled with the fecal into new human host. Hence, this could be another possible reason to the high number of infections among children compared to adult populations (Dunn, 1972).

Another key factor that was found to be significantly associated with STH infections was their habit of walking barefooted. It was not surprising that person who

prefers walking barefooted had significantly higher risks of being infected specially with hookworm species as reported in Temuan and Jakun subgroups, a finding that in accordance with other local studies (Nasr et al, 2013). The chances of being infected are even greater as the surrounding areas of their homes may have already been contaminated by indiscriminate defecation habits of young children.

Close contact with domestic animals particularly dogs and cats were confirmed as significant predictors for STH infections in Temuan and Mah Meri subgroups. It was demonstrated that the Orang Asli communities have a very close relationship with their pets especially dogs and cats. Occasionally, these animals were observed sharing food from the same plate with their owners and sleeping on the clothing racks. They defecate outdoors promiscuously and some cats also defecate indoors especially near the fire wood in the kitchen area. This situation is further exacerbated by the type of kitchen flooring which is usually made of mixed soil and sand, providing an ideal condition for the development, survival and transmission of the STH ova. Thus, it was not surprising that close contact with dogs and cats played a significant role in facilitate the STH infections in Orang Asli communities. Comparable findings were also observed in other studies among Orang Asli communities (Ahmed et al, 2011) and others countries including Thailand (Traub et al, 2008; Jiraanankul et al, 2011), Laos (Sato et al, 2010) and India (Traub et al, 2002).

Besides the environmental and sanitary behavior, low household income has been also identified as a significant associated key factor for STH infections in the Orang Asli communities. Our results showed that persons from low household income had significantly increased risk of having STH infections. Moreover, low household income was confirmed as a significant predictor causing STH infection in Temuan subgroup which persons in low family income that earned a cumulative monthly income

less than RM 500 were at higher risk of getting STH infections. It has been reported previously in local studies conducted among Orang Asli that family income plays an important role in STH infections (Rajeswari et al, 1994; Al-Mekhlafi et al, 2005). Basically, higher income means that they able to seek early medical treatment or afford better food and tend to be healthier.

As have been discussed earlier, although their socioeconomic, environmental and sanitary behavior of the Orang Asli communities appears to be similar in all subgroups with the exception of Orang Kuala in RPS Sungai Layau, certain factors particularly interact with their customary behavior or geographical locations may influence the distribution or pattern or STH infections. Some of these factors include population density and land availability around the village. It has been observed that communities living in small and crowded areas with large populations will experience more intense environmental contamination resulting from their indiscriminate and unsupervised defection habits in given period of time compared to small communities who live in more openly dispersed areas. In contrast, the sanitary condition of the villages is less likely to be poor if it is surrounded by forest and plenty land for cultivation. Under such situations, defecation is well dispersed and soil contamination is minimized (Dunn, 1972; Forrester et al, 1988). In the context of the present study, four Temuan subgroup villages provides clear example of this effects. Gurney village and Kuala Pangsun village are both located in lowland jungle fringe, near town and close to Malay and Chinese villages whereas Kemensah village is surrounded by major urban town were more likely to suffer more severe environmental contaminated results of the indiscriminate defecation that cannot be naturally dispersed. This condition was further aggravated by some degree of inevitably concentrated contamination around the vicinity of their homes. In contrast, Sungai Miak village is situated in the secondary hill land

forest and distant from urbanization most probably suffer less environmental contamination due to ample space to for defecation. Thus, differences in the prevalence of STH infections in these four villages cannot be described simply to differences in their socioeconomic and sanitary behavior alone but certain factors such as population density and land availability may also contribute to this difference. This may possibly explain the low prevalence of STH infections in Sungai Miak (10.0%) compared to the other three Temuan villages in which overall prevalence were ranging from 75.9 to 84.4%. This finding was consistent with a study conducted by Dunn which reported that high prevalence of STH infections were recorded in Orang Asli subgroups where their villages are located near a town, highway, Malay village and barren tin-mining wasteland (Dunn, 1972).

Associated changes in temperature and humidity due to altitude may affect STH transmission (Brooker & Michael, 2000). In an extensive study carried out by Dunn in1972 among 7 subgroups of Orang Asli in Malaysia living in different forest altitude, demonstrated that the groups that live at higher and cooler elevations have fewer STH infections most probably due to the lower soil temperature may reduce the embryonation rate of eggs (Dunn, 1972). In contrast, groups that live in warmer lowland forest acquired STH more rapidly as the soil conditions are more favorable to embryonation of eggs (Dunn, 1972). However, it is difficult to assess and conclude this effect in this study as none of the surveyed villages are located at high altitude. Only Temuan subgroup in Sungai Miak village is located in secondary hill land area at altitudes of approximately 390 meter above sea level. However, it cannot be concluded that residents in Sungai Miak may suffer less from STH infections as they live in cooler and higher elevation than the other villagers. Moreover, it has been reported that *T. trichiura* and *A. lumbricoides* infections do not occur in areas where land surface

temperature (LST) more than 37 ^{o}C (Brooker et al, 2002a, 2002b; 2009, Pullan et al, 2011). However, survey in South Africa found that *A. lumbricoides* infection still can occurred at altitude up to 1700 meter above sea level (Appleton & Gouws, 1996). Thus, the application of advanced tools such as of Geographical Information System (GIS) coupled with Remote Sensing (RS) data (i.e., satellite sensor data) may lead to a better understanding of the STH ecology and their epidemiology (Brooker & Micheal, 2000). Such approach has been widely used to collate and map the geographical distribution of STH infections from any available data and relate it to the factors that may influence their distribution including elevation, vegetation and temperature (Brooker & Micheal, 2000; Hay, 2000).

