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NEGLECTED TROPICAL DISEASES

Social and Economic Impact Review on Neglected Tropical Diseases

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I. Executive Summary

The Hudson Institute's Center for Science in Public Policy entered into a partnership with the Sabin Vaccine Institute's Global Network for Neglected Tropical Diseases (GNNTD) to undertake a comprehensive research and policy analysis study on the economic impact of neglected tropical diseases (NTDs). The intent of the research was to validate the hypothesis that investing in NTD control and elimination is a cost effective public health measure and thus one of the best buys in healthcare interventions. This review takes a unique look at NTDs by combining research and interviews with key experts in the field to examine the case of NTDs not solely as a health issue, but also as a global macroeconomic issue that deserves increased attention from ministries of agriculture, education, and finance.[1]

The paper describes the specific economic impact of the seven most common NTDs, then addresses them in general terms, states the case for integration of these diseases and how NTD treatment contributes to the achievement of the Millennium Development Goals (MDGs), discusses the problems with communicating successes in the treatment and prevention of NTDs with the larger community—both in health and elsewhere, and characterizes the role of public-private partnerships in the management and control and elimination of these diseases.

NTD burden is expressed through disability-adjusted life years (DALYs) lost, which refers to the years of healthy life lost as a result of premature death or years lived with a disability. There are 17 neglected tropical diseases that together constitute the fourth largest disease burden of all communicable diseases, accounting for roughly 46-57 million DALYs lost. Seven of these 17 diseases are the subject of this review. These seven, lymphatic filariasis, onchocerciasis, trachoma, schistosomiasis, and three soil-transmitted helminth infections (hookworm, ascariasis and trichuriasis), are the most prevalent and are responsible for the majority of the NTD disease burden, affecting 1.4 billion people worldwide.

These diseases disproportionately affect the poorest people in developing countries, often striking in childhood and causing a cascade of debilitating consequences throughout the life of infected individuals that limits their educational opportunities, labor productivity and wage earning potential.[2]

While NTDs do not pose an immediate threat to mortality, the disability associated with these diseases is extremely burdensome. They disproportionally affect the world's poor, decreasing quality of life, worker productivity, and agricultural outputs. The inescapable

[1] Special acknowledgement to Thomas Engels' Annotated Bibliography: The health and socio-economic evidence for controlling endemic tropical helminthiasis and trachoma by preventive chemotherapy. Updated May 2008.

[2] Research for this review covered the period 2000-2010, but the report is being delivered well into the end of 2012.Therefore, this Paper contains references from 2011 that appeared in the general media (e.g., New York Times), from press releases from WHO, and from papers published in 2011. It also contains information from 28 personal interviews conducted with staff in the academic community, the research-based pharmaceutical companies, and NGOs working on NTDs.

conclusion is that NTDs are a serious detriment to economic development in many developing nations.

NTD control and elimination is feasible though mass drug administration (MDA), which includes the mass dispensation of inexpensive, currently available medication and often the amelioration of the environmental conditions that contribute to their spread, such as clean water, improved sanitation initiatives, and vector control. Medicines to treat these NTDs are often donated by pharmaceutical companies or provided at discounted prices at less than a dollar per treatment.

Research has shown that an integrated MDA approach, which typically uses a combination of four medicines to prevent or treat the seven most prevalent NTDs, yields the best return.[3] USAID's NTD program has had significant success by using an integrated approach. By merging existing vertical programs to use an integrated approach, the cost per treatment was reduced by 41%.[4] The high geographic overlap among NTDs allows for integrated drug distribution of multiple treatments for different diseases. This approach is estimated to cost as little as $0.50 per treatment annually.[5] The cost-effectiveness of integration programs compared to stand alone MDA programs is due to lower distribution costs and pharmaceutical companies' donations of the majority of drugs used in the MDA approach.

The benefits from these relatively inexpensive programs are significant, with an economic rate of return of 15% to 30%, showing that investments made in NTD programming produce a positive return, taking into account inflation and other variables influencing the program over time. Studies indicate that one year of treating these seven NTDs would cost $200 million, compared to $1.7 billion of global funding put toward anti-malaria initiatives in 2009.[6,7] On a treatment cost comparison, for just $0.50 per person per year, seven of the most common NTDs can be treated. This is compared to an estimated $6.64 to treat one case of malaria and $700 to treat one case of HIV/AIDS per year.[8,9]

In addition to being inexpensive, NTD programs have shown historical success. In Hudson's review of the literature it was found that 28 countries reported controlling or eliminating one or more NTD. According to the World Bank, one large scale control initiative stands out as among the most successful and cost-effective public health efforts

[3] Hotez PJ, Molyneuw DH, Fenwick A, Kumaresan J, Sachs SE, Sachs JD, Savioli L. "Control of Neglected Tropical Diseases." New England Journal of Medicine, 2007. 357:1018-27.
[4] U.S. Global Health Policy: Fact Sheet: The U.S. Government Response to Global Neglected Tropical Diseases. May 2012 http://www.kff.org/globalhealth/upload/7938-03.pdf (Accessed May 19 2012)
[5] Molyneux DH, Hotez PJ, Fenwick A. "Rapid-impact interventions": how a policy of integrated control for Africa's neglected tropical diseases could benefit the poor. PLoS Med. 2005 Nov;2(11):e336.
[6] Vogel G. Tackling neglected diseases could offer more bang for the buck. Science. 2006 Feb 3;311(5761):592-3.
[7] World Malaria Report 2009. WHO. 2009. http://whqlibdoc.who.int/publications/2009/9789241563901_eng.pdf (Accessed May 19, 2012).
[8] Are Malaria treatment expenditures catastrophic to different socio-economic and geographic groups and how do they cope with payment? Top Med Int Health. 2010 Jan;15(1):18-25. Epub 2009 Nov 3.
[9] Testing African Couples for HIV Is Cost-Effective Prevention Strategy. Science Daily. September 30, 3010. Treating one ARVT patient for 10 years costs about $7,000. http://www.sciencedaily.com/releases/2010/09/100930143345.htm (Accessed June 6, 2012).

ever launched, resulting in the elimination/control of onchocerciasis in more than a dozen countries. The Onchocerciasis Control Program (OCP) and its follow-on program, The African Programme for Onchoceriasis Control (APOC), are broad international public-private partnerships that have succeeded in eliminating or controlling onchocerciasis in Benin, Burkina Faso, Cote d'Ivoire, Ghana, Guinea Bissau, Guinea, Mali, Niger, Senegal, Sierra Leone, and Togo.

Based on Hudson's research of these successful NTD control programs, one of the most important factors for effective implementation has been the work of public-private partnerships. These programs have involved not only pharmaceutical companies but multilateral funding agencies such as the World Bank, the World Health Organization (WHO), the Pan-American Health Organization (PAHO), and implementing agencies such as Deworm the World, Helen Keller International, Schistosomiasis Control Initiative, national ministries of health, education and agriculture, and active participation from the affected communities themselves.

Far too often, NTDs have been categorized as "other diseases" and exist in the shadow of efforts to control the more widely publicized diseases such as malaria, tuberculosis, and HIV/AIDS. Combating NTDs is clearly integral to health and well being, and even more so to the economies of developing countries. Yet, only 1.3% of the U.S. government global health budget goes to efforts to eliminate these diseases. Furthermore, unlike many global health initiatives, NTD programs have had tremendous successes at low costs, which may be an unanticipated deterrent to fundraising rather than a benefit.

Based on this research, seven recommendations are suggested for the control and elimination of NTDs:

- Prioritize an integrated approach targeting multiple NTDs coupled with MDA, as the most feasible solution to combat NTDs on a global level;
- The global health community should increase advocacy and funding for NTDs for greater awareness by the public and policy-makers;
- NTDs as a brand name needs to be strengthened in order to increase awareness in their value of achieving the MDGs;
- NTDs need to become a part of the larger development agenda and move from an exclusive health framework to a broader socio-economic context;
- The NTD community should become a unified voice for advocacy and public awareness about NTD programming successes and their cost-effectiveness and impact on economic growth;
- Integrated control programs which involve NTDs and other major disease control programs should be encouraged where possible;
- Because corporations play such an enormous role in drug supply for NTDs, the global health community should expand this successful public-private partnership model in order to combat these diseases.

Given the disproportionate impact of NTDs on the poorest of the poor, sustainability efforts in developing countries will falter unless NTDs are fought with integrated MDA programs through long term public-private partnerships. Furthermore, considering the high burden of NTDs on women and children, addressing these diseases is critical to reaching the MDGs. This review forms the basis for a platform of global solidarity with the capacity to communicate to both donors and policy-makers that NTDs are one of the best buys in public health.

II. Introduction

In 2011, Hudson Institute's Center for Science in Public Policy entered into a partnership with the Sabin Vaccine Institute's Global Network for Neglected Tropical Diseases (GNNTD) to undertake a comprehensive research and policy analysis on the economic impact of neglected tropical diseases (NTDs). The research was to validate the hypothesis that investing in NTD control and elimination is a cost-effective public health measure and thus one of the best buys in healthcare interventions.

The analysis was conducted in two phases. First, the Center developed a bibliography of 222 articles on seven NTDs: lymphatic filarasis, onchocerciasis, schistosomiasis, three soil-transmitted helminthes, and trachoma. These articles were published in peer-reviewed journals between 2000 and 2010. Second, the Center conducted a policy analysis that summarizes and underscores the impact and cost effectiveness of the control and elimination of NTDs. In addition to the secondary research, Hudson staff interviewed 28 people who are active in NTD control, including academics, practitioners, foundation staff, and corporate personnel as follows:

- Dr. Steven Ault, Regional Advisor, Communicable Diseases, PAHO
- Dr. Sara Baird, Assistant Professor Global Health and Economics, George Washington University
- Doug Balfour, CEO, Geneva Global, Inc.
- Dr. Moses Bockarie, Director, Center for Neglected Tropical Medicine, Liverpool School of Tropical Medicine
- Don Bundy, Program Coordinator, African Program for Onchocerciasis, World Bank
- Simon Bush, Director Advocacy and African Alliances, Sightsavers
- Dr. Luis Castellanos, Epidemiologist, PAHO
- Brenda Colatrella, Executive Director, Merck & Co., Inc.
- Robert Dintruff, Director of Commercial Development, Abbott
- Dr. Marcos Espinal, Area Manager Health, PAHO
- Dr. Alan Fenwick, Director, Schistosomiasis Control Initiative and Professor, Imperial College London
- Ken Gustavsen, Director Office of Corporate Responsibility, Merck & Co., Inc.
- Dr. Danny Haddad, Director, International Trachoma Initiative
- Dr. Peter Hotez, President, Sabin Vaccine Institute and Dean, National School of Tropical Medicine at Baylor College of Medicine
- Dr. Julie Jacobson, Senior Program Officer, Bill & Melinda Gates Foundation
- Kim Korporc, Director of Program Implementation, Children Without Worms
- Seung-Hee Lee, Advisor, School Health and Nutrition, Save the Children
- Dr. Paul Samson Lusamba-Dikassa, Director, African Programme for Onchocerciasis Control, WHO
- Chad MacArthur, Director of NTD Control, Helen Keller International
- Suki McClatchey, Research Chair, Abbott
- Tracey Noe, Senior Director Global Citizenship and Policy, Abbott
- Jon Pender, Vice President, Government Affairs, GlaxoSmithKline
- Dr. Rahim Rezaie, Post Doctoral Fellow, University of Toronto
- Dr. Jeff Richardson, Vice President, Abbott
- Dr. Joanna Rubinstein, Chief of Staff, Earth Institute, Columbia University

- Jon P Santamauro, Senior Director Global Government Affairs, Abbott
- Dr. Jeffrey Sturchio, former President and CEO, Global Health Council
- Dr. Ignez Tristao, Social Protection Economist, Inter-American Development Bank

Using these references and interviews, this review addresses the seven key NTDs, reviewing results from their endemicity and overall burden. It takes a unique look at these diseases by combining published research and personal interviews to present the case of NTDs not only as a global health issue, but as a global macroeconomic issue that deserves increased attention.

