



Milestones of networking and global engagements for the Regional Network on Asian Schistosomiasis and other Helminthic Zoonoses (RNAS⁺)

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Abstract

This paper introduces the three stages of development of the Regional Network on Asian Schistosomiasis and other Helminthic Zoonoses (RNAS⁺), namely the preparatory stage, the strengthening stage and the expanding stage. Significant achievements have been made through the help of RNAS⁺, particularly on research on helminthiasis. As scientists, researchers, academics work closer with control authorities, elimination of these diseases is slowly getting nearer and within reach. RNAS⁺, at present can boast of the following strengths: (i) strong collaboration in the regional research area with support from experts on research and control; (ii) presence of experts in various areas who can improve and promote both research and control; (iii) RNAS⁺ has been successful in translating research output to field application; (iv) setting up a platform that is capable of advancing the mechanisms of sharing information through its website, databases, publications and meetings; (v) RNAS⁺ has proved that it is capable of undertaking joint collaborative projects on operational research through multi-country, multi-disease using multi-disciplinary approach and involving different academic and research institutions in the region. Most importantly, experts who are members of RNAS⁺ are also linked with control programmes of the endemic member countries in the region.



1. Introduction

The history of the Regional Network on Asian Schistosomiasis (RNAS) can be traced back to 1996 during an international meeting in Nanjing, PR China. Since then, significant achievements on research and control of helminths have been made that inspired developing countries to aspire beyond control and prevention of schistosomiasis which is elimination. The development of RNAS and RNAS⁺ has attracted much attention in the international community as the network transitioned through the following three development stages and emerging as the longest surviving network of this nature.



2. The preparatory stage

The Regional Network on Asian Schistosomiasis (RNAS) originated out of a discussion at an international workshop held in Nanjing, PR China in 1996. This meeting, ‘Research, Surveillance and Control of Asian Schistosomiasis’ was supported by the UNICEF/UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR). Two years later, on September 8–10, 1998, 70 scientists and representatives from control authorities from the People’s Republic of

China (PR China), the Philippines and other countries gathered in the Chinese city of Wuxi to plan for a network based on intersectoral, inter-regional and international collaboration for research, surveillance and control of schistosomiasis japonica. The proceedings produced after this meeting published by McGarvey et al. (1999) marked the informal beginning of the Regional Network on Asian Schistosomiasis (RNAS) that was formally established in the year 2000 as an initiative to bring together all possible stakeholders in a bid to step up the fight against schistosomiasis japonica.



3. The first years of the network

The first meeting of the newly founded network was held on February 18–19, 2000 in Tagaytay City, the Philippines and attended by 28 participants from Australia, China, Denmark, Japan, Switzerland and the Philippines. The meeting formally organized the overall plan to control schistosomiasis japonica in all endemic areas in Southeast Asia (Zhou et al., 2002). A total of 15 papers covering progress on research and control of Asian schistosomiasis were presented and a round table discussion was conducted to draw up the next 2-year plan of work of the new organization. One and a half years later, on the first 2 days of July 2001, the network returned to Wuxi, PR China for its second official meeting which drew 38 participants representing government health agencies, research institutes on human and animal parasites and the academe from Australia, China, Denmark, Japan, Philippines and USA and for the first time, also from Indonesia. Representatives from TDR and the Western Pacific Regional Office (WPRO) of the World Health Organization (WHO) were also present. Reports presented included updates on diagnostic techniques, immunological studies. For the first time, a major session was devoted to the use of geographical information systems (GIS) for monitoring transmission and various issues related to control of schistosomiasis.

Two additional meetings, 3–4 (Table 1) followed, the first in Cambodia and the next in Lao PDR. The third meeting attracted 73 participants representing 12 countries and international organizations. Participants gathered in historic Phnom Penh for the latest updates given by scientists from Australia, China, Denmark, Germany, Indonesia, Japan, Laos, Sweden, the Philippines and USA. The network chair, Dr. Feng Zheng of the National Institute of Parasitic Diseases (NIPD) in Shanghai, PR China, made a strong call to consider capability strengthening aspects as part of the activities and thus create a strengthened RNAS, tentatively called SRNAS.

Table 1 Overview of meeting activities within the RNAS/RNAS⁺ framework.

