CHAPTER 9

GENERAL CONCLUSIONS AND RECOMMENDATIONS

9.1 GENERAL CONCLUSIONS

The main objectives of this thesis include the development of a novel diagnostic technique and the creation of a geospatial database for soil-transmitted helminthiasis in Malaysia. Findings of the present thesis have been reported in **Chapters 3 to 7**. Here, we only highlight the findings of our above two main objectives.

Novel diagnostic technique for soil-transmitted helminthiasis (i.e., hookworm)

1. The five hookworm species (i.e., *Necator americanus*, *Ancylostoma duodenale*, *Ancylostoma ceylanicum*, *Ancylostoma caninum* and *Ancylostoma braziliense*) can be easily distinguished from one another based on their unique and distinct melting characteristic HRM curves.

2. Each species has their own curve profiles and characterized by different melting temperature (T_m) peaks (i.e., *N. americanus*: 79.24 ± 0.05°C and 83.00 ± 0.04°C; *A. duodenale* 79.12 ± 0.10°C; *A. ceylanicum*: 79.40 ± 0.10°C; *A. caninum*: 79.63 ± 0.05°C; *A. braziliense*: 79.70 ± 0.14°C).

3. Speciation at genus level was straightforward as demonstrated by the presence of double-peaks for *N. americanus* but only single peak for *Ancylostoma* spp.

4. The present real-time PCR- HRM assay (100%) had higher sensitivity compared to conventional semi-nested PCR (84.1%). However both techniques gave similar sensitivity (100%).

5. *N. americanus* (52/58; 89.6%) was the most common hookworm species found in human fecal samples, followed by *A. ceylanicum* (11/58; 19.0%). No *A. duodenale* infection was detected in this study. Of this, 81.0% (47/58) and 10.3% (6/58) of humans had single infections with *N. americanus* and *A. ceylanicum*, respectively and 8.6% (5/58) had mixed infections with both species.

Geospatial database for soil-transmitted helminthiasis

6. The observed prevalence maps of *Trichuris trichiura, Ascaris lumbricoides*, hookworm and estimated combined STH prevalence vary considerably with no clear pattern across the surveyed locations.

7. The observed mean prevalence of STH infections also varies considerably over time for each of the species.

8. The logistic regression analysis shown that Land Surface Temperature (LST) (i.e., maximum and mean) and Normalized Difference Vegetation Index (NDVI) (i.e., minimum and mean) were significantly associated with the observed distribution of *A. lumbricoides*. These two variables were then used to develop predictive risk map of *A. lumbricoides*.

9. The odds of *A. lumbricoides* was significantly negatively associated with maximum LST (OR = 0.88; 95% CI = 0.78-0.99) and minimum NDVI (OR = 0.78; 95% CI = 0.96-0.98).

10. As for *T. trichiura*, hookworm and estimated combined STH prevalence, no model could be developed since no statistically significant explanatory variables were recorded.

11. The model accuracy (67.7%) to correctly predict areas with and without infections was generally good and reliable. It also well-fitted to the data at an acceptable level as assessed by Hosmer and Lemeshow Goodness-of-Fit test (X^2 = 6.268; df = 8; p = 0.508).

12. *Moran' I* test shown that distribution of *A. lumbricoides* was spatially clustered at certain areas or locations (*Moran's I* index = 0.04; z-score = 6.98; p <0.01).

13. The predictive risk map of *A. lumbricoides* showed that prevalence is high in central and northern plains of Peninsular Malaysia but low along the west coast and southern part of Peninsular Malaysia.

14. The continuous probability contour map showed areas with probabilities of more than 70% (i.e., areas within red color range) that mass drug administration (MDA) threshold of 50% will be exceeded. Areas within green color range (i.e., indicating probabilities of at least 30%) are those areas whereby low probability of 50% MDA threshold is exceeded. The maps also indicated areas of high

uncertainty (i.e., areas within yellow color range) with probabilities between 30% and 70% in which further surveys would be helpful or continued surveillance program are recommended.

15. On the basis of our prediction model for *A. lumbricoides*, it is estimated that there may be up to 3.5 million individuals of the total populations are infected with *A. lumbricoides*. Of these, 728,360 are school-aged children.

16. Using the national estimates of the proportion of school-aged children and based on WHO intervention threshold, it is estimated that 587,482 school-aged children in 75 out of 81 districts (or corresponds to 359 out of 842 sub-districts) in the country would be targeted with mass treatment with MDA intervention at least once yearly.

9.2 RECOMMENDATIONS

The following are the recommendations to be made to the public health authorities or relevant agencies for the formulation and implementation of sustainable and effective control programs of soil-transmitted helminthiasis in Malaysia. For this to be successfully implemented, a smart partnership should be built between several government agencies such as the Ministry of Health, Ministry of Education, Ministry of Rural and Regional Development particularly through the Department of Orang Asli Development (*Jabatan Kemanjuan Orang Asli, JAKOA*).