III. Background

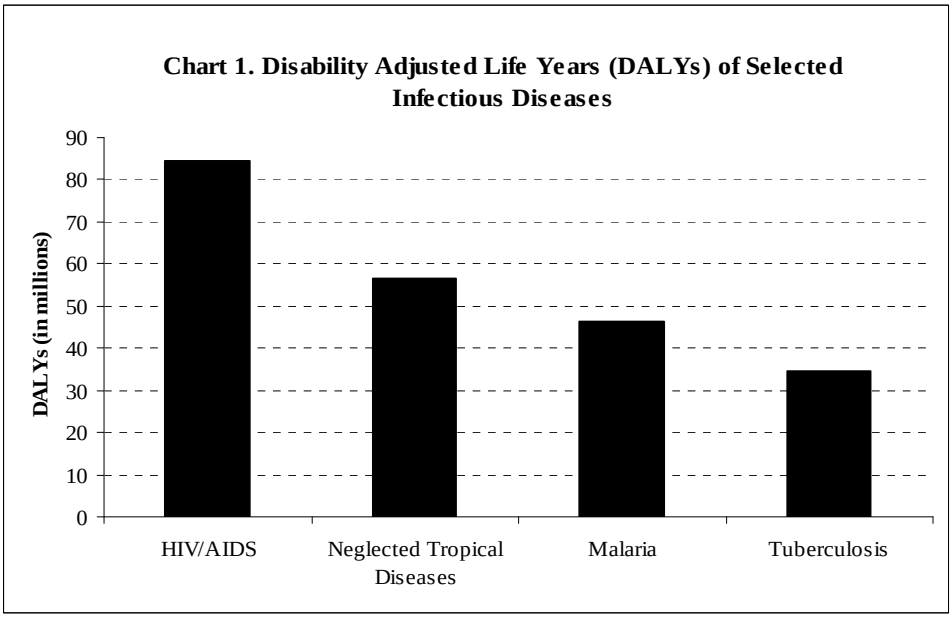
Neglected tropical diseases (NTDs) were part of the global health agenda before the HIV/AIDS epidemic, the rise of non-communicable diseases in developing market economies and the Millennium Development Goals (MDGs). Some of these diseases, which are caused by worms, bacteria, viruses and parasites, are ancient, with evidence of their existence dating back to the era of the Egyptian pharaohs. Their treatment can be as simple as a pill that costs pennies and elimination can be achieved through a combination of transmission interruption through repeated mass drug administration (MDA) and improvements to local water and sanitation standards.

Neglected Tropical Diseases	
Buruli Ulcer	Leprosy
Chagas disease (American trypanosomiasis)	Lymphatic filariasis
Cysticercosis	Onchocerciasis
Dengue/Severe dengue	Rabies
Dracunculiasis (guinea-worm disease)	Schistosomiasis
Echinococcosis	Soil transmitted helminthiasis
Fascioliasis	Trachoma
Human African trypanosomiasis	Yaws
Leishmaniasis	

*World Health Organization's list of neglected tropical diseases.

NTDs are a group of 17 individual diseases prevalent in sub-Saharan Africa, Latin America, and parts of Asia. Seven of these 17 diseases are responsible for more than 90 percent of the disease burden. NTD burden is expressed through disability-adjusted life years (DALYs), which refer to the years of healthy life lost as a result of premature death or years lived with a disability. One DALY equals one year of healthy life lost.[1] The NTD burden amounts to roughly 46-57 million DALYs lost annually.[2] When measured using DALYs, NTDs are second only to HIV/AIDs and before malaria and tuberculosis in DALYs lost.[3]

[1] Christopher J. L. Murray and Alan D. Lopez, The Global Burden of Disease, Harvard University Press, 1996.
[2] Hotez PJ, Fenwick A, Savioli L et al. Rescuing the bottom billion through control of neglected tropical diseases. Lancet 2009; 373: 1570–75.
[3] WHO: Global Burden Data 2004: DALYs by age, sex and cause for the year 2004 http://apps.who.int/ghodata/?vid=110001. (Accessed November 11, 2011).



* Data taken Hotez PJ, Molyneux DH, Fenwick A et al. Control of Neglected Tropical Diseases. N Engl J Med 2007; 357:1018-1027.

The seven diseases compromising the bulk of the NTD burden - lymphatic filariasis, onchocerciasis, schistosomiasis, three soil-transmitted helminth (STH) infections (hookworm, ascariasis, and trichuriasis) and trachoma—affect 1.4 billion people worldwide.[4] NTDs are often referred to as diseases of poverty because they are disproportionately prevalent in the world's most marginalized populations, with the majority of people infected living at the bottom of the economic pyramid.[5]

The unquestionable association between NTDs and poverty has made their elimination a necessity in order to achieve the Millennium Development Goals (MDGs).

MDG number six aims to combat HIV/AIDS, malaria and other diseases. Although NTDs are grouped within this goal as other diseases, the consequences of NTDs directly inhibit the achievement of many other MDGs. As they disproportionately affect women and children, NTDs correlate with MDGs three, four and five which focus on promoting gender equality and improving child and maternal health. These diseases also lead to decreased school attendance rates, which relates to MDG number two, which aims to improve education for children. NTDs have a significant economic impact on individuals and communities perpetuating the cycles of poverty and hunger in the developing world. Spread of NTDs is closely tied to poor water and sanitation conditions making success in controlling and eliminating NTDs part of the larger work to improve global development. While compared to other health issues, the cost of treating NTDs is relatively low, the challenges lie in achieving sustainable drug administration programs and, more importantly, in addressing long-term solutions such as vector control and water and sanitation improvements.

[4] Hotez PJ, Fenwick A, Savioli L et al. Rescuing the bottom billion through control of neglected tropical diseases. Lancet 2009; 373: 1570–75.
[5] Ibid.

Although NTDs do not have comparatively high death rates, their morbidities are daunting. They can lead to permanent damage and deformities such as loss of eyesight, cognitive impairment, and growth stunting, resulting in a lifetime of disability. The STH infections, which account for 80% of the disease burden of the top seven NTDs, are most prevalent in school-aged children. The infections cause severe anemia, which decreases school attendance and impairs overall cognitive development, impeding earning potential in adulthood.

Schistosomiasis, which is often co-endemic with STHs, can cause severe complications including kidney disease and bladder cancer, as well as death. Lymphatic filariasis, commonly known as elephantiasis, occurs mainly in working-aged men. It produces stigmatizing physical deformities and has a severe impact on agricultural productivity in sub-Saharan Africa.[6] Trachoma and onchocerciasis are the two leading causes of preventable blindness worldwide. The economic burden of each of these diseases is massive and takes a heavy toll on the world's most impoverished areas.

The elimination of NTDs is necessary to achieve the MDGs, yet less than 5% of global health funding actually goes to efforts to eliminate these diseases.[7] NTDs exist in the shadow of massive funding efforts to combat HIV/AIDS, malaria, and tuberculosis. Combating each of these diseases is clearly integral to development. The only way to reach the MDGs and improve the quality of life for the poorest people in the developing world, however, is through increased attention to NTDs, not just for purposes of better health, but for the economies of these countries as well.

IV. The Macroeconomic Impact of NTDs

A. Impact Assessment

There are two issues which must be taken into consideration when addressing the economic impact of NTDs. First, in much of the existing research, while per unit costs are mentioned, there isn't a consistent metric applied in its determination. Some include only drug costs; others add in transport, taxes, duties, and tariff expenses to get the drug into the country but don't specify whether these charges are applied on the basis of retail or wholesale value; while some include staff time and use of clinics. Despite these discrepancies in research methodologies, this review argues that NTD treatment programs provide a high return relative to their low costs.

The second issue is that these articles cover a time span of ten years (2000-2010). Therefore, some of the data is derived from an article in 2004, while a latter article in 2010 may show different and higher values for the same NTD. In addition, authoritative sources have not always used equivalent methodologies in their studies. Taken individually and collectively, these seven NTDs have substantial macroeconomic consequences to societies, most particularly in poor countries with marginal population groups in agricultural areas. Appendix A provides a table covering prevalence, treatment

[6] Ibid.
[7] Frew SE, Liu VY, Singer PA. "A business plan to help the 'global South' in its fight against neglected diseases." Health Aff (Millwood). 2009 Nov-Dec;28(6):1760-73.

costs, and key economic benefits of NTD programs.

Finally, there has been no economic evaluation to assess the complex impacts of several diseases, particularly for co-morbidity. Many regions, particularly sub-Saharan Africa, are endemic for multiple NTDs, increasing the possibility that individuals may be infected with more than one at any time. Additionally, these areas have high concentrations of malaria, tuberculosis, and other diseases that weaken the immune system and cause nutritional deficiencies, among other detrimental health impacts. Despite the likelihood of overlap, there has been little done to evaluate the effects – including economic effects—of co-infection.

