

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

Contents

1 Introduction	2
2 Why Reproductive, Maternal, Newborn and Child Health and WASH?.....	3
3 WASH-Related Diseases	4
4 Microbiological WASH-Related Diseases	5
4.1 Amoebiasis	5
4.2 Cholera	6
4.3 Cryptosporidiosis.....	6
4.4 <i>Escherichia coli</i>	7
4.5 Giardiasis	7
4.6 Hepatitis E.....	8
4.7 Hookworm.....	8
4.8 Malaria	9
4.9 Rotavirus.....	9
4.10 Schistosomiasis	10
4.11 Toxoplasmosis	10
4.12 Trachoma.....	11
4.13 Typhoid Fever	12
5 Chemical WASH-Related Diseases	12
5.1 Arsenicosis.....	12
5.2 Fluorosis	13
5.3 Methaemoglobinaemia	13
6 Additional Resources	14
7 References	14

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

1 Introduction

This Technical Brief introduces water, sanitation and hygiene (WASH)-related diseases of concern for reproductive, maternal, newborn and child health (RMNCH). It also discusses the impacts of these diseases on RMNCH. CAWST has several resources focused on health and WASH at www.cawst.org/resources:

- **Technical Brief on RMNCH and the Importance of WASH:** This Technical Brief introduces the overall impact of poor WASH on RMNCH, discusses nutrient deficiencies, and identifies ways to prevent WASH-related diseases.
- **Technical Brief on Health and WASH-Related Diseases:** This Technical Brief has detailed information about WASH-related diseases, such as the symptoms, prevalence, transmission routes, and prevention methods.

CAWST focuses on the planning, design and implementation of household-based water, sanitation and hygiene (WASH) solutions in low-income, non-networked communities. The target audience for CAWST's health and WASH education resources and training workshops are individuals and organizations who are:

- Working in health, WASH, or community development projects seeking solutions for WASH
- Program organizers or project managers with the responsibility for organizing projects and making decisions
- Motivated to start or strengthen projects for improving health



Definitions

Child: A person that is up to five years old.

Fetus: Is in the later stages of development in the pregnant woman.

Infant: A child that is between 1–12 months old.

Low birth weight: The weight of a baby at birth of less than 2,500 grams (5.5 pounds).

Maternal: Includes women from the time a child is conceived, through pregnancy, and up to six weeks after birth.

Newborn: A child that is between 0–28 days old.

Pathogen: Any living organism that causes disease. Pathogens commonly found in drinking water include bacteria, viruses, protozoa and helminths.

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

Perinatal period: Begins at 22 completed weeks (154 days) of gestation and ends 7 completed days after birth.

Premature birth: Also called preterm birth. A baby born alive before 37 weeks of pregnancy are completed.

Reproductive age: Includes women between 15-44 years old.

Stunting: Being too short for one's age. Stunting is a measure of chronic malnutrition

2 Why Reproductive, Maternal, Newborn and Child Health and WASH?

Improving water supply, drinking water quality, sanitation, hygiene, and management of water resources can dramatically benefit reproductive, maternal, newborn and child health (PMNCH, 2014). Globally, WASH has an impact on the health of pregnant women, newborns and children. For example,

- In developing countries an estimated 10–15% of maternal deaths, are due to infections that can be directly linked to unhygienic conditions during labour and birth, at home or in facilities, and to poor hygiene practices in the six weeks after birth (PMNCH, 2014).
- About 1,000 children die each day because of unsafe drinking water, inadequate sanitation and poor hygiene (Prüss-Ustün, 2014).
- 50% of global malnutrition is due to waterborne diseases such as diarrhea and intestinal worms, and 25% of stunting can be attributed to five or more episodes of diarrhea before two years of age (PMNCH, 2014).

