A Research and Development Agenda for the Control and Elimination of Human Helminthiases

Jürg Utzinger$^1,2$*

$^1$Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, Basel, Switzerland, $^2$University of Basel, Basel, Switzerland

In this issue of PLoS Neglected Tropical Diseases, the Disease Reference Group on Helminth Infections (DRG4) has put forward a collection of eight reviews that, taken together, outline a compelling research and development agenda for the control and elimination of helminthiases of humans (http://www.ploscollections.org/helminths; [1–8]). Emphasis is placed on six major helminth infections: (i) soil-transmitted helminthiasis; (ii) schistosomiasis; (iii) lymphatic filariasis; (iv) onchocerciasis; (v) food-borne trematodiases; and (vi) cysticercosis/taeniasis. Selection of these helminthiases is justified on multiple grounds. Firstly, as shown in Table 1, more than half of the world’s population is at risk of one or several of these helminthiases, and hundreds of millions of people are currently infected. Secondly, consequences of the mainly long-term chronic infection include suffering, stigmatisation, subtle and gross morbidity (e.g., anaemia, limb deformations and blindness), and premature death, hence causing an intolerable global burden [9–17]. These features, in turn, exacerbate poverty [18–20]. Thirdly, there is growing commitment at all levels—from local communities to politicians, philanthropic organisations, and civil society—to control and eventually eliminate/eradicate the major human helminthiases.

Figure 1 shows that the six helminthiases are at distinctively different stages of control and elimination with geographical idiosyncrasies for some of them [21]. Several helminthiases have been targeted for elimination (e.g., lymphatic filariasis and onchocerciasis in the Americas), and progress made thus far gives hope that this goal can indeed be achieved by 2015 or 2020 if certain conditions are met [14,21]. For schistosomiasis and soil-transmitted helminthiases, discussions are escalating to shift the focus from control to elimination [22,23], and in Africa, the African Programme for Onchocerciasis Control (APOC) is also moving towards this goal [24]. The pivotal role of research, coupled with teaching and training of strong cadres of researchers from endemic settings as essential backbones and platforms to design, implement, and adapt the control and elimination agenda for major helminthiases as well as other tropical diseases, cannot be emphasised enough [25–27].

In 2007/2008, the Special Programme for Research and Training in Tropical Diseases (TDR), based at and executed by the World Health Organization (WHO), and co-sponsored by the United Nations Children’s Fund (UNICEF), the United Nations Development Programme (UNDP), the World Bank and WHO, initiated a network of disease-specific and thematic reference groups (DRGs/TRGs). DRG4 was particularly prolific, as witnessed in the collection of authoritative reviews presented here. This accompanying editorial summarises the goal, objectives and expected outcomes of the DRGs/TRGs global research “think tank”. Next, light is shed on the composition of DRG4, its mode of operation and its first outputs. It is then argued that PLoS Neglected Tropical Diseases is an appropriate outlet for the studies reviewed and synthesised by DRG4. Indeed, open access to the identified and ranked research priorities by all stakeholders is a major asset and is likely to reinforce the control and elimination agenda of the major helminthiases.

A Global Research “Think Tank”

The idea to create a global network of DRGs and TRGs as a major international research “think tank” stems from the fourth external review of TDR that took place between February 2005 and May 2006 [28]. The role and operation of this “think tank” were incorporated into the 10-year strategic plan of TDR, which is endorsed by WHO. A key recommendation of the aforementioned external review was that TDR should shift its emphasis from pursuing a model of disease portfolio (“neglected diseases”) [29] to infectious diseases of poverty-related research needs (“needy populations”). As a result of this thinking, the 10-year strategy and underlying business plan of TDR recommended two strong pillars to position and further enhance the organisation’s strategic advantages in a rapidly changing global landscape of funding, research and development: (i) knowledge management that should lead to the concept of stewardship, and (ii) capacity building that should foster empowerment [30].

Conceptualised in 2007/2008, a total of 10 reference groups, six of them with a disease-specific focus, and the remaining four with a thematic and cross-cutting emphasis, were initiated [2] (Table 2; see also Table S1 in [2]). Each reference group comprises 10–14 international experts. Groups are chaired and co-chaired by renowned scientists, at least one of whom is based in a developing country. A competitively selected young career research fellow is offered the opportunity to be part of the group, primarily pursuing research within the realm of the group, but also charged with some limited operational and managerial tasks to ascertain smooth operation of the groups. The reference groups are hosted by WHO country offices in Africa, Asia, and Latin America.