Lymphatic Filariasis results in severe disability and deformities, which are often a target of social stigma in the poorest regions of the world. A number of studies have addressed the impact of this NTD on worker productivity. In India, two-thirds of those infected with lymphatic filariasis live in rural areas, and the average age of a chronic patient is 49.[89] According to some estimates, chronic lymphatic filariasis patients in India lose as much as 11 years of productivity, at $50 lost per year or 15% of an individual's income.[10, 11]

This burden is likely to be an underestimate because in many cases, the stigmatization of lymphatic filariasis leads individuals to avoid public life and abandon work.[12] Because this disease already impacts the most marginalized people in society, any additional burden is likely to significantly impact their ability to move out of poverty. In addition to chronic lymphatic filariasis, acute episodes of the disease also cause an individual to lose up to five days of work per episode. In total, it is estimated that India alone loses an average of $1 billion per year to lymphatic filariasis because of treatment costs and lost productivity.[13] In endemic populations this amounts to $2 lost per patient per year, while a single dose of treatment per year costs $0.03 per person.[14]

Treatment and control efforts have resulted in 22 million people being protected from this disease with an estimated savings of $24.2 billion.[15] More than 28 million individuals already infected with this disease have benefited from treatment which has halted its progression, resulting in an associated lifetime economic benefit of $19.5 billion. Reduced morbidity has saved health systems in endemic countries $2.2 billion.[16] Cost per person treated has ranged from $0.06 to $2.23, depending on countries which have

[8] K.D. Ramaiah, P.K. Das, E. Michael and H. Guyatt. The Economic Burden of Lymphatic Filariasis in India. Parasitology Today. 2000; 16 (6); 251-253.
[9] Ramaiah KD, Das PK. Mass drug administration to eliminate lymphatic filariasis in India. Trends Parasitol. 2004 Nov;20(11):499-502.
[10] Ibid.
[11] Ramaiah KD, Das PK, Michael E, Guyatt H. The economic burden of lymphatic filariasis in India. Parasitology Today 2006; 16: 251-253.
[12] Ibid.
[13] Chu BK, Hooper PJ, Bradley MH, et al. The economic benefits resulting from the first 8 years of the Global Programme to Eliminate Lymphatic Filariasis (2000-2007). PLoS Negl Trop Dis. 2010 Jun 1;4(6):e708.
[14] Ramaiah KD, Das PK, Michael E, Guyatt H. The economic burden of lymphatic filariasis in India. Parasitology Today 2006; 16: 251-253.
[15] Global Alliance to Eliminate Lymphatic Filariasis. Half-Time in LF Elimination: Teaming Up with NTDs. Sixth Meeting of the Global Alliance to Eliminate Lymphatic Filariasis, June 1- 3, 2010, Seoul, Korea.
[16] Chu BK, Hooper PJ, Bradley MH, et al. The economic benefits resulting from the first 8 years of the Global Programme to Eliminate Lymphatic Filariasis (2000-2007). PLoS Negl Trop Dis. 2010 Jun 1;4(6):e708.

eliminated this disease as compared to others which are in the process.[17] Eight years of mass drug administrations (MDA) around the world have prevented the spread of filarial infection to 6.6 million newborns and stopped the progression of clinical morbidity in 9.5 million individuals already infected[18].

Studies show significant economic gains by treating this disease. It is estimated that $21.8 billion of direct economic benefits will be gained over the lifetime of 31.4 million individuals treated during the first eight years of the Global Programme to Eliminate Lymphatic Filariasis, which was launched by the World Health Organization in coordination with GlaxoSmithKline and Merck & Co., Inc.[19] The economic return on treating this disease has been estimated at as much as $60 per individual, with more conservative estimates at $20 in benefits for every $1 invested.[20] In China, each $1 invested in treating lymphatic filariasis produced a $15 return.[21]

Summary Points

- Lymphatic filariasis is most prevalent in working aged men, making the economic impact of this disease significant;
- Affected patients lose as much as 11 years of productivity, mainly in the agricultural sector;
- Cost per patient treated is no higher than $2.23 and the economic return is between $20 - $60.

Onchocerciasis is the world's second leading cause of infectious blinding, resulting in 1 million cases of blindness or severe visual disability.[22] The disease has been found to diminish productivity, decrease earnings, lead to the abandonment of arable land and ultimately reduce agricultural output. In Ethiopia, workers on coffee plantations who were infected with onchocerciasis earned significantly less than uninfected workers.[23] In addition to lowered productivity, individuals with the infection were found to spend seven extra hours over a six-month period seeking medical help.[24] Onchocerciasis in Africa alone causes 640,000 DALYs. Programs aimed at treating onchocerciasis have been deemed cost-effective. For example, the Onchocerciasis Control Program (OCP), which used aerial spraying of an insecticide, benefitted 26 million people, produced an economic rate of return of 6% on labor and 18% on land. The success of the program is likely to be an underestimate because blindness is often used as the major consequence of onchocerciasis. However, other symptoms, such as severe weight loss and debilitating

[17] Goldman AS, Guisinger VH, Aikins M, et al. National mass drug administration costs for lymphatic filariasis elimination. PLoS Negl Trop Dis. 2007 Oct 31;1(1):e67.
[18] Chu BK, Hooper PJ, Bradley MH, McFarland DA, Ottesen EA (2010)The Economic Benefits Resulting from the First 8 Years of the Global Programme to Eliminate Lymphatic Filariasis (2000–2007).PLoS Negl Trop Dis 4(6):e708.

[19] Chu BK, Hooper PJ, Bradley MH, et al. The economic benefits resulting from the first 8 years of the Global Programme to Eliminate Lymphatic Filariasis (2000-2007). PLoS Negl Trop Dis. 2010 Jun 1;4(6):e708.
[20] Chu BK, Hooper PJ, Bradley MH, et al. The economic benefits resulting from the first 8 years of the Global Programme to Eliminate Lymphatic Filariasis (2000-2007). PLoS Negl Trop Dis. 2010 Jun 1;4(6):e708.
[21] Molyneux DH, Zagaria N. Lymphatic filariasis elimination: progress in global programme development. *Ann Trop Med Parasitol* 2002; 96: S15–40.
[22] Seymour J, Kinder M, Benton B. "Controlling Onchocerciasis (River Blindness) in Sub-Saharan Africa," in Case Studies in Global Health: Millions Saved. Sudbury, MA: Jones and Bartlett Publishers, 2007.
[23] Waters HR, Rehwinkel JA, and Burnham G. Economic evaluation of Mectizan distribution. Trop Med Int Health. 2004 Apr;9(4):A16-25.
[24] Ibid.

itching, also have a significant impact on worker productivity.[25]

Onchocerciasis programs have successfully controlled transmission of this disease in central West Africa, at an annual cost per person of $0.58.[26] As a result of the work of the OCP, improved health among the adult population and additional onchocerciasis-free land has led to increased agricultural and labor productivity generating an estimated $3.7 billion. The estimated economic rate of return for the OCP is 20% over a span of 39 years.[27]

Its follow-on intervention, the African Programme for Onchocerciasis Control (APOC), which uses a drug therapy rather than insecticide spraying, demonstrated a cost-effectiveness for *ivermectin* use that was estimated at $14-$30 per DALY prevented.[28] WHO has found that treatment cost for *ivermectin* is $0.57 per person, yielding a 17% economic rate of return. The prevalence of blindness was 0.40% in 1995 (385,000 cases); dropping to 0.28% in 2010 (265,000 cases). The APOC program in Uganda is on track to eliminate onchocerciasis at a cost of $0.78 per person.[29]

As a result of onchocerciasis programs, uninhabited fertile areas along river banks, which were breeding grounds for flies spreading onchocerciasis, can now be utilized.[30] This is best illustrated by a World Bank evaluation of onchocerciasis control programs, which looked at river-based communities that had abandoned land due to endemic blindness in their populations. It found that once onchocerciasis was controlled in these areas, 25 million hectares of land was returned to agricultural production, enough to feed 18 million people.[31] Programs that address this disease not only significantly improve the standard of living of the people affected by alleviating the physical symptoms, but also enable these populations to increase their economic productivity.

Summary Points:

- Control and elimination have been proven to increase agricultural production;
- Per person cost for treatment is less than $1 and can yield a high economic rate of return;
- Onchocerciasis programs have prevented blindness in at least 1 million people;
- MDA and vector control have substantially reduced the DALYs caused by this disease;
- Successful programs involved numerous partners in corporate and government sectors in addition to having strong local leadership.

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[25] Ibid.
[26] Seymour J, Kinder M, Benton B. "Controlling Onchocerciasis (River Blindness) in Sub-Saharan Africa," in Case Studies in Global Health: Millions Saved. Sudbury, MA: Jones and Bartlett Publishers, 2007.
[27] Kim A, Benton B. Cost-Benefit Analysis of the Onchocerciasis Control Program. World Bank Technical Paper #282. Washington, DC: The World Bank.
[28] Waters HR, Rehwinkel JA, and Burnham G. Economic evaluation of Mectizan distribution. Trop Med Int Health. 2004 Apr;9(4):A16-25.
[29] Haddad D, Cross C, Thylefors B, Richards FO Jr, et al. Health care at the end of the road: opportunities from 20 years of partnership in onchocerciasis control. Glob Public Health. 2008;3(2):187-96
[30] Interview with Moses Bockerie, Director, Centre for Neglected Tropical Diseases, Liverpool School of Tropical Medicine. 11-8-11
[31] Brooker S, Kabatereine NB, Gyapong JO, et al. Rapid mapping of schistosomiasis and other neglected tropical diseases in the context of integrated control programs in Africa. Parasitology. 2009 Nov;136(13):1707-18.

Schistosomiasis is the second largest cause of parasite related morbidity and mortality worldwide.[32] There are an estimated 207 million cases of schistosomiasis, and it is the second most prevalent NTD after the soil-transmitted helminths. Over 90% of schistosomiasis infections occur in sub-Saharan Africa, with the highest prevalence in children, adolescents, and young adults.[33] Until recently, disability from schistosomiasis has focused on direct organ pathology, such as bladder fibrosis. However, evidence shows that secondary symptoms from this disease can lead to chronic problems such as anemia, inflammation, growth stunting, malnutrition, and slow overall cognitive development.[34] Women with female genital schistosomiasis also have a three-fold increased risk of contracting HIV.[35] Thus the disease burden for schistosomiasis, which is estimated between 1.7 and 4.5 million DALYs, is likely to be significantly underestimated due to failure to include secondary morbidities.[36] The inclusion of those morbidities can increase the disease burden by as much as two-fold. The species of schistosomiasis that are prevalent in sub-Saharan Africa are particularly detrimental due to the high mortality associated with liver fibrosis and haematemesis, with nearly 300,000 deaths annually.[37]

Some control programs have addressed schistosomiasis and helminth infections simultaneously. For example, in Burkina Faso the MDA of albendazole and praziquantel to children through schools and the community achieved over 90% coverage at a cost of $0.32 per child.[38] The total cost of the program was $1.07 million, two thirds of which was spent on drugs. In Tanzania, the Ministry of Health launched a school-based deworming initiative that focused on treating children in areas where infection rates were above 50%. Treatment was distributed annually through the primary schools, and drugs were also distributed annually at the household level in areas of exceptionally high endemicity. After two years of MDA, the levels of disease in the community dropped significantly and only annual drug administration was necessary within the primary schools.[39]

In Cambodia, a long-term drug administration program for schistosomiasis was found to be extremely cost-effective. The program provided treatment to the entire population in two endemic regions and reduced the prevalence from 77% to 0.5%.[40] At a cost of roughly $1 per beneficiary per year, the program increased worker productivity by an