CAWST recommends a comprehensive WASH approach to improve maternal, newborn and child health: safe drinking water, improved sanitation and proper hygiene practices. Increasing use of improved water sources can decrease maternal mortality because pregnant women will be exposed to less WASH-related diseases, which cause diarrhea and can contribute to anemia. Diarrhea in infants can be decreased by more than a third when mothers practice proper handwashing, food hygiene and household hygiene. Safe disposal of feces decreases the risk of diarrhea in infants by 37% (PMNCH, 2014).

“Creating multi-sectoral interventions that address WASH and RMNCH, and integrating WASH into existing frameworks and agendas for health, has the potential to bring about lasting and positive change for women, children, families and communities.”

(PMNCH, 2014)

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

A variety of WASH-related diseases significantly increase illness and death in pregnant women, newborns and children. Many of these health impacts are long lasting and increase the vulnerability of pregnant women and children.

It's important to understand the impact of WASH-related diseases in order to find solutions to prevent these diseases. To learn more about ways to prevent WASH-related diseases, see CAWST's resources about household water treatment and safe storage, sanitation, community WASH promotion, and our Technical Brief on RMNCH and the Importance of WASH. All resources are found at www.cawst.org/resources.

3 WASH-Related Diseases

When access to safe water, adequate sanitation and proper hygiene is poor, WASH-related diseases are common. WASH-related diseases include diseases caused by microbiological organisms and chemicals found in water. Microbiology is the study of organisms that are too small to be seen with the naked eye.

Water naturally contains many living things. Most are harmless or even beneficial to people, but others can cause illness. Living things that cause disease are also known as pathogens. They are sometimes called other names, such as microorganisms, microbes or bugs, depending on the local language and country. There are four main categories of WASH-related pathogens: bacteria, viruses, protozoa and helminths.

Water may also contain chemicals, which can be helpful or harmful to our health. There are different ways that chemicals get into drinking water. Some are found naturally in groundwater, such as arsenic, fluoride, sulphur, calcium, magnesium and manganese. Human activities such as agriculture, industry and our daily lives can also add chemicals such as nitrogen, phosphorous and pesticides to water.

Some chemicals can cause illness after drinking water with high levels of the chemical over a long time. Even though there are many chemicals that may occur in drinking water, only a few cause health effects on a large-scale. Arsenic and fluoride are usually the chemicals that are most concerning. Other chemicals, such as nitrates and nitrites may also be an issue in certain situations (WHO, 2006b).

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

Table 1: WASH-Related Diseases

Type	How People Get Sick	Example Diseases	How to Prevent Illness
Waterborne	Drinking water with pathogens	Diarrhea, cholera, typhoid, shigellosis, hepatitis A and E, cryptosporidiosis, giardiasis	Improve drinking water quality by removing or killing pathogens. Improve basic hygiene practices. Improve sanitation.
Water-washed	Pathogens touch the skin or eye	Trachoma, scabies	Provide enough water for basic hygiene. Improve basic hygiene practices.
Water-based	Pathogens go through the skin	Schistosomiasis	Do not contact water that is known to be contaminated. Improve sanitation. Kill or reduce habitat of snails or other hosts of the pathogen.
Insect vector	Pathogens are passed on by insects that breed or live in water, such as mosquitos	Malaria, dengue, yellow fever, filariasis, river blindness, sleeping sickness	Prevent insects from breeding in water. Use pesticides to control insects. Prevent insects from biting by using bed nets and wearing long clothes.
Water-chemical contaminant	Drinking chemically contaminated water	Arsenicosis, fluorosis	Use a source of water that is low in that chemical. Improve drinking water quality by removing chemicals.
Soil-transmitted helminths	Pathogens go through the skin, or eating food with pathogens	Hookworm, ascariasis	Use latrines that are clean and well maintained. Treat feces that are used on crops. Improve food hygiene.

(Adapted from Cairncross et al., 1996)

4 Microbiological WASH-Related Diseases

In this section, we describe the health impacts of microbiological WASH-related diseases on pregnant women, fetuses, newborns and children.

4.1 Amoebiasis

Amoebiasis is a common waterborne disease caused by a protozoa called *Entamoeba histolytica* (*E. histolytica*). Amoebiasis is common worldwide (Heymann, 2008).