Meeting place	No.	Time	Focus of training course	Outcome
Nanjing, PR. China	–	1996		Conclusion to initiate network
Wuxi, PR. China	–	September 8–10, 1998		Preparatory discussions
Tagaytay City, Philippines	1	February 18–19, 2000		Formal organization of the ‘Regional Network on Asian Schistosomiasis’ (RNAS)
Wuxi, PR. China	2	July 1–2, 2001		
Phnom Penh, Cambodia	3			Inclusion of Cambodia as RNAS member approved
Vientiane, Lao PDR	4	November 25–27, 2003		Inclusion of Lao PDR as RNAS member approved. TDR beginning to fund research specific network projects
Bali, Indonesia	5	August 8–10, 2005	Research Ethics	Expansion into other diseases (cysticercosis, clonorchiasis, opisthorchiasis, paragonimiasis and fascioliasis) and countries (Vietnam, Thailand, South Korea and Japan) changing into ‘Regional Network on Asian Schistosomiasis and other Helminthic Zoonoses’ (RNAS ⁺)

Muntinlupa, Philippines	6	September 11–15, 2006	GIS in epidemiology and surveillance of parasitic diseases conducted in Bohol in central Philippines.	
Lijiang, PR China	7	September 5–6, 2007	Burden Assessment of Important Helminth Zoonoses	RNAS ⁺ registered as a non-government, non-profit organization with the Philippine Securities and Exchange Commission effective August 31, 2017.
Jeju, South Korea	8	October 1–2, 2008		Meeting together with the scientific sessions on schistosomiasis at the 17th meeting of ICTMM
Vientiane, Lao PDR	9	October 19–20, 2009		RNAS ⁺ vision marked as fully compatible with WPRO's research strategic plan
Wuxi, PR China	10	November 16–19, 2010	Climate change and dynamic transmission modelling	Regional Research Plan of Action for Infectious Diseases of Poverty presented
Siem Reap, Cambodia	11	October 17–19, 2011	Social Marketing	Inclusion of Vietnam as RNAS ⁺ member approved
Hanoi, Vietnam	12	November 8–9, 2012	Serology and Molecular Techniques in Diagnosis of Parasitic Infections and Their Vectors	Focus on NTDs; opening of Facebook account
Khon Kaen, Thailand	13	October 24–26, 2013	Geospatial techniques for Public Health	Inclusion of Myanmar as RNAS ⁺ member approved

Continued

Table 1 Overview of meeting activities within the RNAS/RNAS⁺ framework.—cont'd

Meeting place	No.	Time	Focus of training course	Outcome
Bogor, Indonesia	14	October 13–14, 2014	Conventional and Molecular Techniques for Helminthiasis Diagnosis	Preliminary report on suspected schistosomiasis in Myanmar presented
Philippines	15	July 23–24, 2015	Use of LAMP and Miracidial Hatching as Diagnostic Tools in Schistosomiasis	A donor meeting was held with several presentations
Yangon, Myanmar	16	October 27–28, 2016		Memorandum of understanding signed with African countries to strengthen schistosomiasis research
Vientiane, Lao PDR	17	October 24–25, 2017		
Shanghai, PR China	18	June 25–26, 2018		Inclusion of Malaysia as RNAS ⁺ member approved, meeting together with the 'Fourth Symposium on Surveillance Response Systems for Tropical Diseases Elimination'

The fourth meeting was held in 2003 in Vientiane, Lao PDR on November 25–27, showing the largest number of delegates so far, which also included industry, e.g., Shin Pong, the first producer of praziquantel besides Merck AG in Germany. After the two-day presentation of progress reports, country reports, research results and round table discussions, participants expressed strong support for the continuous exchange of experts among the member countries. Now with an established record of participation in scientific assemblies, the network started addressing problems, such as the urgency to increase awareness about ethical issues, the need to establish guidelines for surveillance and the standardization of a training manual for use in endemic areas. Annual reporting of data from the member countries was also encouraged together with efforts to elucidate the morbidity index for schistosomiasis. Participants also expressed commitment to assist the Ministry or Department of Health of member countries. Discussions of how to absorb training and capability strengthening into the network continued.

These years marked the transition to SRNAS and this stronger RNAS featured stronger communications among members through the creation of an internet homepage that enabled continued exchange of information on diagnosis, surveillance and control of schistosomiasis. As the organization made its way into its fourth year of existence, the benefits of membership had become clear and obvious. Participants agreed that the meetings had indeed become a useful vehicle for in-depth discussion and dissemination of new information. Outcomes of researches and results of new control modalities continued to fan optimism in possibly eliminating schistosomiasis. Multi-country research projects on different aspects of the disease achieved widespread sustainable collaboration among scientists from all the member countries. At this time TDR also began funding research projects from the network.



