

## **Building a better egg-trap: *how a simple filtration device is aiding the fight against Schistosomiasis***

Schistosomiasis is a parasitic disease caused by Schistosome flatworms and is considered one of the Neglected Tropical Diseases, which are a group of tropical diseases endemic to low-income populations of Africa, Asia, and the Americas. However, Schistosomiasis affects more than 200 million people worldwide, and the CDC has placed it second only to malaria as the most devastating parasitic disease.

Efforts to combat this infection are ramping up dramatically. As an example, the Bill and Melinda Gates Foundation granted The Imperial College of London \$30 million dollars in 2002 to establish the Schistosomiasis Control Initiative (SCI), which initially partnered the college and the foundation with the World Health Organization and the Harvard School of Public Health. Their goal was to identify hot spots for infection, provide health education within those regions, treat victims, and monitor impact of the treatment program.

Schistosomiasis is relatively easy and inexpensive to treat. The major efforts to control this disease hinge, in part, upon the availability of simple, affordable methods of disease detection in at-risk populations. These methods include simple filtration devices that can be used in the field to easily detect the presence of schistosome eggs in the urine of infected individuals.

### **What is Schistosomiasis?**

Schistosomiasis is a parasitic infection by flat worms of the genus *Schistosoma*. In humans, Schistosomiasis is primarily caused by 3 species of Schistosomes: *Schistosoma haematobium* and *Schistosoma mansoni*, which are generally found throughout Africa, and *Schistosoma japonicum*, which is found in Indonesia and parts of China and Southeast Asia.

### **Schistosome worms have a 4-stage life cycle:**

- Stage 1: Juvenile Schistosomes infect fresh water snails.
- Stage 2: In snails, Schistosomes mature to semi-adult forms that are released into the water where they must infect vertebrate hosts, such as humans, within 48 hours.
- Stage 3: In their vertebrate hosts, Schistosomes complete maturation to sexually competent adults that inhabit specific host blood vessels. These mature adults then lay eggs that are released to the environment through feces and urine.
- Stage 4: Once the eggs hit fresh water, juvenile worms hatch to begin the next life cycle.

### **What are the symptoms of Schistosomiasis?**

The symptoms of Schistosomiasis are not caused by the worms themselves but by the body's reactions to eggs laid by mating pairs. Thus most people have no symptoms upon

initial infection. However, left untreated, chronic Schistosomiasis can have devastating consequences. Furthermore, the different species of worms reside within two main niches within their hosts. *S. mansoni* and *S. japonicum* generally inhabit veins of the intestines, and their eggs are released through the walls of the intestines to be expelled from the body with the feces. On the other hand, *S. haematobium* generally inhabits veins of the bladder, ureters, and kidneys to release its eggs into the urine. Habitation of these two niches results in distinct symptoms that stratify cases of Schistosomiasis as either intestinal or urogenital (listed below).

### Intestinal Schistosomiasis

- Abdominal pain
- Diarrhea
- Blood in the stool
- Liver enlargement

### Urogenital Schistosomiasis

- Haematuria (blood in urine)
- Bladder and ureteral fibrosis
- Potential kidney damage
- Potential bladder cancer
- Potential infertility
- Lesions of the cervix and vagina
- Vaginal bleeding
- Vaginal pain during intercourse
- Nodules on the vulva
- Pathologies of the seminal vesicles and prostate

Due to constant bleeding, both forms of Schistosomiasis can result in anemia and malnutrition. In children, chronic forms of Schistosomiasis can stunt growth and reduce the ability to learn; in adults, it can reduce work efficiency. While many of the symptoms of Schistosomiasis can be reversed with treatment, chronic Schistosomiasis can also lead to death. In fact, in sub-Saharan Africa alone, Schistosomiasis causes more than 200,000 deaths per year.

## **Who is at risk of infection?**

Because of Schistosome's dependence on specific species of freshwater snails, Schistosomiasis is restricted to the regions in which their hosts live. However, it is notable that within these regions, over 600 million people are at risk of infection<sup>2</sup>. Also, because of the dependence on fresh water snails, infection and reinfection occurs through contact with contaminated water. As such, the most at-risk populations are: (1) children who bath and swim in contaminated waters, (2) women who use contaminated water sources for domestic tasks, such as laundry, and (3) agriculture workers.