As per TDR’s latest 10-year strategy and vision, the global network of DRGs and TRGs operate within the guiding principles of knowledge management and capacity building, thus emphasising stewardship and...
Table 1. Helminth Infections Emphasised by DRG4 for Development of a Research Agenda for Control and Elimination.

| Helminth Infection                  | Causative Agent(s)                                                                 | At-Risk Population ( Millions ) | No. of People Infected ( Millions ) | No. of People with Morbidity ( Millions ) | No. of Deaths per Year (Thousands) | Global Burden (Thousand DALYs) | Reference(s) |
|-------------------------------------|-----------------------------------------------------------------------------------|---------------------------------|------------------------------------|-----------------------------------------|-----------------------------------|-------------------------------|---------------|
| Soil-transmitted helminthiasis      |                                                                                  |                                 |                                    |                                         |                                   |                               |               |
| Ascariasis                          | Ascaris lumbricoides                                                             | 5,416                           | 807–1,221                          | 350                                     | 3–60                              | 1,817–10,500                 | [10,11,17]    |
| Trichuriasis                        | Trichuris trichiura                                                              | 5,307                           | 604–795                            | 220                                     | 3–10                              | 1,006–6,400                 | [10,11,17]    |
| Hookworm infection                  | Ancylostoma duodenale and Necator americanus                                    | 5,346                           | 576–740                            | 150                                     | 3–65                              | 59–22,100                    | [10,11,17]    |
| Strongyloidiasis                    | Strongyloides stercoralis                                                       | n.d.                            | 30–100                             | n.d.                                    | n.d.                              | n.d.                         | [10]          |
| Schistosomiasis*                    | Schistosoma haematobium, S. japonicum, and S. mansoni                           | 779                             | 207                                | 120                                     | 15–280                            | 1,702–4,500                 | [11,12]       |
| Food-borne trematodiasis            |                                                                                  |                                 |                                    |                                         |                                   |                               |               |
| Clonorchiasis                       | Clonorchis sinensis                                                             | 601                             | 15.3                               | 1.1                                     | 5.6                               | 275                          | [13,16]       |
| Paragonimiasis                      | Paragonimus spp.                                                                | 292                             | 23.2                               | 5.3                                     | 0.2                               | 197                          | [13,16]       |
| Fascioliasis                        | Fasciola gigantica and F. hepatica                                             | 91                              | 2.6                                | 0.3                                     | 0                                 | 35                           | [13,16]       |
| Opisthorchiasis                     | Opisthorchis felineus and O. vivenini                                           | 80                              | 8.4                                | 0.3                                     | 1.3                               | 74                           | [13,16]       |
| Intestinal fluke infections         | Echinostoma spp., Fasciolopsis buski, Metagonimus spp., and Heterophyidae       | n.d.                            | 6.7                                | 0.9                                     | 0                                 | 84                           | [13,16]       |
| Onchocerciasis                      | Onchocerca volvulus                                                             | 120                             | 37                                 | n.d.                                    | 0.05 (in the OCP area)            | 484                          | [9,14]        |
| Cysticercosis/taeniasis             | Taenia solium and T. saginata                                                   | n.d.                            | n.d.                               | n.d.                                    | n.d.                              | >2,000                       | [15]          |

*Listed are the three main schistosome species parasitising humans; of lesser importance are S. guineensis and S. intercalatum (both restricted to West and Central Africa) and S. mekongi (restricted to Cambodia and Lao PDR). DALY, disability-adjusted life year; n.d., not determined; OCP, Onchocerciasis Control Programme.

doi:10.1371/journal.pntd.0001646.t001
empowerment. The specific objectives are to systematically review, debate, and synthesise available information and to define and rate research priorities. This is facilitated by regular meetings (it was initially planned that the groups would meet once a year for 3–5 days), usually in the hosting country of a specific group. Broad stakeholder consultation, usually at the outset of the meetings, was adopted as an integral part of the modus operandi of the groups.