[32] Fenwick A, Webster JP, Bosque-Oliva E, et al. The Schistosomiasis Control Initiative (SCI): rationale, development and implementation from 2000-2008. Parasitology 2009; 136 (13): 17190-30.
[33] Hotez PJ, Kamath A. Neglected Tropical Diseases in sub-Saharan Africa: Review of their prevalence, distribution, and disease burden. *Parasit Vectors.* 2009 Sep 24;2(1):44.
[34] Ibid.
[35] Kjetland, EF; Ndhlovu, PD; et al. Association between genital schistosomiasis and HIV in rural Zimbabwean women. AIDS. Issue: Volume 20(4), 28 February 2006; 593–600
[36] Hotez PJ, Kamath A. Neglected Tropical Diseases in sub-Saharan Africa: Review of their prevalence, distribution, and disease burden. *Parasit Vectors.* 2009 Sep 24;2(1):44.
[37] Fenwick A, Webster JP, Bosque-Oliva E, et al. The Schistosomiasis Control Initiative (SCI): rationale, development and implementation from 2000-2008. Parasitology 2009; 136 (13): 17190-30.
[38] Gabrielli AF, Touré S, Sellin B, et al. A combined school- and community-based campaign targeting all school-age children of Burkina Faso against schistosomiasis and soil-transmitted helminthiasis: performance, financial costs, and implications of sustainability. Acta Tropica 2006; 99(2-3)L 234-42.
[39] Fenwick A, Webster JP, Bosque-Oliva E, et al. The Schistosomiasis Control Initiative (SCI): rationale, development and implementation from 2000-2008. Parasitology 2009; 136 (13): 17190-30.
[40] Gabrielli AF, Touré S, Sellin B, et al. A combined school- and community-based campaign targeting all school-age children of Burkina Faso against schistosomiasis and soil-transmitted helminthiasis: performance, financial costs, and implications of sustainability. Acta Tropica 2006; 99(2-3)L 234-42.

estimated $2.7 million at a total program cost of $750,000.[41] In Nigeria, four different treatment strategies were tested with the most cost-effective strategy being MDA treatment of all school-age children. This strategy cost only $15,500 for five years for 30,000 school children in heavily infected areas of Nigeria.[42]

Schistosomiasis control programs have been extremely successful in northern Africa and the Caribbean.[43] Emerging economies such as Brazil and China have effectively controlled the disease as well.[44] In China, schistosomiasis was controlled by MDAs conducted on an annual basis. The program was especially successful because in addition to drug administration, China's program addressed snail control and water and sanitation issues.[45] While MDA alone was successful in decreasing prevalence rates in the short term, prevalence rates increased rapidly within two years after treatment was discontinued.[46] This clearly suggests the maintenance of schistosomiasis control requires activities beyond MDA.

Summary Points

- The burden of schistosomiasis has been underestimated due to subtle symptoms such as anemia, inflammation, growth stunting, malnutrition, and retarded cognitive development;
- An effective strategy is presumptive treatment of all school-age children in programs which target STH and schistosomiasis simultaneously;
- Medicines are the least expensive component in treatment and prevention;
- By significant improvements in worker productivity, schistosomiasis control has proven to be extremely cost-effective;
- Mass drug administration is necessary to address immediate health concerns, while long-term solutions in water and sanitation are developed.

Soil-transmitted helminths (STH) refer to numerous helminth species, however the three most prevalent species are included in this analysis: roundworm (ascariasis), whipworm (trichuris) and hookworm. According to the World Health Organization (WHO), STHs infect more than 1 billion people and are some of the most common infections in developing countries. While today hookworm is endemic in developing nations, less then a century ago it was present in many developed nations as well. In the American South, the economic burden of hookworm infection was so large that it accounted for almost one-fifth of the income difference between the wealthier North and the impoverished South.[47] Research on this one disease showed that an infected child had a 20% lower probability of school enrollment and a 40% reduction in subsequent adult

[41] Croce D, Porazzi E, Foglia E., et al. Cost-effectiveness of a successful schistosomiasis control program in Cambodia (1995-2006). Acta Tropica 2010; 113(3): 279-84.
[42] Gutman J, Richards FO Jr, Eigege A, et al. The presumptive treatment of all school-aged children is the least costly strategy for schistosomiasis control in Plateau and Nasarawa states, Nigeria. Annals of Tropical Medicine and Parasitology 2009; 103(6): 501-11.
[43] Utzinger J, Raso G, De Savigny D, et al. Schistosomiasis and neglected tropical diseases: towards integrated and sustainable control and a word of caution. Parasitology 2009; 136(13): 1859-74.
[44] Ibid.
[45] Qing-Wu J, Li-Ying W, Jia-Gang G, et al. Morbidity control of schistosomiasis in China. Acta Tropica 2002; 82(2): 115-25.
[46] Qing-Wu J, Li-Ying W, Jia-Gang G, et al. Morbidity control of schistosomiasis in China. Acta Tropica 2002; 82(2): 115-25.
[47] Hoyt Bleakley, Disease and Development: Evidence from Hookworm Eradication in the American South. The Quarterly Journal of Economics, February 2007.

wage income.[48] Other research demonstrated that for every dollar spent on deworming, society gains more than $30.[49] In the 1950s, Japan's successful deworming efforts were credited with contributing to the country's subsequent economic progress and international competitiveness.[50]

Of the three STHs, hookworm accounts for one-third of the disease burden from all the NTDs in sub-Saharan Africa.[51] It infects an estimated 740 million people, which is about 10% of the global population. The disease burden is highest in children, resulting in anemia, chronic fatigue, growth stunting, and slowed cognitive development. In turn, these factors affect school attendance and future wage earnings.[52] Additionally, of the STHs, hookworm uniquely impacts adults as well as children. In pregnant women, anemia due to hookworm can result in low birth weight and increased maternal and child mortality and morbidity.[53] Nearly 50 million women are estimated to be infected with hookworm alone.[54]

Due to its high burden, and a high rate of re-infection within 4 to 12 months after treatment, work towards a hookworm vaccine has been highly advocated and is currently in progress. Through the Human Hookworm Vaccine Initiative, researchers are hoping to develop a reliable way to prevent hookworm re-infection. A vaccine would mitigate some of the issues related to chronic infection, such as potential drug resistance to anthelmithic drugs.

In sub-Saharan Africa, STHs infect an estimated 90 million children, but could be treated with a single dose of anthelmintic using a school-based approach at an estimated cost of $5-$7.6 million.[55] A wide-scale deworming program in Vietnam reached 2.7 million children at a cost of $0.03 per student.[56] A school-based program in Tanzania, using the same therapy, reduced anemia by one-quarter and severe anemia by one-half at a cost of $1 per child; the cost per anemia case prevented was $6-$8.[57] The cost of a school-based program in Uganda was estimated at $0.04-0.08 per child.[58] A two-phase program in Cambodia that was expanded from 1 million children to all school children cost $0.11 per

[48] Hoyt Bleakley, Disease and Development: Evidence from Hookworm Eradication in the American South. The Quarterly Journal of Economics, February 2007.
[49] Michael Kremer, The Wisest Investment We Can Make: Using Schools to Fight Neglected Tropical Disease. February 2008. http://blogs.cgdev.org/globalhealth/2008/02/the-wisest-investment-we-can-m.php (Accessed November 2, 2011)
[50] Interview with Dr. Rubinstein, Professor, Earth Institute, Columbia University. 11-1-11
[51] Hotez PJ, Kamath A. Neglected Tropical Diseases in sub-Saharan Africa: Review of their prevalence, distribution, and disease burden. *Parasit Vectors.* 2009 Sep 24;2(1):44.
[52] Brooker S, Clements AC, Bundy DA. Global epidemiology, ecology and control of soil transmitted helminth infections. Adv Parasitol. 2006;62:221-61.
[53] Bethony J, Brooker S, Albonico M, et al. Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm. Lancet. 2006 May 6;367(9521):1521-32.
[54] Bungiro R, Cappello M. Twenty-First Century Progress Toward the Global Control of Human Hookworm Infection. Curr Infect Dis Rep. 2011 Apr 5.
[55] Brooker S, Clements AC, Bundy DA. Global epidemiology, ecology and control of soil transmitted helminth infections. Adv Parasitol. 2006;62:221-61.
[56] Montresor A, Cong DT, Le Anh T, et al. Cost containment in a school deworming program targeting over 2.7 million children in Vietnam. Trans R Soc Trop Med Hyg. 2007 May;101(5):461-4.
[57] Guyatt HL, Brooker S, Kihamia CM, et al. Evaluation of efficacy of school-based anthelmintic treatments against anemia in children in the United Republic of Tanzania. Bull World Health Organ. 2001;79(8):695-703.
[58] Kabatereine NB, Tukahebwa EM, Kazibwe F, et al. Soil-transmitted helminthiasis in Uganda: epidemiology and cost of control. Trop Med Int Health. 2005 Nov;10(11):1187-9.

child in the first phase and $0.06 in the second phase.[59] A single dose of albendazole in a mass chemotherapy strategy at an 18 month interval was found to be most cost-effective in Bangladesh.[60] Controlling STHs in Latin America and the Caribbean would produce an estimated $41 million in economic benefits through 2020[61].

Studies have shown that treating STH infections has been beneficial to treating HIV-1 progression in the short term.[62] Some studies indicate that STH infections elicit an immune response that makes the individual more prone to contract HIV and has shown to increase the replication of HIV.[63] The total morbidity associated with STH infections rivals that of malaria.[64] Studies have shown that treating children with anti-helminths medication increased their appetite, height, body weight and school attendance. STH-related anemia has been found to impair memory and overall learning capacity of children and school achievement has been found to be lower in children infected with STHs.[65] The decreased nutrient absorption caused by STHs causes growth stunting and retards cognitive development. Sensitivity analysis of a hypothetical hookworm vaccine has shown that even at a cost of $100 per patient administered to school-aged children, the vaccine would be cost effective by saving DALYs and savings costs due to loss of productivity.[66]

In addition to impacting school performance and maternal and child health, STH infections also affect worker productivity. In Bangladesh, research has shown that iron-deficiency anemia negatively correlates with daily wages earned.[67] This study also found that labor productivity in agricultural sectors is dependent on the height of the individual. Because STHs decrease growth at an early age, these infections can significantly impact productivity in adulthood, even if they are treated by then.[68]

Summary Points

- STHs infect more than 1 billion people, most of which are the poorest of the poor;
- The total morbidity associated with STH exceeds that of malaria;
- The disease burden is highest in children and agriculture workers, impacting school attendance and productivity;
- STH caused anemia during pregnancy leads to decreased birth weight, and impacts morbidity and mortality;

[59] Sinuon M, Tsuyuoka R, Socheat D, et al. Financial costs of deworming children in all primary schools in Cambodia. Trans R Soc Trop Med Hyg. 2005 Sep;99(9):664-8.
[60] Mascie-Taylor CG, Alam M, Montanari RM, et al. A study of the cost effectiveness of selective health interventions for the control of intestinal parasites in rural Bangladesh. J Parasitol. 1999 Feb;85(1):6-11.
[61] Bitran R, Martorell B, et. al. Controlling and Eliminating Neglected Diseases in Latin America and the Caribbean. Health Affairs. 2009. 28, no 6:1707-1719.
[62] Walson JL, Herrin BR, John-Stewart G. Deworming helminth co-infected individuals for delaying HIV disease progression. Cochrane Database of Systematic Reviews 2009, Issue 3. Art. No.: CD006419. DOI: 10.1002/14651858.CD006419.pub3.
[63] Stephenson LS. Optimizing the benefits of anthelmintic treatment in children. Paediatr Drugs. 2001;3(7):495-508.
[64] Ibid..
[65] Ibid.
[66] Lee BY, Bacon KM, Bailey R, Wiringa AE, et. al. The potential economic value of a hookworm vaccine. Vaccine. 2011 Dec; 29:1201-1210.
[67] Gilgen DD, Mascie-Taylor CG, Rosetta LL. Intestinal helminth infections, anemia and labor productivity of female tea pluckers in Bangladesh. Trop Med Int Health. 2001 Jun;6(6):449-57.
[68] Ibid.