4. Expansion: Creation of RNAS⁺

The fifth meeting of the network took place in Bali, Indonesia on August 8–10, 2005. This became an occasion for the members to take a long hard look at the 6 years of the existence of their organization. It was attended by 60 participants from the Asian member countries as well as representatives of industry, this time Lonza Ltd., the Swiss provider of Bayluscide, as well as other international partners (Denmark, Sweden and Switzerland) together with representatives from TDR, WHO and WPRO. In addition to the usual presentations and updates in the field of schistosomiasis, the members also reviewed the organization's past progress taking note of achievements

and accomplishments and its impact on the region. The task of confronting the challenges and the problems faced by RNAS was discussed with a view to track the best possible direction for the organization. Encouraged by the knowledge that the network has served as a model for other initiatives like the one contemplated for the same disease in Africa and an impetus for groups working on other helminth diseases, the participants responded to the call for change. The decision was to expand the vision and eventually reconfigure the network to accommodate new diseases and new member countries. Henceforth, the network expanded its target from schistosomiasis to a spectrum of other parasitic diseases such as cysticercosis, clonorchiasis, opisthorchiasis, paragonimiasis and fascioliasis with the corollary task of encouraging other endemic countries, such as Japan, South Korea, Thailand and Vietnam and to become RNAS members.

In its expanded form, the network was renamed Regional Network on Asian Schistosomiasis and other Helminthic Zoonoses (RNAS⁺) with the larger vision of becoming the recognized platform for evidence-based information and intersectoral communication bridging the gap between research scientists and control authorities for the prevention of neglected tropical diseases in Southeast Asia. Its mission is to provide a forum for the exchange and dissemination of information about current researches and developments on prevention and control of Asian schistosomiasis and targeted, neglected tropical parasitic diseases including clonorchiasis, cysticercosis, fascioliasis, opisthorchiasis and paragonimiasis through intersectoral collaboration and communication among scientists and control authorities. As a result, more than 90% of all research institutions and control authorities in the nine member countries working on the RNAS⁺ target diseases are represented in the network.



5. RNAS⁺: Vision, mission, goals and strategies

RNAS⁺ by now has become a force in multidisciplinary research and multisectoral collaboration among professionals, scientists and public health experts. In its first 10 years, the network passed through three stages of development. In the establishment stage, from 1999 to 2001, three regular scientific meetings were held and information sharing and collaboration between the Chinese and Filipino scientists expanded noticeably. There were further suggestions to include other members such as Laos and Cambodia which are endemic for schistosomiasis mekongi and Japan which was endemic for schistosomiasis japonica in the past but able to eliminate the

disease in the 1990s. Indonesia which has three focal endemic schistosomiasis areas in the island of Sulawesi already attended the 2001 meeting in Wuxi. From a technical point of view, the importance of GIS and remote-sensing as a tool to monitor schistosomiasis had already been recognized at this time. In fact, remote-sensing was in fact first used for schistosomiasis in the Philippines (Cross et al., 1984).

From 2002 to 2004, in the second or strengthening stage, communications were further strengthened by the creation of the network's internet homepage enabling continuous exchange of information and data on the diagnosis, surveillance and control of *Schistosoma japonicum*. Research and training standardized methods in surveys of areas endemic for schistosomiasis. Research grants were awarded by TDR for three projects, i.e. application of immunodiagnostic kits, standardization of an ultrasound protocol, and development of survey tools for animal schistosomiasis. These grants encouraged the expansion of the network through participation of four countries endemic for oriental schistosomiasis in surveys of schistosomiasis japonica and mekongi in animals and humans.

The third stage, the phase of expansion, started in 2005 when the network expanded its targeted diseases to other helminth zoonoses such as cysticercosis, clonorchiasis, fascioliasis, opisthorchiasis, and paragonimiasis inviting countries endemic for these additional diseases, such as Japan, South Korea, Thailand and Vietnam. The possible coordination and collaboration with the other networks, such as the Regional Network on Schistosomiasis in Africa (RNSA) were raised in the 2005 meeting in Bali, Indonesia. The RNAS⁺ structure was also formalized especially strengthening the secretariat of the network to facilitate communication. The chair of the network was given a term of 2 years after which the elected vice chair would take over. The need for the network to be registered as an official organization was also raised.



6. Further expansion of RNAS⁺

The now expanded RNAS⁺ met in the Philippines on September 11–15, 2006 which marked the 100th year of discovery of *S. japonicum* in the Philippines. Updates on other helminth zoonoses (cysticercosis, clonorchiasis, fascioliasis, opisthorchiasis and paragonimiasis) in the region were provided for the first time aside from the regular status reports on schistosomiasis from the endemic member countries. The organization also saw the need to formalize the governance of RNAS⁺. Additional objectives such as disease mapping, training and advocacy were added to

the original objectives of the network on research, control and surveillance of schistosomiasis. A training course on the application of GIS in epidemiology and surveillance of parasitic diseases was also conducted in the resort island of Bohol in central Philippines.