The Disease Reference Group on Helminth Infections (DRG4)

DRG4 initially comprised 14 individuals. The group is chaired by Sara Lustigman at the Lindsley F. Kimball Research Institute, New York Blood Center in New York, United States of America. Boakye A. Boatin serves as the co-chair, currently affiliated with two institutions, the Institute of Parasitology, McGill University (Montreal, Canada), and the Noguchi Memorial Institute of Medical Research, University of Ghana (Legon, Ghana). The career research fellow is based at the Council for

---

**Table 2.** Global Network of Disease-Specific Reference Groups (DRGs) and Thematic Reference Groups (TRGs).

| DRG and TRG | Disease(s) or Thematic Focus | Hosting Institution(s) and Country(ies) |
|------------|-----------------------------|----------------------------------------|
| DRG1       | Malaria                     | WHO Regional Office for Africa (AFRO), Republic of the Congo |
| DRG2       | Tuberculosis, leprosy, and Buruli ulcer | WHO Country Office for the Philippines |
| DRG3       | Chagas disease, human African trypanosomiasis, and leishmaniasis | WHO Country Offices for Sudan and Brazil |
| DRG4       | Helminthiases                | African Programme for Onchocerciasis Control (APOC), Burkina Faso |
| DRG5       | Dengue and emerging viral diseases | WHO Country Office for Cuba |
| DRG6       | Zoonosis and marginalised infectious diseases | WHO Regional Office for Easter and Mediterranean (EMRO), in collaboration with WHO Country Office for Egypt |
| TRG1       | Social science and gender    | WHO Country Office for Ghana |
| TRG2       | Innovation and biotechnology platforms | WHO Country Office for Thailand |
| TRG3       | Implementation and health systems research | WHO Country Office for Nigeria |
| TRG4       | Environment, agriculture and human health | WHO Country Office for the People’s Republic of China |

---

In 2007/2008, the Special Programme for Research and Training in Tropical Diseases (TDR) set up a global network of DRGs and TRGs as an independent “think tank” of international experts. The groups met regularly to review, debate, and synthesise existing information, including stakeholder consultation. The ultimate aim was to establish and strengthen an evidence base on infectious diseases of poverty and cross-cutting themes, including identifying knowledge gaps and current research priorities.

doi:10.1371/journal.pntd.0001646.t002
The geographical representation of the remaining nine members reveals two from Africa (Côte d’Ivoire and Ghana), two from Asia (Thailand and People’s Republic of China), two from Latin America (Brazil and Peru), two from Oceania (Australia), and one from the Middle East (Egypt). At the outset, the group identified research gaps and pursued a multi-criteria assessment, including stakeholder consultation, and Delphi approach that ultimately resulted in a consolidated list of the 10 top research priorities. This forms the “white paper” of the DRG4, i.e., recognising and pursuing these priorities in order to achieve control and elimination of major human helminthias. This “white paper” is co-authored by the entire group [2]. Next, an in-depth analysis outlines the problem of human helminthiases, emphasising the omnipresence of single and multiple species parasitic worm infections and their intricate relationship with poverty [1]. Visualising this collection as house, the reviews highlighting the problem of human helminthiases, and issues towards control and elimination, are like the foundation upon which the building is erected (Figure 2). Key proposed responses for the helminthiases control and elimination agenda are reviewed in four separate pieces that are the main building blocks of the house. These include basic research and enabling technologies [3], new and improved intervention tools and strategies, such as drugs, vaccines, and for some of the helminthiases also vector control [6], diagnostics [4], and mathematical modelling to inform policy and reinforce research [5]. Understanding social-ecological contexts, environmental determinants, and health systems forms the first layer of the roof [7]. Health research and capacity building in developing country settings is of such pivotal importance that it is layered on top of a well-built house, and hence reinforces the agenda [8].

