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WATER, SANITATION AND HYGIENE:
SUSTAINABLE DEVELOPMENT AND MULTISECTORAL APPROACHES

# *Cryptosporidium* contamination of water in Africa Impact on mortality rates for children with HIV/AIDS

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*There are currently an estimated 2 million children with HIV/AIDS worldwide, 90% of whom are in sub-Saharan Africa. Currently approximately 500,000 to 700,000 children acquire HIV infection per year and approximately 300,000 children died of AIDS in 2007. Children living with HIV/AIDS are at particular risk of chronic diarrhea from Cryptosporidium (Cryptosporidiosis) and if infected they are far more likely to suffer major complications or death. Cryptosporidiosis has been found to be a significant predictor of childhood death in sub-Saharan Africa. Studies in sub-Saharan Africa have shown a high prevalence of, cryptosporidiosis in children aged 6-36 months, particularly among children who are malnourished or HIV positive and during rainy seasons. For example, heavy rains from November 2005 to February 2006 in Botswana led to a dramatic increase in admissions and visits to hospitals and health centers of infants leading to the death of 22% of inpatient infants. Adequate sanitation and water treatment are critical for minimizing Cryptosporidium exposure for children living with HIV/AIDS.*

## Introduction

The waterborne pathogen *Cryptosporidium* is now one of the most commonly identified intestinal pathogens throughout the world and one of the most common waterborne pathogens associated with diarrhea in people with AIDS. *Cryptosporidium* causes Cryptosporidiosis which is a severe and life-threatening illness in immunocompromised patients such as individuals with HIV/AIDS (Abubakar et al., 2007). There are currently an estimated 2.1 million children with HIV/AIDS worldwide (WHO, 2008) 90% of them in sub-Saharan Africa. Currently approximately 500,000 to 700,000 children aged less than 15 years of age acquire HIV infection per year (17% of new infections), the great majority from the mother during pregnancy, delivery or from breastfeeding. Approximately 300,000 children died of AIDS in 2007 representing 14% of all AIDS deaths (WHO, 2008). Persistent and/or chronic diarrhoea is a major cause of mortality in AIDS patients and children are at particular risk. A pooled analysis of 9 clinical studies of infants in sub-Saharan Africa found that by 2 years of age, 52.5% of HIV positive infants and 7.6% of HIV negative infants had died (Newell et al., 2004). Brahmbhatt et al., 2005 found similar results in Uganda.

*Cryptosporidium* may account for as much as 50% of cases of diarrhea in HIV-infected patients in less developed countries (Morgan et al., 2000). The introduction of antiretroviral therapy (ART) has significantly reduced the impact of cryptosporidiosis on HIV-infected individuals in developed countries but most adults and children living with HIV/AIDS in sub-Saharan Africa are currently not being treated with ART. In sub-Saharan Africa as of December, 2007, only 30% of people living with HIV/AIDS and needing ART were receiving ART (WHO, 2008) and the percentage for children is likely lower. WHO reports that for countries reporting data, only 8% of children born to mothers living with HIV were tested for HIV within the first 2 months of birth. This is due in part to the fact that standard HIV antibody testing cannot identify infected infants in their first year of life, it detects maternal HIV antibodies that are transferred to the baby during pregnancy (and later decline slowly in the first year of life). More demanding HIV testing called virological tests, are required for diagnosing HIV infection status for young infants.

## Cryptosporidiosis and children

In sub-Saharan Africa, cryptosporidiosis is most prevalent during early childhood. Children in sub-Saharan Africa are very vulnerable to Cryptosporidiosis because of the effects of immune systems that are not yet fully developed, malnutrition, and HIV infection. Cryptosporidiosis has been found to be a significant predictor of childhood death in sub-Saharan Africa (Mor and Tzipori, 2008). In a study in Tanzania, Cegielski et al., 1999 studied Cryptosporidiosis, microsporidiosis, and cyclosporiasis in admitted patients that included HIV positive children. They found that severe dehydration was more frequent among children with Cryptosporidiosis than among children without it. *Cryptosporidium* was the most frequent and *Cyclospora* the least frequent pathogen identified. Sodemann et al., 1999 identified risk factors for persistent diarrhoea (> 14 days) in Guinea-Bissau, West Africa and current infection with *Cryptosporidium* was one of the most important independent risk factors for the development of persistent diarrhea.