Impact on	Health Impact
Children	<ul style="list-style-type: none"> In a large multi-country study, children with amoebiasis had double the death rate (Kotloff et al., 2013).

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

4.2 Cholera

Cholera is a waterborne disease caused by bacteria called *Vibrio cholerae* (*V. cholerae*). There are three to five million cholera cases every year. Cholera can cause severe dehydration and 100,000 to 120,000 people die from dehydration caused by cholera each year. Up to 80% of cases can be successfully treated by oral rehydration salts (WHO, 2014a). When a pregnant woman becomes dehydrated, the fetus does not get enough blood, oxygen, and nutrients from the woman. Dehydration has serious impacts on pregnant women, newborns and children.

Impact on	Health Impact
Pregnant Women	<ul style="list-style-type: none"> In one study, pregnant women were two times more likely to die from cholera as non-pregnant women (Cartwright et al., 2013).
Fetus	<ul style="list-style-type: none"> In four studies from four different countries, an average of 30% of fetuses died when their mother was infected with cholera (MSF, 2011).
Children	<ul style="list-style-type: none"> In one study, children under two years old with cholera had a risk of death eight times higher than adults. These were children living in countries where cholera is endemic. These are countries where there have been cholera cases in three of the last five years (Ali et al., 2012).

4.3 Cryptosporidiosis

Cryptosporidiosis is a waterborne disease caused by protozoa called *Cryptosporidium*, primarily *Cryptosporidium parvum* and *hominis* (*C. parvum*, *C. hominis*). Cryptosporidiosis is found worldwide. The prevalence of the disease is 3–20%, in developing countries (Heymann, 2008). Cryptosporidiosis can cause diarrhea, which impacts pregnant women and children. In young children and people with weak immune systems, cryptosporidiosis can cause diarrhea that is persistent (lasts more than 14 days).

Impact on	Health Impact
Children	<ul style="list-style-type: none"> A number of studies show increased child mortality when the child has cryptosporidiosis. In a large multi-country study, <i>Cryptosporidium</i> infection was associated with a 130% increase in the death rate for children (Kotloff et al., 2013). Significant risk of death for HIV positive people, including children (Mahin et al., 2011). Cryptosporidiosis can lead to persistent diarrhea in children less than two years old. Persistent diarrhea at a young age can cause poor cognitive development – the process of developing intelligence and problem-solving ability (Guerrant et al., 1999; Niehaus et al., 2002). Persistent diarrhea caused by cryptosporidiosis increases malnutrition and stunting (Iannotti et al., 2014; Kirkpatrick et al., 2002; Tumwine et al., 2003).

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

4.4 *Escherichia coli*

Escherichia coli (*E. coli*) is a group of bacteria, some of which are pathogenic and cause disease. Enterotoxigenic strains (ETEC) of *E. coli* are among the most important pathogens causing dehydrating diarrhea in infants and children under the age of three, in developing countries (Heymann, 2008). Severe, dehydrating diarrhea is a risk to pregnant women, newborns and children.

Impact on	Health Impact
Pregnant Women	<ul style="list-style-type: none"> In a study in Bangladesh and India, adults had severe, dehydrating, cholera-like illness when infected with ETEC (Qadri et al., 2005).
Children	<ul style="list-style-type: none"> <i>E. coli</i> is associated with persistent diarrhea in children (Ochoa et al., 2008). Persistent diarrhea at a young age can cause poor cognitive development – the process of developing intelligence and problem-solving ability (Guerrant et al., 1999; Niehaus et al., 2002). <i>E. coli</i> is associated with greater rates of moderate-to-severe diarrhea in children (Kotloff et al., 2013).

4.5 Giardiasis

Giardiasis is a waterborne disease caused by a protozoa called *Giardia lamblia*. Giardiasis is found worldwide. In developing countries, approximately 33% of people have been infected by *Giardia* (CDC, 2014a). Giardiasis can cause diarrhea that is persistent (lasts 14 days or more) (Heymann, 2008).