The seventh meeting of the network in Lijiang, China in 2007 attracted a total of 150 participants from 19 countries and international organizations. Since the venue was in China, the largest contingent of attendees (51%) were from the PR China. The conference was supported in part by the Chinese Ministry of Health in, TDR, the Danish Bilharziasis Laboratory (DBL) and the Global Network on Geospatial Health (GnosisGIS).

By this year, the network has been successfully registered as a non-governmental and non-profit organization with the Philippine Securities and Exchange Commission effective August 31, 2017. The officers of the network included Dr. Remigio Olveda from the Philippines as president; Dr. Zhou Xiaonong from PR China as vice president; Dr. Lydia Leonardo from the Philippines as secretary and Ms. Marilou Venturina from the Philippines as treasurer. For the first time, a representative from RNSA (Regional Network on Schistosomiasis in Africa) attended the meeting giving a report on the African network.

The eighth meeting of the network was held in Jeju, South Korea and incorporated as scientific sessions on schistosomiasis at the 17th International Congress for Tropical Medicine and Malaria between September 30 and October 2, 2008. Seven scientific sessions were organized by the network in the international congress that included international network for control; current status of vaccine programme; genomics and proteomics; disease burden; epidemiology; new tools for prophylaxis and treatment and clinical epidemiology.

The ninth meeting of RNAS⁺ in Vientiane, Lao PDR on October 19–20, 2009 confirmed how the vision of RNAS⁺ is fully compatible with WPRO's research strategic plan as well as with TDR's global vision. The ninth meeting eventually became a forum to refine and update WPRO's Research Strategic Plan Draft; to identify issues and operational research priorities that address key programmatic gaps in research areas of RNAS⁺'s target diseases; and to reassess the roles of RNAS⁺, define its strategies and future plans in contributing to the development of the NTD research agenda in Asia.

The network celebrated its 10th anniversary on November 16–19, 2010 back in Wuxi at the Jiangsu Institute of Parasitic Diseases (JIPD) where it was first conceptualized in 1998. A representative of RNSA talked about how

the African network has influenced national and regional decision on schistosomiasis research and control. The Regional Research Plan of Action for Infectious Diseases of Poverty was presented by Dr. Jun Nakagawa of Western Pacific Regional Office of the WHO. The importance of networks and south to south collaborations was reiterated by Dr. Glenn Laverach, a leader in health promotion, public health and empowerment who worked for more than 30 years in Europe, Asia, Africa and the Pacific region. A training course on climate change and dynamic transmission modelling was attended by junior scientists.

The inclusion of Vietnam in the board of RNAS⁺ was approved on the 11th meeting of the network October 17–19, 2011 at Siem Reap in Cambodia. The need for social marketing of RNAS⁺ was also noted in the business meeting. The 12th meeting held for the first time in Hanoi, Vietnam was marked by presentation of member countries of diseases other than those targeted by RNAS⁺, particularly neglected tropical diseases such as STH, filariasis, food-borne trematode diseases and others like trichinosis and angiostrongylosis. The network also decided to create a Facebook account for RNAS⁺ in addition to the homepage to augment communication and visibility of the network.

The 13th meeting held for the first time in Thailand on October 24–26, 2013 marked the nomination and acceptance of Myanmar as a member country of RNAS⁺. The plan to participate in the EcoHealth Conference in Montreal, Canada in August 2014 was approved which allowed RNAS⁺ members to present their results on the multi-country, multi-disciplinary IDRC project. The meeting was capped by a visit to Thailand's trans-disciplinary Eco-Health project called the Lawa Model (Sripa et al., 2017). A half-day training on geospatial techniques for public health purposes was also given at this time.

The 14th meeting that took place in Bogor, Indonesia on October 13–14, 2014 was held simultaneously with two other international meetings, namely the fifth Annual Meeting of the Southeast Asian Veterinary Schools Association and the third Scientific Meeting of the Indonesian Veterinary Schools Association. A representative from Myanmar participated for the first time in the meeting giving a preliminary report on suspected schistosomiasis and other NTDs in this country.

At the 15th meeting, held in the Philippines for the third time in 2015, the RNAS⁺ board decided to keep the website in China but set up an additional platform for communication with member countries and other people who could be interested to join the webpage. Dr. Shan Lu, NIPD, PR

China reported that a memorandum of understanding has been made between PR China and eight African countries to initiate South/South collaboration on schistosomiasis. A pilot study on schistosomiasis would be conducted in Tanzania. The board approved the inclusion of Dr. Mario Jiz from the Philippines as replacement of Dr. Luz Acosta who had migrated to Canada. A donors' meeting was also held where several presentations were made.