It is, perhaps, interesting to note that key research and development (R&D) issues have already been discussed in connection with a malaria eradication research agenda (malERA). Facilitated by a 2-year broadly integrative and iterative process led by a core team, and assisted by various experts groups and involving more than 250 scientists, programme managers and decision-makers from the public and private sectors in a series of consultations, the malERA went live in a special issue of *PLoS Medicine* in early 2011 [27]. Similar R&D issues were identified in parallel by the malERA and the series presenting the research agenda for helminth infections of humans. Once the collection of malERA papers came out, they served as an inspiration to also publish the comprehensive R&D agenda pertaining to human helminthiases in a collection of reviews, and *PLoS Neglected Tropical Diseases* was deemed a suitable outlet. Both agendas feature basic science and enabling technologies [3,31], diagnostics and diagnostics [4,32], modelling [5,33], and health systems issues [7,34]. While the helminthiases agenda has a single chapter on interventions (due to the fact that, for instance, interventions such as anti-helminth vaccines are in earlier stages of development for use in humans [35]), in the malERA, there are three separate contributions for interventions: drugs, vaccines, and vector control [36–38]. This difference further emphasises the neglect in R&D funding for novel and repositioned intervention tools to control human helminth infections as opposed to malaria [39]. Additionally, the malERA views the issues of monitoring, evaluation, and surveillance (the latter further developed as “surveillance as an intervention”) of such great importance that space is given for a full contribution [40]. Together with a piece on cross-cutting issues for eradication, lessons learned from the first malaria eradication era in the 1950s and 1960s, and the aforementioned umbrella [27], the malERA certainly is a key resource for developing control and elimination/eradication agendas for human infectious diseases, including human helminthiases. However, the research agenda for helminthiases is unique in its contribution of a separate article fully considering the issues of capacity building for health research and disease control in endemic countries.

![Figure 2. A research agenda for the control and elimination of major helminthiasis put forth by DRG4. This figure synthesises the key written outputs from DRG4, visualising this collection of eight reviews as a house (strong foundation, major building blocks and a two-layered roof).](https://doi.org/10.1371/journal.pntd.0001646.g002)
[8], which is absent in the malERA collection. Both collections therefore should be considered together as prime examples of major outputs produced by think tanks, driven by core writing teams and stakeholder engagement in the current global efforts to help control and eliminate poverty-related diseases [21].

**Going Live in PLoS Neglected Tropical Diseases**

In terms of writing, the various DRGs and TRGs were charged to produce annual reports. Additionally, the groups were requested to have these reports further developed into stand-alone comprehensive Technical Report Series, to be published by the WHO. Unfortunately, at the time these reports were submitted to TDR, the organisation sailed through troubled waters, delaying internal processing and external peer review. Yet, there is new traction and it is hoped that the planned WHO Technical Report Series will soon come to bear. In the meantime, the Disease Reference Group on Zoonoses and Marginalized Infectious Diseases (DRG6) disseminated a most useful overview article through the open-access journal *Parasites & Vectors* [41].

The efforts made by DRG4 to produce no less than eight major reviews are commended and *PLoS Neglected Tropical Diseases* clearly is an appropriate outlet for this collection of articles. To wit, within 2–3 years after the launch of *PLoS Neglected Tropical Diseases* in late 2007, this open-access vehicle established itself as the leading peer-reviewed journal in tropical medicine. Two seminal papers published in 2005 and 2006 provided an initial list of 15 neglected tropical diseases, the majority of which were due to helminth infections [42,43]. Indeed, all of the six helminthiases emphasised by DRG4 were part of the initial scope of *PLoS Neglected Tropical Diseases*. Meanwhile, the scope of the journal has broadened considerably [44], and now also includes a growing number of bacterial, protozoal, viral, and ectoparasitic infections, but helminthiases still figure prominently. Indeed, as shown in Table 3, more than 20% of the over 1,300 original articles, reviews, and front-matter pieces focus on helminth infections.

**Lessons Learned and Next Steps**

Sixty-five years after the landmark publication of Norman R. Stool entitled “This Wormy World” [45], it is clear that helminthiases are still widespread and continue to pose a huge public health problem. Indeed, a situation analysis reveals that more than half of the word’s population is at risk of helminth infection, more than a billion people are currently infected, often with multiple species, and helminthiases are rife where poverty and malnutrition prevail, in the face of lack of access to basic infrastructure (e.g., clean water and sanitation) and hygiene [17,20,46]. These facts form the foundation of the current article collection [1,2].