Impact on	Health Impact
Pregnant Women	<ul style="list-style-type: none"> Persistent <i>Giardia</i> infection can lead to malabsorption in pregnant women (SA, 2014). Malabsorption is when the body is not able to properly absorb nutrients.
Children	<ul style="list-style-type: none"> Giardiasis has been associated with persistent diarrhea in children (Muhsen et al., 2012). Persistent diarrhea at a young age can cause poor cognitive development – the process of developing intelligence and problem-solving ability (Guerrant et al., 1999; Niehaus et al., 2002). Malnourished children with <i>Giardia</i> commonly experience persistent diarrhea leading to stunting (Dupont et al., 2013; Bartelt et al., 2013).

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

4.6 Hepatitis E

Hepatitis E is a waterborne disease caused by the Hepatitis E virus. There are 20 million Hepatitis E infections each year. More than 56,000 people infected with the virus die each year (WHO, 2014b). Pregnant women are very susceptible to Hepatitis E.

Impact on	Health Impact
Pregnant Women	<ul style="list-style-type: none"> Mortality rates for pregnant women who contract HEV are approximately 20% (WHO, 2014b) One study in Bangladesh found that just under 10% of maternal deaths in the study area were related to Hepatitis, most likely Hepatitis E (Labrique et al., 2012).
Newborns	<ul style="list-style-type: none"> Hepatitis E has been associated with higher rates of fetal death and premature birth (Krain, 2014).

4.7 Hookworm

Hookworm is a soil-transmitted disease caused by a helminth, such as *Ancylostoma duodenale* and *Necator americanus*. It is found mostly in tropical and sub-tropical regions of the world (Heymann, 2008).

Impact on	Health Impact
Pregnant Women	<ul style="list-style-type: none"> Up to 44 million pregnant women are infected with hookworm. Hookworm infection increases the rate of anemia in pregnant women. In pregnant women, anemia caused by hookworm results in increased risk of death for the woman and reduced breast milk production. <p>(USAID, 2014a)</p>
Newborns	<ul style="list-style-type: none"> Anemia in pregnant women caused by hookworm infection causes low birth weight of the newborn. <p>(USAID, 2014a)</p>
Children	<ul style="list-style-type: none"> Hookworm infection increases the rate of anemia in children. Anemia results in an increased risk of death in children. Chronic hookworm infection has been shown to impair physical and intellectual development, reduce school performance and attendance, and adversely affect future productivity and wage-earning potential. <p>(USAID, 2014a)</p>

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

4.8 Malaria

Malaria is a water-insect vector disease transmitted by the *Anopheles* mosquito. The disease is caused by protozoa called *Plasmodium falciparum*, *P. vivax*, *P. ovale*, or *P. malariae*. Malaria is found mostly in tropical and sub-tropical regions of the world (Heymann, 2008). About 3.4 billion people live in areas where malaria is transmitted in 97 countries, and 1.2 billion live in high-risk areas. Pregnant women, newborns and children are very vulnerable to malaria (WHO, 2013c). In 2012, 482,000 children died from malaria, which was 76% of the total deaths from malaria. (WHO, 2013c). The disease is also a high risk for pregnant women (Heymann, 2008).

Impact on	Health Impact
Pregnant Women	<ul style="list-style-type: none"> Malaria in pregnancy is associated with anemia in pregnant women. Infection with <i>P. falciparum</i> and <i>P. vivax</i> is associated with chronic anemia in pregnant women (WHO, 2013c).
Fetuses	<ul style="list-style-type: none"> Fetuses whose mothers have malaria are at a higher risk of death (WHO, 2013a).
Newborns	<ul style="list-style-type: none"> Newborns born to pregnant women with chronic anemia have a higher risk of death (WHO, 2013c). Pregnant women with anemia are more likely to have low birth weight newborns (WHO, 2013c). Low birth weight newborns have higher levels of a variety of health problems. Low birth weight is also a major contributor to newborn and infant mortality (Yasmin et al., 2001; Carlo et al., 2010).
Children	<ul style="list-style-type: none"> Children with malaria are at high risk of severe anemia (WHO, 2013b). Children are more likely to develop cerebral malaria (WHO, 2013b), which is a severe type of malaria.