- Evidence shows that treating STH infections can improve HIV/AIDS outcomes in the short run.

Trachoma is the world's leading cause of preventable blindness, affecting 150 million people. Trachoma caused blindness results in an estimated loss of $2.9 billion in productivity each year and the loss of 1.3 million DALYs.[69,70,71] Regions that are considered more economically productive are associated with decreased levels of this disease.[72] [73] Other analysis which includes productivity loss to blindness, low vision, and informal care estimates that trachoma can cause as much as $5.3 billion in losses annually.[74] While trachoma has a significant impact on agriculture, due to its high prevalence in women, it can also have an impact on child-rearing.[75]

Since trachoma is frequently passed on from child to mother, or from child to child, classrooms are a prime site for MDA and SAFE strategy programs. A combination of MDA strategy coupled with the SAFE program (surgery, antibiotics, facial cleanliness, and environment) allows for sustainable solutions to trachoma. There have been many impressive outcomes from trachoma control programs; however, treatment for trachoma is complex because of the external factors that cause the disease. Lack of clean water and proper sanitation are heavily linked to the prevalence of trachoma.[76] Many studies show that treatment for trachoma is needed more than once. For example, infection rates in children in 16 communities in Ethiopia were reduced from 63.5% to 2.6% after MDA, but returned to 25.5% 18 months after treatment ended.[77] In Mali, three years after a MDA program was completed, the prevalence of trachoma increased in one area from 3.9% to 7.3% and in another from 2.7% to 8.2%.[78]

Surgery is also essential to reverse trichiasis, a condition that happens as a result of trachoma where eyelashes grow back toward one's eye. Providing trichiasis surgery to 80% of those who need it can avert 11 million DALYs per year globally, with a cost-effectiveness ranging from $13 to $78 per DALY averted.[79] Surgery to reverse trichiasis

[69] Burton MJ, Mabey DCW (2009) The Global Burden of Trachoma: A Review. PLoS Negl Trop Dis 3(10): e460. doi:10.1371/journal.pntd.0000460
[70] Kumaresan JA, Mecaskey JW. The global elimination of blinding trachoma: progress and promise. Am J Trop Med Hyg. 2003 Nov;69(5 Suppl):24-8.
[71] Frick KD, Basilion EV, Hanson CL, et al. Estimating the burden and economic impact of trachomatous visual loss. Ophthalmic Epidemiol; 2003Vol. 10 (2), pp. 121-32.
[72] Matthew J Burton, David C.W. Mabey. The Global Burden of Trachoma: A Review. PLoS Neglected Tropical Diseases 2009; 3(10): e460.
[73] Frick KD; Hanson CL; Jacobson GA. Global burden of trachoma and economics of the disease. The American Journal Of Tropical Medicine And Hygiene 2003 Nov; Vol. 69 (5 Suppl), pp. 1-10.
[74] Frick KD; Hanson CL; Jacobson GA. Global burden of trachoma and economics of the disease. The American Journal Of Tropical Medicine And Hygiene 2003 Nov; Vol. 69 (5 Suppl), pp. 1-10.
[75] Courtright P, West SK. Contribution of sex-linked biology and gender roles to disparities with trachoma. Emerging Infectious Diseases 2004 Nov; Vol. 10 (11), pp. 2012-6.
[76] Ngondi JM, Matthews FE, Reacher MH, King J, Brayne C, Gouda H, Emerson PM. What will happen if we do nothing to control trachoma: health expectancies for blinding trachoma in southern Sudan. Plos Neglected Tropical Diseases 2009; Vol. 3 (3), pp. e396.
[77] Lakew T, House J, Hong KC et al. Reduction and return of infectious trachoma in severely affected communities in Ethiopia. PLoS Negl Trop Dis. 2009;3(2):e376.
[78] Bamani S, King JD, Dembele M, et al. Where do we go from here? Prevalence of trachoma three years after stopping mass distribution of antibiotics in the regions of Kayes and Koulikoro, Mali. PLoS Negl Trop Dis. 2010 July 6;4(7):e734.
[79] Porco TC, Gebre T, Ayele B et al. Effect of mass distribution of azithromycin for trachoma control on overall mortality in Ethiopian children: a randomized trial. JAMA. 2009 Sep 2;302(9):962-8.

has been successful; however, if the outside factors that lead to trachoma continue to exist, individuals simply become re-infected. Surgery for trichiasis is effective if an individual no longer has trichiasis two years after surgery. Evidence shows that without addressing external factors such as sanitation, the effectiveness of surgery can be as low as 40%, largely because of re-infection.[80]

One of the main trachoma programs is the International Trachoma Initiative (ITI),founded by the Clark Foundation and Pfizer. It has implemented programs in 10 countries, using *azithromycin*. More than 7 million individuals have received this drug donated by Pfizer, reducing active disease presence by 50% in children. In Ethiopia, communities treated with a single dose of oral azithromycin were found to have half the rate of child mortality compared to communities without azithromycin treatment. It is also possible that this reduction of mortality can be attributed to other diseases treated by azithroymycin.[81] Current cost-effectiveness studies of trachoma vary between studies, with some suggesting that it is more expensive to treat than other NTDs. For example, in Benin MDA of azithromycin is estimated to cost between $3,000 and $5,000 per DALY averted.[82] However, in a Myanmar study, researchers found MDA to cost $3 dollars per DALY saved.[83] The differences in these results depend on the number of years the drug was administered.

The SAFE strategy addresses the numerous factors essential for long term treatment of trachoma, such as surgery to reverse trichiasis, antibiotics to treat the disease, facial cleanliness to stop the spread of the disease, and the environmental factors that allow the disease to persist despite treatment. A joint strategy of MDA and SAFE not only treats the disease but also creates a stable environment free from persistent trachoma rates. In addition, the estimated cost for MDA of $.50 per individual per year also takes into account the costs for the SAFE strategy.

Summary Points

- Trachoma causes an estimated loss of $2.9 billion in productivity each year;
- A large portion of the loss of productivity is in the agricultural sector;
- Trachoma related blindness is two to four times higher in women than men, which can have serious impact on child rearing;
- Treatment of children in the classroom can prevent disease transmission and prevent subsequent blindness in adulthood;
- Lack of clean water and proper sanitation are heavily linked to the prevalence of trachoma;
- Combination of MDA and promotion of the SAFE strategy are essential to combat this disease.

[80] Baltussen RM, Sylla M, Frick KD et al. Cost-effectiveness of trachoma control in seven world regions. Ophthalmic Epidemiol. 2005 Apr;12(2):91-101.
[81] Porco TC, Gebre T, Ayele B et al. Effect of mass distribution of azithromycin for trachoma control on overall mortality in Ethiopian children: a randomized trial. JAMA. 2009 Sep 2;302(9):962-8.
[82] Baltussen RM, Sylla M, Frick KD et al. Cost-effectiveness of trachoma control in seven world regions. Ophthalmic Epidemiol. 2005 Apr;12(2):91-101.
[83] Burton MJ, Mabey DCW (2009) The Global Burden of Trachoma: A Review. PLoS Negl Trop Dis 3(10): e460. doi:10.1371/journal.pntd.0000460

B. Analysis of the Economic Impact

Within the last decade, researchers have reassessed the burden of disease caused by NTDs, asserting that it has been underestimated in the past. The areas in which NTDs have high endemicity are often difficult to reach and lack diagnostic capabilities, making accurate assessment challenging.[84] Moreover, some diseases, e.g., schistosomiasis, in addition to causing extreme morbidity through organ failure, have subtle symptoms leading to functional disabilities that have been overlooked.[85] Similarly, onchocerciasis, which was originally thought to cause an annual loss of 480,000 DALYs, has been estimated to be responsible for 1.5 million DALYs.[86]

The burden from soil-transmitted helminths (STH) has focused on the infections' effects in its strongest forms. However, evidence has shown that even mild infection at an early age can cause long-term effects on cognitive development due to anemia and malnutrition. STHs are especially dangerous for pregnant women, causing both maternal and child morbidity. With these subtle symptoms, it is likely that the DALYs estimates are undervalued.

Taking these updated analyses into account, NTDs, grouped together, account for the fourth largest disease burden of all communicable diseases, following lower respiratory infections, HIV/AIDS, and diarrheal diseases.[87] The consequences of NTDs extend beyond their impact on health and on the morbidity of other diseases. Table 1 provides a summary of the prevalence of NTDs, their low treatment costs, DALYs, and economic benefits to help us understand the overall health and economic impact of NTD treatment and control programs.

NTD programs have been unquestionably deemed as cost effective, primarily because many of the drugs that treat NTDs are either donated or can be obtained for less than a dollar. Companies such as Merck & Co., Inc., Pfizer, GlaxoSmithKline, and Johnson & Johnson, which manufacture drugs for the treatment of onchocerciasis, trachoma, lymphatic filariasis, and soil-transmitted helminths, have made these drugs available at no cost. The price of praziquantel, the drug that treats schistosomiasis, has decreased significantly to $.07 per dose.[88] Merck KGaA recently increased its donations of praziquantel from 25 million to 250 million tablets a year.[89] Some estimates show that NTDs in sub-Saharan Africa can be treated at a rate of $0.40 to $0.79 per patient for a total $204 million per year on the continent.[90] [91] The benefits from these relatively

[84] Hotez PJ, Ottesen E, Fenwick A, Molyneux D (2006) The neglected tropical diseases: The ancient afflictions of stigma and poverty and the prospects for their control and elimination. Adv Exp Med Biol. In press.
[85] Lambertucci, J.R. et al. (2000) Schistosomiasis mansoni: assessment of morbidity before and after control. Acta Trop. 77, 101–109.
[86] Ibid.
[87] Hotez PJ, Molyneux DH, Fenwick A et al. Incorporating a Rapid-Impact Package for Neglected Tropical Diseases with Programs for HIV/AIDS, Tuberculosis, and Malaria. PLoS Med 2006 3(5): e102.#
[88] Molyneux DH, Hotez PJ, Fenwick A. "Rapid-impact interventions": how a policy of integrated control for Africa's neglected tropical diseases could benefit the poor. PLoS Med. 2005 Nov;2(11):e336.
[89] Uniting to Combat Neglected Tropical Diseases, Ending the Neglect and Reaching 2020 Goals: Table of Commitments. January 2012
http://www.unitingtocombatntds.org/downloads/press/ntd_event_table_of_commitments.pdf (Accessed May 15 2012)
[90] Hotez PJ, Molyneuw DH, Fenwick A, Kumaresan J, Sachs SE, Sachs JD, Savioli L. "Control of Neglected Tropical Diseases." New England Journal of Medicine, 2007. 357:1018-27.

inexpensive programs are significant. Integrating treatment of NTDs can produce an economic rate of return 15% to 30%, depending on the program.[92] When compared to treatment of HIV/AIDS, which can exceed $700 per person per year, addressing NTDs is extremely low cost – $0.50 per person per year." [93]

Programs to treat NTDs do not pose the same threat of drug resistance as do treatment programs aimed at HIV/AIDS, malaria, and tuberculosis. The sustainability of programming depends mainly on two activities: MDA and addressing the cause of infection, whether through vector control or water and sanitation improvements. Compared to treatment programs aimed at HIV/AIDS, malaria, and tuberculosis, NTD programs are extremely successful and cost effective and can even positively affect the outcomes of HIV/AIDS, malaria, and tuberculosis.