Responses on how to control and eventually eliminate human helminthiases require ethically, technically and scientifically sound research to improve current tools and strategies, as summarised in the

---

**Table 3. Number and Percentage of Helminth-Related Articles Published in PLoS Neglected Tropical Diseases.**

| Search Strategy                      | No. (%) of Hits |
|--------------------------------------|-----------------|
| PLoS Neglected Tropical Diseases     | 1335 (100)      |
| Protozoan infections                 | 294 (22.0)      |
| Helminth infections                  | 277 (20.7)      |
| Viral infections                     | 212 (15.9)      |
| Bacterial infections                 | 185 (13.9)      |
| Fungal infections                    | 11 (0.8)        |
| Ectoparasitic infections             | 0               |
| **Helminths (parasitic worms)**      |                 |
| Trematodes                           | 103 (7.7)       |
| Nematodes                            | 101 (7.6)       |
| Cestodes                             | 26 (1.9)        |
| Helminthic diseases                  | 260 (19.5)      |
| Schistosomiasis                      | 138 (10.3)      |
| **Lymphatic filariasis**             |                 |
| **Soil-transmitted helminthias**     |                 |
| **Onchocerciasis**                   |                 |
| **Echinococcosis**                   |                 |
| **Cysticercosis**                    |                 |
| **Taeniasis**                        |                 |
| **Toxocarisias**                     |                 |
| **Loiasis**                          |                 |
| **Food-borne trematodiasis**         |                 |
| **Dracunculiasis**                   |                 |
| Important helminth species           |                 |
| Schistosoma mansoni                  | 80 (6.0)        |
| Hookworm                             | 49 (3.7)        |
| Schistosoma japonicum                | 39 (2.9)        |
| Trichuris trichiura                  | 32 (2.4)        |
| Ascaris lumbricoides                 | 31 (2.3)        |
| Brugia malayi                        | 21 (1.6)        |
| Strongyloides stercoralis            | 17 (1.3)        |
| Taenia solium                        | 15 (1.1)        |
| Wuchereria bancrofti                 | 14 (1.0)        |
| Onchocerca volvulus                   | 13 (1.0)        |
| Clonorchis sinensis                  | 8 (0.6)         |
| Fasciola hepatica                    | 8 (0.6)         |
| Opisthorchis viverrini                | 6 (0.4)         |

Search performed on PubMed on March 15, 2012, using the advanced search builder. In a first step, the term “*PLoS Neglected Tropical Diseases*” was entered in the field “journal”, which revealed 1,335 hits. In subsequent steps, helminth-specific terms were added using the Boolean operator “AND”. Bold text in the table indicates parasites, parasitic infections, and diseases covered by the Disease Reference Group on Helminth Infections (DRG4).  

doi:10.1371/journal.pntd.0001646.t003
present helminthiasis agenda [2–6]. Research and capacity building must accompany the entire process and innovation is key to developing and validating the next generation of tools and strategies [9]. For example, there is a need for developing rapid and inexpensive integrated mapping approaches for those helminthiases where the extent of the problem is not yet appreciated [47]. The recent development of high-resolution, spatially explicit global databases for helminthiases and other neglected tropical diseases provides an exciting new opportunity for targeting control interventions, and subsequent monitoring, evaluation, and surveillance [48,49]. Importantly, once the emphasis shifts from morbidity control towards transmission control and finally local elimination, the need for highly accurate diagnostics tools must be stressed. Indeed, the diagnostics must be adapted to the current stage of a control programme [50]. Moreover, lessons learned from past successful helminthiasis control and elimination programmes emphasize the need for integrated approaches with close collaboration between different sectors (e.g., health, education, and water) and long-term political commitment [51–53].

These issues must be seen in rapidly changing demographic, health systems, and socio-economic contexts [7]. A deep understanding at different spatial and temporal scales is mandatory so that some of the most ancient afflictions of mankind can be consigned to history in the not too distant future.

Acknowledgments

Thanks are addressed to the core writing team of DRG4 and Prof. Marcel Tanner from the Swiss Tropical and Public Health Institute for a series of useful and constructive comments regarding the current editorial.