3.5 CONCLUSIONS

The present study provided a comprehensive and details analyses of the soil-transmitted helminth (STH) infections among various subgroups of Orang Asli taking into consideration they diversity in habitats, cultural, socioeconomic and sanitary behavior. Overall, 634 Orang Asli representing five subgroups (i.e., Temuan, Semelai, Jakun, Mah Meri and Orang Kuala) from eight villages were involved in this study. With regards to gender, 276 (43.5%) and (358) 56.5% were male and female, respectively. They consisted of 392 (61.8%) children and 242 (38.2%) adults with age ranging from 1 to 83 years (median = 11 years).

The following conclusions are a synopsis of the analysis undertaken through this study in which they were discussed:

1. With the exemption of Orang Kuala subgroup, the socioeconomic, environmental and sanitary behavior of the Orang Asli communities was generally poor and appears to be similar in all subgroups.

2. The overall prevalence of STH infections across all subgroups was 59.9 % (95% CI = 56.1-63.7%). *Trichuris trichiura* infection (54.3%; 95% CI = 50.4-58.2%) as the most common helminthic infection followed by *Ascaris lumbricoides* (26.7%; 95% CI = 23.3-30.1%) and hookworm (9.1%; 95% CI = 6.9-11.3%) infections.

3. Single infection with one species (31.9%; 95% CI = 28.3-35.5%) was the most predominant followed by double infections (23.5%; 95% CI = 20.2-26.8%) whilst triple infections with all the three STH species (2.8%; 95% CI = 1.5-4.1%) had the least.

4. There was a significant difference in prevalence of STH infections between the villages. Gurney village (Temuan subgroup) had the highest prevalence of STH infections (84.4%; 95% CI = 78.4-90.4%) whilst RPS Sungai Layau (Orang Kuala subgroup) had the lowest prevalence rates (4.5%; 95% CI = -0.2-8.8%).

5. There was a significant difference in prevalence of STH between the subgroups. The highest prevalence of STH infections was recorded among Mah Meri subgroup in Sungai Bumbun village (75.9%; 95 CI% = 64.5-87.3%). The lowest prevalence was reported in Orang Kuala subgroup in RPS Sungai Layau (4.5%; 95 CI% = 0.2-8.8%).

6. The prevalence of STH infections was significantly higher among the school-age children, i.e., ages of 5 to 12 years old compared to other age groups.

7. The prevalence of STH infections were significantly higher among persons from family with low household income that earned cumulative monthly income less than RM 500, using untreated water supply for their domestic needs, household with no toilet facilities, defecated openly or indiscriminately, walking barefooted, eating with hand without prior washing properly and close contact with domestic animals particularly dogs and cats.

8. With the exemption of Orang Kuala subgroup in RPS Sungai Layau, factors such as low parental educational attainment, jobless parents, low household income, lack of toilet facility, defecated openly or indiscriminately, walking barefooted, eating with hand without prior washing and close contact with domestic animals (i.e., dogs and cats) were identified as significant associated key factors for STH infections among Orang Asli communities.

9. In Temuan subgroup, associated key factors such as low household income, open or indiscriminate defecation, walking barefooted outside the house, eating with hand without prior washing properly and close contact with domestic animals (i.e., dogs and cats) were significantly associated with STH infections. The final multiple logistic regression analysis confirmed that low family income, study participants with no toilet facility available at home and persons who walked barefooted had significantly higher odds of having STH infections.

10. In Semelai subgroup, associated key factors such as children less that 12 years old, those with no formal education, low household income and eating with hand without prior washing properly were significantly associated with STH infections. The final multiple logistic regression analysis found that children and using untreated water supply for their daily chores had significantly higher odds more likely to suffer from STH infections.

11. In Jakun subgroup, being children aged less than 12 years, persons who do not wear shoes or sandal outside the house and close contact with domestic animals (i.e., dogs and cats) were significantly associated with STH infections. The final multiple logistic regression model indicated that residents who walking barefooted when outside the house had significantly increased odds for having STH infections.

12. In Orang Kuala subgroup, none of the potential risk factors were significantly associated with STH infections in these communities, thus reflecting of their better quality of life compared to other subgroups.

13. In Mah Meri subgroup, children less than 12 years old, non working parents, persons from family with low household income, defecated in the open and indiscriminate places, walking barefooted when outside the house and close contact with domestic animals (i.e., dogs and cats) were identified as significant associated key factors for STH infections. The final multiple logistic regression model showed that non working parents and close contact with domestic animals had significantly higher odds of having STH infections.