## **How is Schistosomiasis detected in patients?**

### *Urine and stool analysis*

The most broadly accepted method for diagnosing Schistosomiasis is by a microscopic evaluation of feces or urine for the presence of schistosome eggs. Fecal samples are

evaluated by a method called the Kato-Katz smear method, which can detect the presence of intestinal schistosomes. In contrast, urine filtration is the only method that can detect schistosomes in the urine<sup>5</sup>.

An advantage of urine filtration is that it is easily used in the field at remote locations. With this method, urine is manually filtered through a polycarbonate, nylon, or paper filter using a syringe. Any eggs present in the urine are caught by the filter, which is then mounted on a microscope slide and stained to allow clear visualization of the eggs by microscopy. Using a standard volume of 10mL, the severity of infection can also be determined by quantifying the number of eggs present<sup>5</sup>. Similarly, methods have been established to evaluate egg reduction over time to determine drug treatment effectiveness<sup>4</sup>.

Despite the potential ease of urine filtration as a field application for detecting schistosomes, urine filtration kits can be cost prohibitive; for example, the Millipore schistosome filtration device cost over \$2 per filter. However, less expensive filtration kits are becoming available on the market and are being evaluated for accuracy compared to the established, but costly Millipore filtration device<sup>1</sup>. Reduction in the cost of these devices will allow increased testing and monitoring of schistosomiasis in resource-poor settings.

#### *Other indicators of disease*

Blood in the urine can also be an indicator of Schistosomiasis. The parasite *S. haematobium* almost always causes at least microscopic levels of blood in urine, and chemical reagent test strips can be used to detect this in infected patients. Finally, in the case of travelers or immigrants from areas where schistosomiasis is endemic, doctors can diagnose schistosomiasis by determining if specific schistosomiasis antibodies are present in a patient's blood.

## **How is Schistosomiasis treated?**

The standard treatment for Schistosomiasis is simple and inexpensive- a single oral tablet of Praziquantel, costing 18 cents per treatment, effectively combats all species of schistosomes known to cause schistosomiasis<sup>6</sup>. Upon exposure to the drug, schistosomes contract and break their attachment from the blood vessels, and eventually disintegrate.

While treatment is straightforward, the ability to combat Schistosomiasis is limited by drug accessibility. In 2011, only 10% of Schistosomiasis patients needing treatment were able to obtain the drug<sup>6</sup>. Treatment of schistosome-infected children is particularly important, as prompt treatment reduces the risk of developing severe disease, even upon reinfection.

## **Can Schistosomiasis be controlled and/or prevented?**

Schistosomiasis can be prevented by (1) a single, annual dose of Praziquantel, (2) access to clean water, (3) improved sanitation, and (4) reduction and elimination of the snail schistosome hosts. The WHO has developed guidelines for community treatment of Schistosomiasis which involves periodic, targeted treatment of at-risk groups with Praziquantel. The at-risk groups target by WHO reside within areas with endemic disease and include school-aged children, adults who have contact with infested water (i.e., fisherman, farmers, irrigation workers, women who have domestic tasks that use infested

water), and communities living within highly endemic areas. Monitoring infection frequencies by detecting the presence of eggs in urine and stool is a key component of these prevention control strategies, as the frequency of preventative treatment is dictated by prevalence of the disease in school-age children.

In the past 20 years, several countries, including Brazil, Cambodia, China, Egypt, Saudi Arabia, and possibly Morocco have successfully implemented Schistosomiasis control programs. Other countries such as Burkina Faso, Niger, and Uganda have increased Schistosomiasis treatment campaigns. Indeed, the number of people treated for Schistosomiasis doubled from 12.4 million in 2006 to 28.1 million in 2011. However, the implementation of treatment programs can be severely impacted by unreliable funding, as seen in the severe fluctuations in treatment numbers in the intervening years between 2006 and 2011.

More consistent progress in controlling Schistosomiasis globally is anticipated in the near future as more than 70 governments, NGOs, and pharmaceutical companies pledged to implement a WHO roadmap to guide policies and political strategies<sup>3</sup>. Central to this goal will be monitoring disease severity within populations as well as monitoring treatment effectiveness, both of which rely on urine filtration devices. Thus, reliable, cost-effective filtration devices are paramount to treating, controlling, and preventing Schistosomiasis on a global level.

## References

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