References

1. Lustigman S, Prichard RK, Gazzinelli A, Grant WN, Boatin BA, et al. (2012) A research agenda for helminth diseases of humans: the problem of helminthiasis. PLoS Negl Trop Dis 6: e1502. doi:10.1371/journal.pntd.0001502
2. Boatin BA, Basáñez MG, Prichard RK, Ameh KE, Barakat RM, et al. (2012) A research agenda for helminth diseases of humans: towards control and elimination. PLoS Negl Trop Dis 6: e1547. doi:10.1371/journal.pntd.0001547
3. Lustigman S, Geldhof P, Grant WN, Oeri-Aweneboasa MY, Sripa B, et al. (2012) A research agenda for helminth diseases of humans: basic research and enabling technologies to support control and elimination of helminthiasis. PLoS Negl Trop Dis 6: e1465. doi:10.1371/journal.pntd.0001465
4. McCarthy JS, Lustigman S, Yang GJ, Barakat RM, Garcia HH, et al. (2012) A research agenda for helminth diseases of humans: diagnostics for control and elimination programmes. PLoS Negl Trop Dis 6: e1601. doi:10.1371/journal.pntd.0001601
5. Basáñez MG, McCarthy JS, French MD, Yang GJ, Walker M, et al. (2012) A research agenda for helminth diseases of humans: modelfree mapping and monitoring. PLoS Negl Trop Dis 6: e1548. doi:10.1371/journal.pntd.0001548
6. Prichard RK, Basáñez MG, Boatin BA, McCarthy JS, Garcia HH, et al. (2012) A research agenda for helminth diseases of humans: interventions to control and elimination. PLoS Negl Trop Dis 6: e1549. doi:10.1371/journal.pntd.0001549
7. Gazzinelli A, Correa-Oliveira R, Yang GJ, Boatin BA, Kloos H (2012) A research agenda for helminth diseases of humans: social ecology, environmental determinants, and health systems. PLoS Negl Trop Dis 6: e1603. doi:10.1371/journal.pntd.0001603
8. Oeri-Aweneboasa MY, Lustigman S, Prichard RK, Boatin BA, Basáñez MG (2012) A research agenda for helminth diseases of humans: health research and capacity building in disease endemic countries for helminthiasis control. PLoS Negl Trop Dis 6: e1602. doi:10.1371/journal.pntd.0001602
9. Little MP, Brething LP, Basáñez MG, Alley ES, Boatin BA (2004) Association between microfilarial load and excess mortality in onchocerciasis: an epidemiological study. Lancet 363: 1514–1521
10. Bertiényi J, Brooker S, Albonico M, Geiger SM, Loukas A, et al. (2006) Soil-transmitted helminthology in the 21st century. Science 293: 1437–1438
11. Lumenta PJ, Pfister R, Utzinger J (2006) A blueprint for success: integration of neglected tropical disease control programmes. Trends Parasitol 22: 313–321
12. Steinnmann P, Keiser J, Bos R, Tanner M, Utzinger J (2006) Schistosomiasis and. water resources development: systematic review, meta-analysis, and estimates of people at risk. Lancet Infect Dis 6: 411–425
13. Keiser J, Utzinger J (2009) Food-borne trematodiases. Clinical Tropical Med Rev 22: 466–483
14. Taylor MJ, Hoerauf A, Bockarie M (2010) Lymphatic filariasis and onchocerciasis. Lancet 375: 1173-1183
15. Torrison PR, Macpherson CN (2011) The socioeconomic burden of parastic zoonoses: global trends. Vet Parasitol 182: 79–95
16. Fuest T, Keiser J, Utzinger J (2012) Global burden of human food-borne trematodiasis: a systematic review and meta-analysis. Lancet Infect Dis 12: 210–221
17. Pullan RL, Brooker SJ (2012) The global limits and population at risk of soil-transmitted helminth infections in 2010. Parasit Vectors 5 In press.
18. Hotez PJ, Fenwick A, Savioli L, Molyneux DH (2009) Rescuing the bottom billion through control of neglected tropical diseases. Lancet 373: 1570–1579
19. Hotez PJ, Ehrenberg JP (2010) Escalating the global fight against neglected tropical diseases through interventions in the Asia Pacific region. Adv Parasitol 72: 51–33
20. King CH (2010) Parasites and poverty: the case of schistosomiasis. Acta Trop 113: 95–104
21. WHO (2011) Technical guidance to overcome the global impact of neglected tropical diseases: a roadmap for implementation. Geneva: World Health Organization. 37 p.
22. Kaapo S, Stoobard JK, Rollinson D, Mohammed KA, Khansus IS, et al. (2012) From morbidity control to transmission control: time to change tactics against onchocerciasis in Unguja Island, Zanzibar. Acta Trop In press. doi:10.1016/j.acttropaea.2011.04.010
23. Spear SG, Seto EYW, Carlton EJ, Liang S, Remai JV, et al. (2011) The challenge of effective surveillance moving from low transmission control to elimination of schistosomiasis in China. Int J Parasitol 41: 1243–1247
24. WHO/APOC (2010) Conceptual and operational framework for onchocerciasis elimination with ivermectin treatment. Ouagadougou: African Programme for Onchocerciasis Control, World Health Organization. 23 p
25. Colley DG, Leke EEa, Godfrey-Laird P, Savioli L (2001) Medical helminthology in the 21st century. Science 293: 1437–1438
26. Zhou XN, Wayling S, Bergquist R (2010) Concepts in research and capacity building in disease-endemic countries for integrated approaches with close collaboration between different sectors (e.g., health, education, and water) and long-term political commitment [51–53].