In a study of 243 children admitted to Uganda's Mulago National Referral Hospital for persistent diarrhea (> 14 days), 74% of HIV-positive children and only 6% of HIV-negative children were infected with *Cryptosporidium* (Tumwine at al., 2005). In a study conducted of 200 children admitted to the malnutrition ward at the University Teaching Hospital in Lusaka, Zambia, HIV status was found to influence nutritional states of all children. Antibodies to HIV were found in 54% of patients and *Cryptosporidium* was the most common pathogen detected. 20% of the admitted children died within 28 days and cryptosporidiosis and severe malnutrition were independent predictors of death (Amadi et al., 2001).

| **Table 1. Cryptosporidium water contamination risk issues** |
|---|
| Surface water: Surface water sources increase risk of infection, particularly in the rainy season. |
| Well water: During rainy season(s), runoff can contaminate shallow wells resulting in Cryptosporidium contamination (Gamba et al. 2000) |
| Sanitation: The importance of good sanitation - In Africa, the main source of Cryptosporidium is humans based on the latest research but animals also contribute to a smaller extent. |
| HIV/AIDS: Cryptosporidium is particularly dangerous for immunocompromised adults and children with AIDS. Infection rates increase in the rainy season. |

## Seasonal and rainfall impacts on *Cryptosporidium* levels

A number of studies in Africa have shown a high prevalence of cryptosporidiosis in children aged 6-36 months, particularly among children who are malnourished or HIV positive and particularly during rainy seasons. The Water Environment Research Foundation funded the development of a model to predict *Cryptosporidium* oocyst levels in watersheds. As part of that effort, a sensitivity analysis showed that variations of the levels of rainfall intensity consistently had the largest effect on receiving water *Cryptosporidium* levels (WERF, 2004). Molbak et al., 1993 found that Cryptosporidiosis was most common in younger children and at the beginning of the rainy seasons. Cryptosporidiosis prevalence was 15% in cases of persistent diarrhoea compared with 6% in diarrhoea lasting less than two weeks. They found that Cryptosporidiosis was correlated with increased mortality in children who had the infection in infancy, and this increased mortality lasted into the second year of life (risk ratio of 2.9). The increased mortality could not be explained by factors such as breast-feeding or malnutrition. Tumwine at al., 2003 conducted a study over a 15-month period of hospitalized children (0–5 years old) with diarrhea at Mulago Hospital in Kampala, Uganda. They found that 25% of the children with diarrhea had *Cryptosporidium* and that the prevalence rate was highest during the rainy season of April to June. 12.6% of the children with *Cryptosporidium* died, compared with 6.2% without *Cryptosporidium.*

In community-based studies conducted for 7 years in Guinea-Bissau, West Africa, stool specimens from children with diarrhoea aged less than 5 years old were routinely examined for parasites. *Cryptosporidium* was the second most common parasite found in the 4,922 samples, exceeded only by *Giardia*, which is less of a significant health threat. The highest prevalence of *Cryptosporidium* was found in children 6-11 months old. Cryptosporidiosis showed a distinct seasonal pattern, with peak rates found consistently at the beginning of the rainy seasons. No seasonal trend was found for the enteric parasites *Giardia* or *Entamoeba histolytica* (Perch et al., 2001). Muchiri et al., 2009 found that the surface waters in Kenya they sampled were *Cryptosporidium*-contaminated at the end of rainy seasons. This was consistent with the timing of

Cryptosporidiosis reported by other researchers from East Africa but differed from results reported by others for West Africa where peak levels have been reported at the beginning of the rainy season.