October 27–28, 2016 saw the 16th meeting of RNAS⁺ for the first time in Myanmar. Replacements for retiring members of the board were approved such as those for Dr. Muth Sinuon in the person of Dr. Virak Khieu from Cambodia and Dr. Khay for Dr. Khin from Myanmar. A memorandum of understanding was signed with African countries to strengthen collaboration and research on schistosomiasis there. A move to organize an e-mail group was proposed for the purpose of sustaining discussion even beyond the regular annual meeting of the network. Issues, such as surveillance, criteria for elimination and the different phases of control, problems with mass drug administration (MDA) need for more sensitive diagnostics, development of new control strategies and challenges presently faced by member countries were addressed.

The 17th meeting of the network was held for the third time in Lao PDR in Vientiane October 24–25, 2017. The assumption of Dr. Somphou Sayasone of the RNAS⁺ presidency was announced. There was an intense discussion on the development of sensitive diagnostic tests especially in the light of the progress achieved by member countries in controlling RNAS⁺ target endemic diseases. Preliminary reports were presented on the results of the consultative meeting to accelerate elimination of Asian schistosomiasis held in May 2017 in Shanghai. The network decided however to await official results of the consultative meeting before developing any framework on schistosomiasis elimination. The same decision was made to base guidelines for cut-off for MDA (20% vs. 10%) on the results of the expert consultation on Food-Borne trematodiasis (FBTs). It was decided to produce a book about RNAS⁺ for the occasion of the 20th anniversary celebration of its founding.

The 18th meeting of RNAS⁺ was held in Shanghai, PR China (the fifth time in PR China) on June 25–26, 2018 embedded as special sessions in the Fourth Symposium on Surveillance Response Systems for Tropical Disease Elimination. Dr. Somphou Sayasone from Lao PDR assumed the presidency of RNAS⁺ for a term of 2 years from 2018 to 2020 and Dr. Virak Khieu from Cambodia was elected vice president. Malaysia was accepted

as the 11th member country of the network with Dr. Vickneshwaran Muthu, senior principal assistant director from Zoonoses Sector, Disease Control Division, Ministry of Health in Malaysia as member of the RNAS⁺ board. The board recognized the significant contribution of Malaysia in the field of NTDs particularly in the development of diagnostic tests for lymphatic filariasis.



7. Research projects: Objectives and outcomes

7.1 Three projects funded by TDR

In 2002, during the second meeting of RNAS in PR China, Dr. Steve Weyling, TDR informed the network that funds, as well as opportunities for research support, were open to member countries as well as individuals. At the third meeting of the network held in Phnom Penh, Cambodia in 2003, three round table discussions were conducted to flesh out the details of three research subprojects to be submitted by the network for funding from WHO TDR. These subprojects were ‘Application and evaluation of the dipstick dye immunoassay kit for community diagnosis of schistosomiasis mekongi in Cambodia and Lao PDR’ coordinated by Dr. Zhu Yinchang, Director of the Jiangsu Institute of Parasitic Diseases of China; ‘Standardization of ultrasound findings in Asian Schistosomiasis’ coordinated by Dr. Remigio Olveda of the Research Institute for Tropical Medicine (RITM), Muntinlupa, the Philippines and ‘Asian Schistosomiasis in animal hosts’ coordinated by Dr. Lin Jiaojiao of the Institute of Animal Husbandry of Shanghai, PR China. Eventually, research grants were awarded by TDR for three projects.: application of immunodiagnostic kits; standardization of the ultrasonography; and development of survey tools for animal schistosomiasis.

The previous year, 2002, Dr. Zhu of JIPD, PR China, had informed the network on the development of this rapid diagnostic tool in their laboratory. The technique which is similar to ELISA uses schistosome egg antigens (SEA) conjugated with a colloidal dye to detect the presence of antibodies against SEA in the serum. The sensitivity of the test ranges from 94.1% to 96.7% and specificity is from 96.7% to 100% (Zhu et al., 2002). This Dipstick Dye Immunoassay (DDIA) takes 5–10 min to complete, is simple to prepare, does not require special equipment and the dye-conjugated antigen is stable at room temperature for 6 months. To evaluate the usefulness of the DDIA kit in the diagnosis of schistosomiasis mekongi, the project was carried out in Lao PDR and Cambodia training nine professionals from the National Center for Parasitology of Cambodia.