These issues must be seen in rapidly changing demographic, health systems, and social-ecological contexts [7]. A deep understanding at different spatial and temporal scales is mandatory so that some of the most ancient afflictions of mankind can be consigned to history in the not too distant future.

Acknowledgments

Thanks are addressed to the core writing team of DRG4 and Prof. Marcel Tanner from the Swiss Tropical and Public Health Institute for a series of useful and constructive comments regarding the current editorial.

www.plosntds.org 6 April 2012 | Volume 6 | Issue 4 | e1646
41. Molyneux D, Hallaj Z, Keusch GT, McManus DP, Ngowi H, et al. (2011) Zoonoses and marginalised infectious diseases of poverty: where do we stand? Parasit Vectors 4: 106.

42. Molyneux DH, Hotez PJ, Fenwick A (2005) “Rapid-impact interventions”: how a policy of integrated control for Africa’s neglected tropical diseases could benefit the poor. PLoS Med 2: e336. doi:10.1371/journal.pmed.0020336.

43. Hotez PJ, Molyneux DH, Fenwick A, Ottesen E, Ehrlich Sachs S, et al. (2006) Incorporating a rapid-impact package for neglected tropical diseases with programs for HIV/AIDS, tuberculosis, and malaria. PLoS Med 3: e102. doi:10.1371/journal.pmed.0020102.

44. Hotez PJ, Yamey G (2009) The evolving scope of PLoS Neglected Tropical Diseases. PLoS Negl Trop Dis 3: e379. doi:10.1371/journal.pntd.0000379.

45. Stoll NR (1947) This wormy world. J Parasitol 33: 1–18.

46. Ziegelbauer K, Speich B, Maüezahl D, Bos R, Keiser J, et al. (2012) Effect of sanitation on soil-transmitted helminth infection: systematic review and meta-analysis. PLoS Med 9: e1001162.

47. Brooker S, Kabaterine NB, Gyapong JO, Stothard JR, Utzinger J (2009) Rapid mapping of schistosomiasis and other neglected tropical diseases in the context of integrated control programmes in Africa. Parasitology 136: 1707–1718.

48. Brooker S, Hotez PJ, Bundy DAP (2010) The global atlas of helminth infection: mapping the way forward in neglected tropical disease control. PLoS Negl Trop Dis 4: e779. doi:10.1371/journal.pntd.0000779.

49. Hurlimann E, Schur N, Boutsika K, Stensgaard AS, Laserna de Himpsl M, et al. (2011) Toward an open-access global database for mapping, control, and surveillance of neglected tropical diseases. PLoS Negl Trop Dis 5: e1404. doi:10.1371/journal.pntd.0001404.

50. Bergquist R, Johansen MV, Utzinger J (2009) Diagnostic dilemmas in helminthology: what tools to use and when? Trends Parasitol 25: 151–156.

51. Holveck JC, Ehrenberg JP, Ault SK, Rojas R, Vasquez J, et al. (2007) Prevention, control, and elimination of neglected diseases in the Americas: pathways to integrated, inter-programmatic, inter-sectorial action for health and development. BMC Public Health 7: 6.

52. Singer BH, Castro MC (2007) Bridges to sustainable tropical health. Proc Natl Acad Sci U S A 104: 16038–16043.

53. Utzinger J, Raso G, Brooker S, de Savigny D, Tanner M, et al. (2009) Schistosomiasis and neglected tropical diseases: towards integrated and sustainable control and a word of caution. Parasitology 136: 1859–1874.

www.plosntds.org 7 April 2012 | Volume 6 | Issue 4 | e1646