As mentioned above, STH infections are the most common NTDs, and these infections are responsible for the greatest portion of NTD DALYs. Thus, focusing on STHs alone could achieve one of the best returns on investment, given the low cost of treatment with donated drugs and high prevalence of STHs. Deworming programs, which are administered through schools, have shown tremendous success and produced positive results in decreasing school absenteeism. Some programs have reduced absenteeism by as much as 25%.[94] In Kenya, an evaluation found that one year of schooling was gained for every $4 invested in school MDA programs.[95] Other evaluations have shown similar cost-effectiveness in terms of increased school attendance and improved test scores. Deworming programs are not only cost-effective, they are also very inexpensive. Some studies estimate that the annual cost of deworming patients in sub-Saharan Africa could be as low as $52 million per year.[96] Furthermore, a school-based approach aimed at children specifically could cost as little as $5-$7.5 million.[97] Compared to the billions spent on other health programs, an annual deworming campaign would benefit millions at the cost for pennies.

The U.S. government global health programs were allocated $7.1 billion for 2012 alone.[98] However, only $89 million was appropriated for NTDs, comprising only 1.3% of U.S. global health funding.[99] The bulk of foreign aid for health dollars is for HIV/AIDS and malaria, consuming at least 60% total global health resource requests. The remainder is

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[91] Molyneux DH, Hotez PJ, Fenwick A. "Rapid-impact interventions": how a policy of integrated control for Africa's neglected tropical diseases could benefit the poor. PLoS Med. 2005 Nov;2(11):e336.
[92] Ibid.
[93] Report to Congress: Costs of Treatment in the President's Emergency Plan for AIDS Relief (PEPFAR), PEPFAR, Washington, D. C., July 2010.
[94] Miguel E, Kremer, M. Worms: Identifying Impacts on Education and Health in the Presence of Treatment Extranalities. Econometrica, 2004. Jan 72 (1), 159-217.
[95] Bitran R, Martorell B, et. al. Controlling and Eliminating Neglected Diseases in Latin America and the Caribbean. Health Affairs. 2009. 28, no 6:1707-1719.
[96] Molyneux DH, Hotez PJ, Fenwick A. "Rapid-impact interventions": how a policy of integrated control for Africa's neglected tropical diseases could benefit the poor. PLoS Med. 2005 Nov;2(11):e336.
[97] Brooker S, Kabatereine NB, Gyapong JO, et al. Rapid mapping of schistosomiasis and other neglected tropical diseases in the context of integrated control programs in Africa. Parasitology. 2009 Nov;136(13):1707-18.
[98] FY2012 State/Foreign Operations Budget Chart-FY12 House SFOps Subcommittee Mark (7-26-2011) provided by Congressman Sam Farr's (D. CA) office.
[99] U.S. Global Health Policy: Fact Sheet: The U.S. Government Response to Global Neglected Tropical Diseases. May 2012 http://www.kff.org/globalhealth/upload/7938-03.pdf (Accessed May 19 2012)

primarily for child survival, maternal child health programs, and family planning.

Since 2006, the U.S. government has increased its focus on NTDs, however, comparatively it still invests far less than the other global health programs. In addition. the amount requested for FY 2013 is a 25% less that FY 2012, making it the largest percentage cut requested among U.S. global health programs.[100] Since the U.S. is the leader in health funding, its program priorities are reflected in other donor's programs. Funding decisions of the U.S. government may send signals to Ministries of Public Health in recipient countries that NTDs have low priority. This message needs to change, especially as governments are looking for ways to cut budgets. Cost effectiveness of NTD programs needs to be taken seriously.

Beyond the cost effectiveness measures of NTDs, treating these diseases provides other benefits. First, NTDs have an end point. Unlike HIV/AIDS or chronic diseases, NTDs can be controlled at a low cost in the short term. And if water and sanitation issues are addressed, NTDs can be permanently managed or eradicated. Second, the treatment for these diseases is easily administrated by community health workers. Third, the donated drugs require minimal storage costs and only need to be administered one or two times per year, as opposed to the daily administration of ARV treatment.

Overall, the treatment of NTDs is significantly more manageable than treating other more expensive diseases such as HIV/AIDS and tuberculosis. The U.S. Congress and most donor agencies have not yet prioritized this important global health issue. That is the puzzling dilemma the NTD community faces today, the downside to effectiveness. NTD programming has the tangible chance for an actual end point; the difficult part is to convince others to side on the solution-orientated approach.

V. Integration

A. The Case for Integration

Individuals who are infected by an NTD rarely have only one infection. Most NTDs overlap in both geographical and economic distribution. In sub-Saharan Africa, multiple infections are frequent in school-age populations, where soil-transmitted helminths (STHs) and schistosomiasis are often co-morbid. Similarly, lymphatic filariasis, onchocerciasis, and trachoma have strong geographical overlap with STHs and schistosomiasis.

Due to the high overlap among NTDs, the global community advocates for an integrated approach, which has been estimated to cost as little $0.50 per treatment annually for all seven NTDs.[101] While each disease is different and has a multitude of options for treatment, the process of mass drug administration (MDA) has been found to be the most cost effective to treat NTDs. MDA works because seven of the most prevalent NTDs,

[100] U.S. Global Health Policy: Fact Sheet: The U.S. Government Response to Global Neglected Tropical Diseases. May 2012 http://www.kff.org/globalhealth/upload/7938-03.pdf (Accessed May 19 2012)
[101] Molyneux DH, Hotez PJ, Fenwick A. "Rapid-impact interventions": how a policy of integrated control for Africa's neglected tropical diseases could benefit the poor. PLoS Med. 2005 Nov;2(11):e336.

schistosomiasis, onchocerciasis, lymphatic filarasis, trachoma and three of the STHs, can be treated at the same time through preventive chemotherapy. MDA programs deliver a single dose of medication to infected communities. The increased susceptibility of people infected with NTDs to other diseases makes this an important target in improving overall health in the poorest populations.

While integration is not the answer in every case, it can significantly cut costs in many situations. When the Inter-American Development Bank (IDB) gathered with three governments to discuss integration, they were able to make momentous strides. Although each program came with its own budget and plan, by the end of the discussion they were able to decrease the budget by 90% by integrating the programs.[102] In many situations, integration also improves logistics for community volunteers because these volunteers are able to combine interventions, which can increase their efficiency.[103]

USAID's NTD program has had significant success by using an integrated approach. By merging existing vertical programs to use an integrated approach their cost per treatment was reduced by 41%.[104] USAID's Neglected Tropical Disease Control program started in 2006 and has partnered with Research Triangle Institute (RTI) to help administer the program. This program is a large public-private partnership that has already delivered an estimated 532 million NTD treatments to almost 233 million people.[105] Research from the program has shown that when treatment is given to high risk populations over successive years, NTDs can be eliminated to a rate where they no longer pose a threat to public health.[106]

In sub-Saharan Africa, NTDs are also common in patients with HIV/AIDS, malaria and tuberculosis. Recent evidence shows that NTD polyparasitism, in combination with malaria or sickle cell disease, can lead to severe anemia with considerable impacts on long-term health, especially in children, pregnant women, and people infected with HIV. The health consequences of anemia for at-risk populations have been coined as the "silent burden of anemia."[107] In HIV/AIDS patients, soil-transmitted helminths, and schistosomiasis can increase the progression of HIV through immune activation.

In the last decade, studies have demonstrated that the health burden of NTDs profoundly impacts the outcome of patients with HIV/AIDS, malaria, and tuberculosis, and advocates have called for integrated programs to address the "big three" and NTDs simultaneously.[108, 109, 110] Adding NTDs into greater global health programming on the

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[102] Interview with Dr. Ignez Tristao, Social Protection Specialist, Inter-American Development Bank, October 18, 2011.

[103] Interview with Julie Jacobson, Senior Program Manager, Gates Foundation, October 26, 2011.

[104] U.S. Global Health Policy: Fact Sheet: The U.S. Government Response to Global Neglected Tropical Diseases. May 2012 http://www.kff.org/globalhealth/upload/7938-03.pdf (Accessed May 19 2012)

[105] USAID NTD Program. http://www.neglecteddiseases.gov (Accessed May 12, 2012).

[106] USAID Neglected Tropical Disease Control Program. http://www.usaid.gov/our_work/global_health/id/ntd_brief.pdf (Accessed May 12, 2012).

[107] Schellenberg D, Arstrong Schellenberg JRM, Mushi A, de Savigny D, Mgalula L, et al. (2003) The silent burden of anaemia in Tanzanian children: A community–based study. Bull World Health Organ 81: 581–

[108] Borkow G, Weisman Z, Leng Q, Stein M, Kalinkovich A, et al. (2001) Helminths, human immunodefi ciency virus and tuberculosis. Scand J Infect Dis 33: 568–571.

[109] Elliott AM, Kyosiimire J, Quigley MA, Nakiyingi J, Watera C, et al. (2003) Eosinophilia and progression to active tuberculosis in HIV-1 infected Ugandans. Trans R Soc Trop Med Hyg 97: 477–480.

big three would cost pennies comparatively. Current estimates indicate that treating NTDs would cost $200 million a year, a small amount compared to $1.7 billion estimated toward anti-malaria initiatives, or an annual $4.1 billion for HIV/AIDS.[111, 112 ,113]

B. The Role of NTDs within the MDGs

One of the key issues that came out in the interviews was that the fight against NTDs needs to be viewed in conjunction to meeting the Millennium Development Goals (MDGS). There are eight MDGs and only one of them, MDG six, indirectly mentions NTDs. Goal six states: *Combat HIV/AIDS, malaria, and other diseases*. While NTDs are conceivably in this category of "other diseases," the lack of specific attention to NTDs is a serious omission of the MDGs. Although it makes sense for NTDs to be in a similar category of the three main pandemics, they cannot simply be "other diseases," for they are equally important in the global health arena.

In a 2004 assessment of the MDGs, The World Bank found that the goals are unlikely to be met by 2015 and this assessment was supported by most of the interviews conducted by Hudson.[114] The lack of progress in the fight against NTDs is a barrier to meeting the MDGs because of the adverse effects NTDs have on five of the eight MDGs. For example, goal one is the eradication of extreme poverty and hunger. All of the NTDs primarily affect the poorest population groups. Goal two is the achievement of universal primary education, a difficult one to reach when soil-transmitted helminths substantially reduce a child's school attendance and attention span in class. Goal four is to reduce child mortality, and goal five is to improve maternal mortality—both of which can be achieved by preventing the spread of lymphatic filariasis to newborns, and controlling soil-transmitted helminths for women of childbearing age. Goal eight is to develop global partnerships, a signature accomplishment of NTDs, through corporate and government public-private partnership, evident in the onchocerciasis, trachoma, lymphatic filariasis, and soil-transmitted helminth programs, each of which have provided access to essential medicines at low or no cost to patients.