In Cambodia, the sensitivity was recorded at 97.1%, correctly diagnosing 33 out of 34 infected people, while in Lao PDR, a sensitivity of 98.6% (69/70) was noted. None of 114 residents living in a non-endemic area in Cambodia tested positive. However, a 18.3% cross-reaction with *Opisthorchis viverrini* was found. The results support the notion that the DDIA using *S. japonicum* SEA antigens can safely be implemented for the diagnosis of schistosomiasis mekongi, but false positive results in areas could appear in areas co-endemic for *O. viverrini* (Zhu et al., 2005).

For the second project, Dr. Christoph Hatz of the Swiss Tropical Institute (TPI) in Basel, Switzerland (now Swiss TPH) and local collaborators presented ultrasound findings of morbidity due to *S. japonicum* and *S. mekongi*. With regards to network findings, there are distinctive signs in *S. japonicum* compared to none for *S. mekongi*. Results were compared to previous efforts to standardize the use of ultrasound in schistosomiasis made in Egypt (Cairo Working Group, 1992) and Niamey, Niger (TDR, 1996). For Asian schistosomiasis, similar discussions had been carried out in meetings in Hunan in 1992, Leyte in 1997, Wuhan in 2000, Yueyang in 2001 and Phnom Penh in 2002. (Leonardo and Bergquist, 2002; Zhou et al., 2002, 2010). Dr. Hatz stressed the need for standardizing the image patterns. For example, according to A (normal); B (questionable); C and D (different degrees of periportal fibrosis); E (strong reticular network of the liver; and E and F (observation of wide meshes indicating serious morbidity). He also presented potential confounders in the assessment of lesions due to *S. japonicum* such as liver cirrhosis, fatty liver, chronic hepatitis, liver tumours and other reasons for portal hypertension. For this project, a workshop was conducted in Hunan, PR China entitled 'Standardization of ultrasonography in schistosomiasis', and a report was drafted and eventually published (Li et al., 2004).

For the project on schistosomiasis in animals, a workshop on diagnostic tests was held at the DBL (Danish Bilharziasis Laboratory) in Denmark in September 2003 attended by 16 participants from eight countries including Cambodia, China, Indonesia, Lao PDR and the Philippines. The purpose of the workshop was to demonstrate, compare and reach consensus about diagnostic tests to be used for surveys, control and surveillance on animal schistosomiasis in Asia (Olveda et al., 2010; Zhou et al., 2008).

7.2 First project funded by the International Development Research Centre in Canada (IDRC)

An ecological intervention to interfere with transmission of schistosomiasis and other helminthic zoonoses became the basis for a 3-year IDRC project

from 2011 to 2014 entitled ‘Innovative Strategies for Sustainable Control of Asian Schistosomiasis and other Helminth Zoonoses through Socio-Ecosystem Based Interventions’. This multi-country and multi-institution project was shared among the NIPD, PR China; the RITM and the University of the Philippines, the Philippines; the National Malaria Center, Cambodia; Khon Kaen University, Thailand; the National Institute of Public Health (NIPH), Lao PDR; the Institute of Ecology and Biological Resources (IEBR), Vietnam; and the Research Institute for Aquaculture, Vietnam. Other collaborators included Swiss TPH, University of Copenhagen and WPRO. Dr. Robert Bergquist, (previously with TDR) was an independent advisor.

The results were expected to be used as basis for developing a classification system for target endemic areas based on environmental and socio-economic factors. The general objective was to develop innovative strategies for the sustainable control of target emerging infectious diseases (EIDs) through socio-ecosystem based interventions. The special objectives were to:

1. elucidate the environmental and socio-economic determinants of transmission patterns of the targeted EIDs;
2. develop a classification system for EID endemic areas based on environmental factors (the physical landscape, land use/land cover, vulnerability to climate change) and socio-economic factors (demography, migration patterns, trading patterns, health behaviour, water and sanitation, poverty and vulnerable populations, e.g., ethnic minorities);
3. define a set of tools for the integrated, sustainable and cost-effective control of Asian schistosomiasis and other important helminth zoonoses which can be readily combined in a modular fashion to meet local conditions; and
4. test the overall and relative effectiveness of individual components in the multi-disease prevention approach of schistosomiasis and other important helminth zoonoses in different environmental and epidemiological settings.

Each study site focused on two or more diseases and each disease was studied in two or more sites. From the baseline survey, a classification system of each study sites was determined. A stakeholder workshop was conducted to design the intervention programme including the monitoring and evaluation tool. The last year of the project was devoted to evaluation of the intervention that included an analysis of cost-effectiveness and sensitivity. Classification into eco-zones into epi-zones was done according to analysis of remotely sensed images and based on the disease-endemic situation.