1. The key recommendation from this study is that the government through Ministry of Health should re-initiate the implementation of mass drug administration (MDA) program particularly among school-aged children in high risk areas since it was discontinued in 1983 (Anon, 1985). Additionally, it also should include other vulnerable groups such as pre-school children and women of childbearing especially among socially disadvantages communities. This is particularly relevant as STH infections are still afflicting and causing significant public health impact among the marginalized Orang Asli as reported in the present study. This finding illustrated that there is a need for the periodic deworming program to be extended with a systematic evaluation process among the Orang Asli communities.

2. The deworming program can be carried out by both public and private sectors. In public sector, the Ministry of Health can be involved in supervising the activities while Ministry of Education assists in the implementation of activity for intervention program particularly through teachers. Participation of private sectors in such approach has been demonstrated to be successful in many low income countries (Brooker et al, 2006). Therefore it is suggested that the private sector, especially the multinational companies should participate and contribute by sponsoring or donating drugs for treatment through the Ministry of Health and Ministry of Education.

3. The MDA program can also be delivered and included through the network of rural clinics which have already been established by the Ministry of Health and at the same time minimizing costs of the program. Likewise, the deworming

program can be incorporated into the many other child health services routinely done at clinics, such as immunizations and growth monitoring programs. Such programs will be of value added services and will promote the mother to bring their children to the clinic, which can then be redirected to include other interventions such as family planning for mothers.

4. As for the school-based deworming program, one way that effective control program could be achieved is by adopting and implementing the program based on the "Focus Resources on Effective School Health" (FRESH) framework (Anon 2000). The FRESH framework was established to provide a consensus approach of good practice for the efficient and successful implementation of health and nutrition services within school health program (Anon 2000). Amongst the early international partners together with WHO were United Nations Educational, Scientific and Cultural Organization (UNESCO), United Nations Children's Fund (UNICEF), World Food Program (WFP), World Bank and Partnership for Child Development (PCD). The framework recommended and suggested four core components that have to be considered in designing a cost-effective school health and nutrition program at school level. Such approach indirectly provides the appropriate mix interventions that can be adopted for STH control program targeting school-aged children. Among of the four components are:

    i. Policy: health and nutrition-related school policies that promote the nutrition and health staff and children. By adopting similar approach,

such policy will promote the role of teachers in delivering anthelminthic treatment.

ii. School environment: access to safe water and provision of efficient sanitation services, which reduces the risk of getting infection by breaking the transmission cycle.

iii. Education: skill-based education including life skills that deal with health, behaviors and personal hygiene such as promotion of positive and hygienic attitudes (e.g., hand washing) that will help to protect against STH infections.

iv. Services: simple, safe and common health and nutrition services such as deworming program that can be delivered cost-effectively in school.

5. The challenges of low self-esteem and over-dependence on government assistance must also be addressed in the Orang Asli communities. One way that this could be achieved is by adopting and implementing the WHO Healthy Villages Initiatives (WHO-HVI) where community's participation is necessary for identifying 'local solutions to local problems' (Howard et al, 2002). The WHO-HVI consists of program that foster a holistic approach to health management through promotion of personal, domestic and community hygiene, provision of health care and environment management (Howard et al, 2002). Some of these initiatives are already in place, but by adopting the WHO-HVI concepts, whereby local communities take a lead in ensuring the success of these

programs. Such program eventually will empower the Orang Asli to take responsibility of their own health, wellbeing, building their self confidence and becoming less dependent on government assistance at the same time realizing that they can make a difference to their own lives. This initiative can be targeted at both local community volunteers and health workers such as by utilizing first-line Orang Asli as health workers which can support not only in the technical matters but also understand their cultural needs. For example in the deworming program, it can be carried out by increasing the involvement of the Orang Asli as part of the health workers at the same time providing them training related to this work. This set of initiatives indirectly act as a platform for the Orang Asli to be empowered and their interaction and communication skills with the relevant authorities through 'local solution for local problems' can be further improved. By adapting these initiatives in which 'model' villages can be identified, their successes can be adopted to other villagers and communities. In this manner, the Orang Asli communities become empowered to take charge of its own issues and not to remain dependent on government efforts alone.

6. For long term benefit, a more comprehensive and integrated approach is required which includes measures dealing with poverty, health care, education and food production. A smart partnership should be built between the Ministry of Health, local governments and non-governmental agencies to mobilize and empower the Orang Asli communities to seek a better quality of life for themselves and their children. Any attempt to reduce STH infections amongst these communities should take an integrated approach especially through education, better provision of basic facilities and support from the government through its related

agencies or ministries particularly the *JAKOA*. With effective control measures in place, the Orang Asli communities especially their young generation will have a greater opportunity for a better future in terms of health, educational attainment and eventually will be at par socially and economically with other communities in Malaysia.