Attention to NTDs in relation to the MDGs has steadily increased. In 2010, after increased efforts requesting NTD inclusion within the MDGs, U.K. Member of Parliament, the Honorable Andrew Mitchell, made a statement formally addressing NTDs as an important component of achieving the goals. The United Nations General Assembly met in 2010 to discuss the MDGs and included NTDs in their outcome documents, mentioning them by name, no longer categorizing them as 'other diseases'. The document acknowledged the progress they have had and "declared to renew efforts to

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[110] Elias D, Akuffo H, Pawlowski A, Haile M, Schon T, et al. (2005) *Schistosoma mansoni* infection reduces the protective effi cacy of BCG vaccination against virulent *Mycobacterium tuberculosis*. Vaccine 23: 1326–1334.
[111] Vogel G. Tackling neglected diseases could offer more bang for the buck. Science. 2006 Feb 3;311(5761):592-3.
[112] World Malaria Report 2009. WHO. 2009. http://whqlibdoc.who.int/publications/2009/9789241563901_eng.pdf (Accessed May 19, 2012).
[113] Country Progress Reports : UNAIDS 2010 http://www.unaids.org/documents/20101123_globalreport_slides_chapter6_em.pdf (Accessed January 5, 2012)
[114] Interview with Doug Balfour, CEO, Geneva Global, Inc., November 22, 2011

prevent and treat NTDs".[115] In April 2012 the chair of the G8 Foreign Ministers Meeting also directly mentioned NTDs by name, urging collaboration to "accelerate progress on controlling and eliminating neglected tropical diseases".[116]

In January 2012, the governments of the United States, the United Kingdom and the United Arab Emirates; pharmaceutical companies; the Bill and Melinda Gates Foundation; the World Bank; and other global health organizations came together to announce a coordinated effort to eliminate or control NTDs by 2020.[117] The impact of the London Declaration has yet to be seen, but the attention and support is a significant step in the right direction.

VI. Key NTD Policy Issues

Hudson Institute asked respondents in the personal interviews for their views on current NTD strategies, advocacy, and overall policy concerns. The main consensus of these interviews was that neither Congress nor the public were sufficiently informed about the value and feasibility of treating NTDs. For example, in the FY 2010 budget, Congress allocated only $65 million to NTDs, while twice as much ($151 million) was given to Avian Flu/Preparedness. While NTDs impact millions of the most marginalized people, avian flu, according to the World Health Organization (WHO), has caused less than 1,000 deaths between 2003 and 2012.

In addition to the need for increased advocacy, experts brought up the value of creating successful integration programs to address multiple infections. While there is clear evidence for integration of NTDs within themselves, there is also growing support for coupling NTD programming with treatment for HIV, malaria and tuberculosis. Because the big three make up such a large component of global health funding, there is concern that despite the large burden caused by NTDs, these infections are overshadowed. Below are a few of the main points brought up during the interviews:

- NTDs are second, only to HIV/AIDS, in global health burden as measured by DALYs lost. While they burden the most marginalized members of society, these diseases do not post an immediate threat to mortality, and thus are overshadowed by the big three;

- Addressing NTDs is essential to reaching the MDGs. The treatment of NTDs is relevant to the health focused goal six. Beyond this, because NTDs have a significant effect on women and children, addressing these infections is imperative to reaching gender equality, increasing school attendance, and improving maternal and child health;

[115] United Nations General Assembly Sixty-Fifth Session Resolution adopted by the General Assembly: Keeping the promise: united to achieve the Millennium Development Goals. September 2010. http://www.un.org/en/mdg/summit2010/pdf/outcome_documentN1051260.pdf (Accessed June 4, 2012).
[116] G8 Foreign Ministers Meeting Chair's Statement. Office of the Spokesperson, U.S. Department of State. April 2012. http://www.state.gov/r/pa/prs/ps/2012/04/187815.htm (Accessed June 5, 2012).
[117] London Declaration on Neglected Tropical Diseases. 2012. http://www.unitingtocombatntds.org/downloads/press/ntd_event_london_declaration_on_ntds.pdf (Accessed June 4, 2012).

- While addressing NTDs is necessary to achieving the MDGs, only 1.3% of the U.S. government global health budget is allocated to efforts to eliminate NTDs;

- These infections have significant impact on worker productivity, perpetuating the cycles of poverty that are endemic to the communities where NTDs thrive;

- Because the cost of treating NTDs can be as little as $0.50, the return on investment is one of the greatest in global health. For example, estimates show that spending $1 on treating lymphatic filariasis in China produced a $15 economic rate of return;[118]

- Integration can have significant cost benefits in treating NTDs, especially when geographic and cultural factors are considered during program design;

- Mass drug administration is essential to tackling these diseases in the short term. To ensure long term sustainability programs that focus on water and sanitation, environment, and vector control are needed;

- Public-private partnerships have been instrumental in achieving some of the successes of NTD programming.

One way to invigorate advocacy for NTDs is to view NTDs from a global health perspective that encompasses developmental issues, from health to agriculture to education. During Hudson Institute's interviews with experts in the field, we asked what sector has received the most gains from NTD programs. Most respondents indicated the health sector, with education and agriculture also frequently mentioned. Given the record of control for soil-transmitted helminths, particularly hookworm, in the American South, China, and Japan, and their contributions to overall economic development, it is not surprising that the educational sector was mentioned by most respondents. Trachoma hits hardest at school-age children, limiting their ability to attend classes on a regular basis and to compete educationally with non-infected peers. Even if a student is not infected, often times they are forced to stay home and care for their family members who have been infected. These findings argue for an increased emphasis on the impact of NTDs as both a public health and an economic issue.

The macroeconomic consequences of NTDs severely affect constituencies in ministries other than health. NTDs dilute agricultural productivity; reduce school attendance; result in growth stunting and slowed cognitive learning; increase poverty rates; impede wage earning potential in adulthood; lead to disabilities in working-age men and women heads of households; reduce the number of days one can work per year; affect the ability of patients to participate in any economic activity; promote social isolation of stigmatized individuals; facilitate the transmission of HIV/AIDS; and decrease life expectancy.

Ministries of Public Health will be held accountable for meeting many of the MDGs.

[118] Ramaiah KD, Das PK. Mass drug administration to eliminate lymphatic filariasis in India. Trends Parasitol. 2004 Nov;20(11):499-502.

However, it is ministries of agriculture and education that will bear the fiduciary burden for their governments' overall societal costs if they ignore the role that NTDs can contribute towards achieving MDGs. These ministries have to control progress towards solutions that are largely economic in nature, yet engage political and social institutions that are beyond the health sector itself.

During Hudson Institute's interviews, the agriculture sector was frequently mentioned. In the Congressional 2012 proposed budget for USAID, agriculture and food security are slated to receive $1.1 billion. This sector is also the beneficiary of substantial new funding from the Bill & Melinda Gates Foundation. Both USAID and the Foundation have based their funding in this sector on finding ways to increase agricultural productivity. Based on this interest, there is a need to further educate members of Congress on the large barrier to increased agriculture production created by NTDs in the poorest countries..

It is highly probable that by increasing productivity in the agriculture sector, many of the MDGs could also be better met, e.g., reducing poverty rates, improving school attendance and lowering maternal mortality rates. Without this programmatic integration, the global health community will not be able to progress along a pathway that allows it to meet its Millennium Development Goals (MDGs) by 2015.

VII. The Role of the Corporate Sector in NTDs

Many of the peer reviewed articles and personal interviews commented on the benefits of NTD integration with other programs. Based on Hudson's research of successful NTD control programs, one of the most important factors is that the implementation has been through effective public-private partnerships. These integrated efforts have involved not only pharmaceutical companies, but multilateral and bilateral funding agencies, national ministries of public health, education and agriculture, civil society, and the affected communities themselves all working in collaboration on a common effort, often with local leadership. The best practice for implementing NTD treatment programs is for countries to emulate the partnerships that have made the onchocerciasis, trachoma, and lymphatic filariasis programs such notable successes thus far.

There are three corporate programs that have made a significant difference in the control and elimination of three NTDs: onchocerciasis, lymphatic filariasis, and trachoma. The onchocerciasis program initiated by Merck & Co., Inc. has been in operation the longest, reaching 68 million people in Africa, Latin America, and Yemen via community-based treatment programs.[119] GlaxoSmithKline and Merck & Co., Inc. joined together to eliminate lymphatic filariasis, which currently has been eliminated or controlled in 16 countries.[120] The Edna McConnell Clark Foundation joined with the WHO to support studies on trachoma epidemiology and control, resulting in the SAFE (surgery, antibiotics, facial cleanliness, and environmental improvement) strategy as the basis for

[119] Waters HR, Rehwinkel JA, and Burnham G. Economic evaluation of Mectizan distribution. Trop Med Int Health. 2004 Apr;9(4):A16-25

[120] Dean M. Lymphatic filariasis has been eliminated in 16 countries, monitoring indicates. BMJ. 2008 Dec 10;337:a2944.

eliminating this disease. The program has made considerable progress through the treatment of more than 7 million individuals, resulting in a 50% cumulative reduction in active disease rates in children.[121] Pfizer also supported the effort to address trachoma by providing more than 200 million azithromycin tablets. A more detailed summary of each of these successful partnerships can be found in Appendix A.

While one can argue that the NTD agenda exists because of donations from the pharmaceutical industry, these corporations should not be the sole or primary players in this field. There are various organizations that have been created to help eliminate these diseases and there has been considerable support from the United States and the United Kingdom. Yet despite this support, the donor portfolio is not diversified and there needs to be increased attention from all global parties to the fight against NTDs.[122] Currently NTD elimination programs rely almost entirely on charitable drug donations from U.S. and U.K.-based pharmaceutical companies. For full elimination of these diseases, it is imperative that other countries and other corporations join the efforts as well.

This is slowly starting to happen as companies in emerging-market countries are beginning to enter the research and development drug sector, perceiving NTD drug development as a business opportunity.[123] Brazil is an example of an emerging country that has begun to enter this space. Due to the high prevalence of STHs, lymphatic filariasis, and trachoma in the BRIC nations, if these countries concentrated their efforts in addressing NTDs, then approximately 20% of the global burden of these three infections would be reduced.[124] In an interview with Hudson, Rahim Rezai, a researcher on emerging market drug development at the University of Toronto, noted that emerging market drug companies are pursuing drug development for NTDs as an investment, rather than a philanthropic initiative. Pharmaceutical companies in these markets may ultimately be the key in developing more effective treatments for NTDs.

VIII. Conclusions and Recommendations

NTD control efforts require increased attention and funding from the international community, as well as the countries where they are endemic, particularly in emerging-market economies that have the ability to shoulder some of the responsibility for control programs. NTD programs require sustained effort over a long period of time to be effective, as well as improvements in water and sanitation infrastructure and/or vector control. Far too often, NTDs have been categorized as “other diseases” and are overshadowed by efforts to combat HIV/AIDS, malaria, and tuberculosis. Yet, given the disproportionate impact of NTDs on the poorest of the poor, efforts to create sustainable growth in developing countries will be slowed if NTDs are not addressed.