The place, the dates and the target populations of the intervention packages were identified and the eco-zones showed the ecological differences, while the epi-zones showed the difference in disease spectrum and animal species infected. Within the epi-zones, hotspots were identified from where risk factors, scales and populations were identified with intervention strategies and intervention packages developed. The disease cover is shown in [Table 2](#).

The project was divided into the following phases: baseline survey in 2011; classification based on results of the baseline survey and strategy setting in 2012; intervention in 2013 and evaluation of the effect of the intervention in 2014. The project ran for 3 years and included the following activities: protocol development, training courses (country-level), stakeholder meeting, training courses (field-level), baseline survey, data management and database production, data analysis, annual report (first), ecosystem classification system, designing intervention strategies, intervention, stakeholder meeting, intervention implementation, annual report (second), evaluation, annual report (third) and final report.

Table 2 Overview of countries and diseases covered by the IDRC multi-country project.

Country	Province/state	Type of ecosystem	Targeted emerging infectious diseases (EIDs)
Cambodia	Kratie	River valley (Mekong Basin)	Schistosomiasis, opisthorchiasis
PR China	Yunnan	Mountainous (upstream Mekong and Red rivers)	Schistosomiasis, cysticercosis, angiostrongyliasis
	Guangdong	River delta (Pearl River)	Clonorchiasis, angiostrongyliasis
Lao PDR	Champasak	River valley (Mekong Basin)	Opisthorchiasis, cysticercosis, schistosomiasis
Philippines	Northern Luzon	Hilly and mountainous areas with lakes and water courses	Schistosomiasis, cysticercosis
Thailand	Khon Kaen	Plain with lakes and water courses	Opisthorchiasis, fascioliasis
Vietnam	Nam Dinh, Ninh Binh	River delta (Red River)	Clonorchiasis, fascioliasis

Results of the project showed that the ecosystem perspective includes transdisciplinarity which integrates the perspectives of all relevant expertise; participation of the stakeholders in research project and understanding equity in the roles of different groups in the community. Lessons from the project include the recognition that the ecosystem of the region is taking responsibility for the helminth transmission and therefore there is a need for a classification system and identification of the hotspots. The helminths identified as problems in the region include cysticercosis/taeniasis, echinococcosis, FBTs (clonorchiasis, fascioliasis, opisthorchiasis and paragonimiasis), lymphatic filariasis, schistosomiasis and STHs. Three clustered zones were identified corresponding to specific helminth groupings. Recognition of social factors linked to local customs such as the food culture and unhealthy behaviour were found to contribute to the difficulty of helminthiasis control. The project confirmed that livestock takes a leading role in helminthiasis transmission (infection and re-infection). Higher re-infection was observed both in humans and livestock, and the lack of multi-sectoral cooperation was also noted.

Information Education Communication (IEC) effectiveness in the control of helminthiasis transmission was difficult to measure. There is no information on economic loss and disease burden, and there is no established model in the delivery of IEC materials leading to a serious situation on liver fluke infections and cholangiocarcinoma. Children, women and minority are vulnerable populations to helminth infections. Children are sensitive population of new infection while women should be targeted population of intervention. It is essential to keep a transdisciplinary team on surveillance and response to emerging infectious diseases (EIDs) in the region. There is however a lack of professional teams with transdisciplinary and EcoHealth knowledge. There is a weak capacity on quick response to EIDs.

Progress reports were given by the participating RNAS⁺ member countries in the regular RNAS⁺ meetings. RNAS⁺ members also presented papers during the fourth Biennial Conference of International Association for Ecology and Health on October 15–18, 2012 in Kunming, China. Final results of the project were also presented in specific sessions of the 2014 EcoHealth Conference in Montreal, Canada August 12–15, 2014.

7.3 Control and elimination of helminth zoonoses in the Greater Mekong Subregion

A follow-up project was supported by the IDRC and dealt with the development of country-specific transformation frameworks to advance the

elimination of schistosomiasis and effective control of schistosomiasis and liver fluke infections in the Greater Mekong sub-region. The project involved China, Cambodia, Lao PDR and Thailand.

The specific objectives were to:

1. understand the dynamic and interlinked drivers of schistosomiasis in Cambodia, China and Lao PDR and liver fluke infections in China, Lao PDR and Thailand;
2. design, implement, and evaluate a set of sustainable and cost optimized intervention strategies to support the control and elimination of schistosomiasis and liver fluke infections from the Greater Mekong sub region;
3. characterize the cost effectiveness of interventions targeting local drivers of transmission of schistosomiasis and liver fluke infections; and
4. identify and advance strategic opportunities to mobilize and generate greater investments for the control and elimination of helminth associated diseases across China and Southeast Asia.