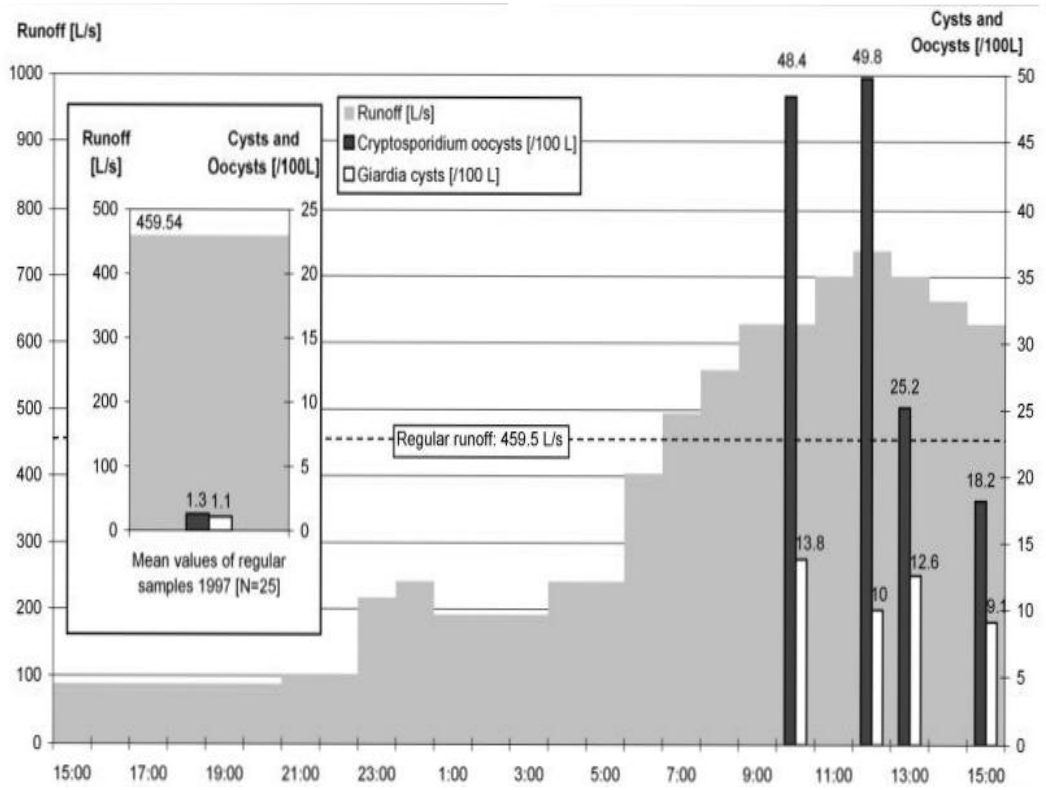


**Figure 1. The increase of *Cryptosporidium* and *Giardia* concentration in a tributary to a drinking water reservoir following heavy rainfall**

Source: WHO 2006

Because of the high HIV prevalence rate for pregnant woman in Botswana (33% in 2005) many young infants are fed with infant formula prepared using local water to prevent mother-to-child HIV transmission from breast-feeding. Heavy rains from November 2005 to February 2006 in Botswana led to contamination of water and a dramatic increase in admissions and visits to hospitals and health centers of infants with severe and prolonged diarrhea. Hospitals were swamped with patients and the Ministry of Health requested assistance from the US Centers for Disease Control (CDC). (Creek et al., 2007 and Table 2 below). Testing from the CDC indicated that *Cryptosporidium* was the pathogen most frequently detected in infant inpatients. Infant mortality rates (22%) were high for infants less than 2 years old and malnutrition was a contributing factor to high death rates regardless of HIV status.

| **Table 2. Example of Impact of Heavy Rains on Infant Mortality Due to *Cryptosporidium* Contamination of Water – Botswana, (2005 – 2006)** |
|---|
| Botswana has high HIV prevalence rate for pregnant women (33% in 2005) which led to high percentage of infants being formula fed using local water instead of breastfeeding. |
| Heavy rains in Botswana led to widespread water contamination and severe outbreak of childhood illness and death. |
| Cryptosporidium was the waterborne pathogen most frequently detected in stools (60%) of children. |
| 22% of inpatients died (90% were < 2 years old), malnutrition was a contributing factor. |
| "Not all diarrhea is equal" – Cryptosporidium and enteropathogenic E. coli caused life threatening diarrheal illness. |

## Conclusions

Children living with HIV/AIDS are at particular risk of persistent diarrhea from *Cryptosporidium* (Cryptosporidiosis) and if infected they are far more likely to suffer major complications or death. In a study of 243 children with persistent diarrhea (> 14 days) in Uganda, 74% of HIV-positive children and only 6% of HIV-negative children were infected with *Cryptosporidium* (Tumwine at al., 2005).

The introduction of antiretroviral therapy (ART) has significantly reduced the impact of cryptosporidiosis on HIV-infected individuals in developed countries but most children living with HIV/AIDS in sub-Saharan Africa are currently not being treated with ART. As of December, 2007, only 30% of people living with HIV/AIDS and needing ART in sub-Saharan Africa were receiving ART (WHO, 2008) and the percentage for young infants is likely much lower.

A number of studies have shown a correlation between infection with *Cryptosporidium* and the rainy season in sub-Saharan Africa. *Cryptosporidium* is particularly associated with use of water sources such as (i) surface water or (ii) shallow wells contaminated by surface water during the rainy season. Effective water treatment and adequate sanitation for human wastes are critical for minimizing *Cryptosporidium* exposure.

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