Cryptosporidium Contamination of Drinking Water for People Living with HIV/AIDS: The Need for Effective Interventions

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***Cryptosporidium* among people living with HIV/AIDS (PLHIV)**. The waterborne pathogen *Cryptosporidium* is currently one of the most frequently identified intestinal pathogens throughout the world and one of the most common waterborne pathogens associated with diarrhoea in people living with HIV/AIDS (PLHIV) [1]. *Cryptosporidium* can be found in surface water sources and also groundwater sources susceptible to flooding or fecal contamination, and may be present in piped "improved" drinking water systems that use these water sources. *Cryptosporidium* causes cryptosporidiosis which is a severe and life-threatening illness in immunocompromised patients such as individuals with HIV/AIDS [2], and cryptosporidiosis was one of the AIDS-defining illnesses before the discovery of the HIV virus [3]. Cryptosporidiosis is difficult to treat, contributes to the debilitation of PLHIV, and often persists longer and may result in higher mortality in PLHIV compared to HIV-negative individuals. In the *Cryptosporidium* outbreaks in piped drinking water in the United States, the majority of subsequent mortality [4] and morbidity [5] was among PLHIV. In low-income countries, cryptosporidiosis may account for as much as 50% of cases of diarrhoea in HIV-infected individuals [6]. Furthermore, the majority of PLHIV live in sub-Saharan Africa (68%, 22.5 million) [7] where the need for safe drinking water is the greatest and where cryptosporidiosis in children is also a significant health issue [8].

Household Water Treatment as a Potential Solution. Household water treatment (HWT) technologies treat water at the household level to make it safe before drinking. HWT has the potential to significantly reduce diarrhoeal disease by improving drinking water quality [9-11], particularly for immunocompromised individuals who are more susceptible to waterborne pathogens. HWT technologies have shown 25-36% reductions in diarrhoeal disease among PLHIV and their infants in low-income settings [12-14]. The World Health Organization (WHO) particularly recommends HWT for PLHIV in low-income settings [15] and the U.S. President's Emergency Plan for AIDS Relief (PEPFAR) currently supports HWT programs for PLHIV and their households [16-17]. Following WHO and PEPFAR policy recognition in 2008, international organizations including USAID, the World Bank, and WHO have called for an integration of water and sanitation activities in HIV/AIDS programs [18-21]. Efforts to integrate HWT into home-based care and multi-disease prevention packages for PLHIV have been successful as implementation strategies [22-27].

Inadequacy of Current Programs and the Need for Effective Interventions. Though efforts to improve drinking water for PLHIV have produced promising results, these programs have not reached the full potential of HWT. In the 2010 PEPFAR country operational plans, chlorination technologies were included more frequently than any other HWT technologies [28] and the majority of HWT interventions included in basic care packages for PLHIV have been in the form of chlorination products [29-30]. However, chlorination is ineffective against *Cryptosporidium* oocysts unless combined with other treatment mechanisms [31]**.** Given that cryptosporidiosis is known to be an important opportunistic infection among PLHIV particularly in low-income settings, health impacts may be greater for HWT interventions that are effective against the full range of waterborne diarrhoeagenic microorganisms.

Though there has been a lack of HWT technology standards until recently, the new 2011 WHO guidelines provide guidance for programs to select interventions which will provide the best standard of care. *Cryptosporidium* is one of three test organisms used in these WHO health-based targets for HWT. In addition to bacteria and virus removal/inactivation, these targets require *Cryptosporidium* removal/inactivation to be at least 99.99% for technologies to be classified as 'highly protective' and at least 99% removal/inactivation to be classified as 'protective'; the remainder of technologies are classified as 'interim' at best [32]. Because the majority of HWT interventions targeting PLHIV have been chlorination technologies that are ineffective against *Cryptosporidium*, the highest achievable WHO target with these interventions would be classified as interim. Though technologies that are 'protective' or 'interim' may contribute to a substantial reduction in waterborne disease risk, HWT technologies should be chosen that achieve the greatest removal possible with consideration of cost-effectiveness and the local context [32]. There are a variety of existing HWT technologies - such as boiling, forms of filtration, flocculation/disinfection, solar disinfection, and ultraviolet disinfection - that are able to remove/inactivate to varying degrees the full array of microbial pathogens, and a combination of technologies may be used to maximize pathogen removal/inactivation.

Therefore, *Cryptosporidium* is one of the most common waterborne pathogens associated with diarrhoea in PLHIV, but the majority of the safe water programs currently targeting PLHIV in low-income countries do not adequately protect against this pathogen of great concern. Though efforts to improve drinking water quality among PLHIV are laudable, more can be done for this vulnerable population. If implementers adhere to the WHO guideline and make it a policy that when available 'highly protective'' interventions should be used and that 'protective' interventions should be a minimum standard, this will ensure that PLHIV are offered the best protection against cryptosporidiosis and waterborne diseases. This is a call to action for safe water programs to maximize protection against *Cryptosporidium* and all microbial contamination for PLHIV - those that need it the most.

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