The proposed activities designed to achieve these objectives are liver fluke countrywide mapping, annual MDAs, survey to determine infection status in humans, determination of the role of animal reservoir hosts in maintaining transmission, health education to promote control of targeted diseases and importance of water, sanitation and hygiene (WaSH), monthly meeting with villages team, review and analysis of the datasets of IDRC Phase I and cost effectiveness analysis of the intervention tools for targeted diseases in each study sites. Progress reports have been produced by the RNAS⁺ member countries involved in this project.



8. Global engagements: International stakeholders

The overarching purpose of RNAS⁺ is to strengthen collaboration among researchers, academe and control authorities in the regional endemic countries. From its humble beginning of a small forum designed for information exchange about research and experiences for the control of schistosomiasis in the Philippines and PR China, the network has gradually expanded its membership and scope to include not only zoonotic helminths but NTDs in general. Further expansion of this plan came as an offshoot of the workshop in 1998 when 70 scientists and representatives from the various control authorities gathered in Wuxi, PR China and planned the beginning of a network based on intersectoral, inter-regional and international collaboration for research, surveillance and control of schistosomiasis japonica.

From the very start, TDR provided the needed resources to gather experts from the Philippines, PRC, Indonesia and technical advisers from the United States, Australia, Denmark, and WHO among others. In its 20 years of existence, the following collaborators have continued to provide not only technical assistance or expertise but even material resources to keep the annual meetings of the network going.

- Australia: The Queensland Institute of Medical Research (QIMR)
- Switzerland: The Swiss TPH
- Denmark: The WHO/FAO Collaborating Center for Parasitic Zoonoses and DBL Center for Health Research and Development, University of Copenhagen
- Italy: Geospatial Health journal
- USA: Louisiana State University
- Control of Neglected Tropical Diseases, WHO
- WHO Regional Office for Western Pacific (WPRO)
- WHO Regional Office for Southeast Asia (SERO)
- UNICEF/UNDP/World Bank Special Programme for Research and Training in Tropical Diseases (TDR)
- The International Society of Geospatial Health (GnosisGIS)

Collaborations with the countries and institutions mentioned above strengthened as RNAS⁺ continued to respond to the challenges involving various aspects of schistosomiasis initially and the network's other target diseases and then NTDs eventually. Aside from funding from TDR and WHO for early research projects of RNAS⁺, IDRC injected research funds for a 3-year project in 2011–2014 involving several countries and several diseases for the purpose of developing innovative EcoHealth-based strategies for the control of the RNAS⁺ target diseases in several member countries. IDRC sustained funding for another 3-year project involving countries along the lower Mekong Basin to continue developing control strategies for endemic diseases in these countries. RNAS⁺ also established and maintained linkages with other networks such as RNSA in Africa, the Cysticercosis Working Group in eastern and southern Africa (CWGESA) and the *International Society of Geospatial Health* by developing and conducting joint training activities and attendance in each others' meetings.

The successful multi-country and multi-disease researches of RNAS⁺ prove that RNAS⁺ is now recognized for its ability to undertake such complex applied and operational researches needed to address the various challenges posed by schistosomiasis and other target diseases of RNAS⁺. As scientists, researchers, academics work closer with control authorities

elimination of these diseases is slowly getting nearer and within reach. Sustaining this linkage is a must to eventually reach the goal of elimination and beyond. RNAS⁺ can boast of the following strengths for this objective:

1. strong collaboration in the regional research area that has successfully attracted a considerable number of experts on research and control
2. presence of experts in various areas who can improve and promote both research and control (For example, RNAS⁺ includes more than 30 global experts who specialize on development of better diagnostics, vaccine and GIS-supported epidemiology.)
3. RNAS⁺ has been successful in translating research output to field application (For example, RNAS⁺ has undertaken development and evaluation of various control strategies for helminth infections while experts have the capacity to develop training packages on GIS applications, diagnostic tools, implementation and evaluation of health metrics and molecular biology research.)
4. setting up of a robust platform that is capable of advancing the mechanisms of sharing information through its website, databases, publications and meetings.
5. RNAS⁺ has proved that it is capable of undertaking joint collaborative projects on operational research through multi-country, multi-disease using multi-disciplinary approach and involving different academic and research institutions in the region. Most importantly, experts who are members of RNAS⁺ are also linked with control programmes of the endemic member countries in the region.

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