[121] Kumaresan JA, Mecaskey JW. The global elimination of blinding trachoma: progress and promise. Am J Trop Med Hyg. 2003 Nov;69(5 Suppl):24-8.
[122] Interview with Chad MacArthur, Director of Neglected Tropical Disease Control, Helen Keller International., October 12, 2011.
[123] Frew SE, Liu VY, Singer PA. "A business plan to help the 'global South' in its fight against neglected diseases." Health Aff (Millwood). 2009 Nov-Dec;28(6):1760-73.
[124] Peter J. Hotez. Neglected Tropical Disease Control in the ‘‘Post-American World.’’ PLoS Negl Trop Dis. 2010 August 4(8): e812.

The cost-effectiveness of NTD programs are undeniable, especially in integrated programs, in areas where co-endemicity occur. In almost all cases, small investments are able to yield large returns. Societies that become healthier become wealthier, and this is evident from the results of NTD programming. NTD control programming leads to increased school attendance rates, increased worker productivity, increased available arable land, increased income, and obvious health impacts. NTD programming really is "one of the best cost-effective buys in global health today."[125]

In this regard, Hudson Institute's research indicates the potential for the NTD community to shift from viewing these diseases strictly within a health context and to also include the important economic context. It is here that the community can amply produce a well-documented record of success in terms of increased productivity, one substantiated by authoritative agencies and publications such as the World Bank, USAID and numerous peer reviewed journals such as the Lancet and the New England Journal of Medicine.

Unfortunately, interviews with key experts in the NTD field reveal that these programs have gone largely unnoticed by the greater global health and policy communities. Therefore, there is a need for more advocacy for NTD control, as well as education, to prevent these diseases from being labeled "other diseases." With increased advocacy efforts, effective NTD control strategies can become model programs, and the importance of addressing these diseases will garner attention on the global health agenda. Programs for HIV/AIDS, malaria and tuberculosis have strong advocacy components, often with at least one organization dedicated to such activities. Advocacy efforts through new or existing organizations, like the Global Network for NTDs, should expand their efforts to highlight the impact of NTDs in economic performance and the successes of NTD control programs.

With regard to best practices, a lot can be learned by examining country programs in combating these diseases. Morocco exemplifies the importance of partnership and the value of a multi-pronged approach to successfully eliminating trachoma. By combining azythromycin with the SAFE strategy and collaborating among the different ministries, corporations, NGOs, and foundations, Morocco was able to eliminate a disease that has been around for thousands of years.[126]

China's schistosomiasis program also shows the importance of a multi-pronged approach, addressing snail control and water and sanitation issues along with MDA.[127] In addition, China illustrates the importance of sustainability. While MDA alone was successful in decreasing prevalence rates in the short term, prevalence rates increased rapidly within two years after treatment was discontinued, showing the importance of the maintenance of schistosomiasis control.[128]

Through research and interviews with NTD practitioners and policymakers, we arrived at seven basic recommendations for progress in NTD control and elimination:

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[125] Interview with Alan Fenwick, Professor, Tropical Parasitology Imperial College, November 7, 2011
[126] Kumaresan JA, Mecaskey JW. The global elimination of blinding trachoma: progress and promise. Am J Trop Med Hyg. 2003 Nov;69(5 Suppl):24-8.
[127] Qing-Wu J, Li-Ying W, Jia-Gang G, et al. Morbidity control of schistosomiasis in China. Acta Tropica 2002; 82(2): 115-25.
[128] Ibid.

- Mass drug administration (MDA) has proven to be largely inexpensive and highly cost-effective, and should be the go-to strategy to manage NTDs in the short-term, during the implementation of long-term water and sanitation programs;

- Integrated control programs which involve NTDs and other major disease control programs should be encouraged where possible;

- The global health community should increase advocacy and funding for NTDs to create greater awareness about NTD programming successes and their cost-effectiveness and impact on economic growth among the public and policy-makers;

- NTDs as a brand name needs to be strengthened so that controlling these diseases is considered important to achieving the Millennium Development Goals (MDGs);

- NTDs need to become a part of the larger development agenda and pivot from an exclusive health context to a broader socio-economic fora;

- The NTD community should be a unified voice for advocacy and public awareness around NTD programming successes and their cost-effectiveness and impact on economic growth;

- Because corporations play such an enormous role in drug supply for NTDs, the public private partnership model should be expanded in order to successfully control or eliminate these diseases.

If these seven recommendations can be achieved, it will mean not only progress in reducing NTD disease burden, but the reality of eliminating NTDs throughout the world. NTDs are proven to be one of the best investments in public health, and the time for neglect is over.

Appendix A

Table 1: Prevalence, DALYs, Treatment, Drug Source, Cost of Treatment, and Selected Economic Benefits of NTDs

Disease	Prevalence[1] (millions)	DALYs[2] (millions)	Treatment[3]	Drug Source[4]	Cost of Treatment	Selected Economic Benefits
Lymphatic Filariasis	120	5.8	Single-dose Ivermectin or Diethylcarbamazine (plus Albendazole)	Mectizan donated by Merck & Co., Inc. and Albendazole by GSK	$0.06 – $2.23/person[5]	• Mass drug administration cost $4–8 per DALY averted.[6] • Increased worker productivity; chronic untreated patients lose as much as 11 years of productivity, at $50 dollars lost per year or 15% of an individual's income.[78] • Estimated economic return of $20-$60 per individual for every $1 invested.[9]
Onchocerciasis	37	0.5	Single-dose Ivermectin	Mectizan donated by Merck & Co., Inc.	$0.58-$0.78/person	• Treatment produced land use and labor return on investment.[10] • Estimated economic rate of return of OCP programs is 20% over a span of 39 years.[11]
Schistosomiasis	207	4.5	Single-dose Praziquantel	Praziquantel at $0.25 per Treatment donated by Merck KGaA[12]	$0.07/tablet or $0.20-$0.32/treatment [13]	• Treatment increased worker productivity and earning potential. • In $750,000 treatment program, worker productivity increased by $2.7 million.[14]
STH: Ascariasis	807	10.5	Single-dose Albendazole or Mebendazole (1–3 times/yr)	Albendazole donated by GSK	$0.03-$0.11/person[15]	• One year of schooling gained for $4 dollars spent per person on MDA in schools.[16] • Improved wage earnings in agricultural workers.[129] • Treating STH improves the outcome of HIV treatment.[130] • For every dollar spent on deworming, society gains more than $30.[131]
STH: Hookworm	576	22.1	Single-dose Albendazole or Mebendazole (1–3 times/yr)			
STH: Trichuriasis	604	6.4	Single-dose Albendazole or Mebendazole (1–3 times/yr)			
Trachoma	84	2.3	Surgery, Azithromycin, Face washing.	Zithromax donated by Pfizer	$0.20/person[132]	• Treatment halved childhood mortality and increased school attendance. [133] • Trichiasis surgery to those in need can avert 11 million DALYs per year, with a cost-effectiveness ranging from $13 to $78 per DALY averted.[134]

[129] Gilgen DD, Mascie-Taylor CG, Rosetta LL. Intestinal helminth infections, anemia and labor productivity of female tea pluckers in Bangladesh. Trop Med Int Health. 2001 Jun;6(6):449-57.
[130] Stephenson LS. Optimizing the benefits of anthelmintic treatment in children. Paediatr Drugs. 2001;3(7):495-508.
[131] Michael Kremer, The Wisest Investment We Can Make: Using Schools to Fight Neglected Tropical Disease. February 2008. http://blogs.cgdev.org/globalhealth/2008/02/the-wisest-investment-we-can-m.php (Accessed November 2, 2011)
[132] Molyneux DH, Hotez PJ, Fenwick A. "Rapid-impact interventions": how a policy of integrated control for Africa's neglected tropical diseases could benefit the poor. PLoS Med. 2005 Nov;2(11):e336.
[133] Porco TC, Gebre T, Ayele B et al. Effect of mass distribution of azithromycin for trachoma control on overall mortality in Ethiopian children: a randomized trial. JAMA. 2009 Sep 2;302(9):962-8.
[134] Porco TC, Gebre T, Ayele B et al. Effect of mass distribution of azithromycin for trachoma control on overall mortality in Ethiopian children: a randomized trial. JAMA. 2009 Sep 2;302(9):962-8.

[1] Hotez PJ, Molyneuw DH, Fenwick A, Kumaresan J, Sachs SE, Sachs JD, Savioli L. “Control of Neglected Tropical Diseases.” New England Journal of Medicine, 2007. 357:1018-27.
[2] Ibid.
[3] Ibid.
[4] Molyneux DH, Hotez PJ, Fenwick A. “Rapid-impact interventions”: how a policy of integrated control for Africa's neglected tropical diseases could benefit the poor. PLoS Med. 2005 Nov;2(11):e336.
[5] Goldman AS, Guisinger VH, Aikins M, et al. National mass drug administration costs for lymphatic filariasis elimination. PLoS Negl Trop Dis. 2007 Oct 31;1(1):e67.
[6] Ibid.
[7] Ramaiah KD, Das PK. Mass drug administration to eliminate lymphatic filariasis in India. Trends Parasitol. 2004 Nov;20(11):499-502
[8] Ramaiah KD, Das PK, Michael E, Guyatt H. The economic burden of lymphatic filariasis in India. Parasitology Today 2006; 16: 251-253.
[9] [9] Chu BK, Hooper PJ, Bradley MH, et al. The economic benefits resulting from the first 8 years of the Global Programme to Eliminate Lymphatic Filariasis (2000-2007). PLoS Negl Trop Dis. 2010 Jun 1;4(6):e708
[10] Brooker S, Kabatereine NB, Gyapong JO, et al. Rapid mapping of schistosomiasis and other neglected tropical diseases in the context of integrated control programs in Africa. Parasitology. 2009 Nov;136(13):1707-18.
[11] Kim A, Benton B. Cost-Benefit Analysis of the Onchocerciasis Control Program. World Bank Technical Paper #282. Washington, DC: The World Bank.
[12] Molyneux DH, Hotez PJ, Fenwick A. “Rapid-impact interventions”: how a policy of integrated control for Africa's neglected tropical diseases could benefit the poor. PLoS Med. 2005 Nov;2(11):e336.
[13] Ibid.
[14]Chu BK, Hooper PJ, Bradley MH, et al. The economic benefits resulting from the first 8 years of the Global Programme to Eliminate Lymphatic Filariasis (2000-2007). PLoS Negl Trop Dis. 2010 Jun 1;4(6):e708.
[15] Montresor A, Cong DT, Le Anh T, et al. Cost containment in a school deworming program targeting over 2.7 million children in Vietnam. Trans R Soc Trop Med Hyg. 2007 May;101(5):461-4.
[16] Bitran R, Martorell B, et. al. Controlling and Eliminating Neglected Diseases in Latin America and the Caribbean. Health Affairs. 2009. 28, no 6:1707-1719.

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