4.9 Rotavirus

Rotavirus infection is spread through feces, often by person-to-person contact or through contaminated objects. It may also be spread by airborne droplets or contaminated food or water, though these are not the main transmission routes. Globally, rotavirus is linked to about 40% of children who are hospitalized with diarrheal disease. They are a leading cause of severe diarrhea. Rotavirus is a disease that primarily infects infants and young children. All children are typically infected by age three. Children are particularly vulnerable between six months and two years old (Heymann, 2008). About 450,000 children under the age of five died from rotavirus in 2008, primarily in developing countries (WHO, 2014c).

Impact on	Health Impact
Children	<ul style="list-style-type: none"> Significant cause of child mortality in developing countries. The WHO recommends better water and sanitation and the rotavirus vaccine as ways to prevent infection (WHO, 2014d). In children, it causes an estimated 40% of hospital admissions for diarrhea (Fewtrell et al., 2005).

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

4.10 Schistosomiasis

Schistosomiasis is a water-based disease caused by a group of helminths called *Schistosoma*. It is common in tropical and sub-tropical areas, affecting almost 240 million people worldwide (WHO, 2014d). According to USAID, “Schistosomiasis is considered second only to malaria as the most devastating parasitic disease in tropical countries (USAID, 2014b).”

Women and children who are in contact with contaminated water are at high risk of being infected with schistosomiasis. Research shows that women who have female genital schistosomiasis are also at greater risk of becoming infected with HIV (WHO, 2014d; Mbabazi et. al., 2011).

Impact on	Health Impact
Pregnant Women	<ul style="list-style-type: none"> In one study, pregnant women with schistosomiasis had a 65% higher rate of anemia (Ajangaa et al., 2006). Pregnant women are at greater risk of developing severe anemia, which increases their risk of death (Nour, 2010).
Fetuses	<ul style="list-style-type: none"> Fetuses whose mothers are infected with schistosomiasis are at higher risk of death (Fairly et al., 2013; Siza, 2008; Siegrist et al., 1992).
Newborns	<ul style="list-style-type: none"> Newborns whose mothers were infected with schistosomiasis have a 45% increased chance of having a low birth weight (Fairly et al., 2013; Siza, 2008; Siegrist et al., 1992).
Children	<ul style="list-style-type: none"> Children can have reduced physical abilities and intellectual growth and an increase in anemia, malnutrition, and learning difficulties (Nour, 2010; USAID 2014b). Children with schistosomiasis have a 40% higher rate of anemia than children who do not have the disease (Deribew et al., 2013).

4.11 Toxoplasmosis

Toxoplasmosis is a food and waterborne disease caused by a protozoa called *Toxoplasma gondii*. Toxoplasmosis is found worldwide, but infections are more common in hot, humid climates and lower altitudes. In some populations, up to 95% of people are infected with *Toxoplasma* (CDC, 2014b). Pregnant women, their fetuses, newborns and children are particularly vulnerable to toxoplasmosis infections if a woman’s first exposure to the protozoa is during pregnancy.

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

Impact on	Health Impact
Fetus	<ul style="list-style-type: none"> • Toxoplasmosis can be transmitted from the woman to the fetus, before the child is born. • <i>Toxoplasma</i> infection can cause death of the fetus (Montoya et al., 2008). In one study, Toxoplasmosis infection increased the rate of fetal death by more than six times (Li et al., 2014). • Pregnant women with toxoplasmosis have a higher risk of fetal abnormality. In one study, the risk of fetal abnormality was six times higher for pregnant women infected with <i>Toxoplasma</i> than women who were not infected (Li et al., 2014). Fetal abnormalities include severe eye infections, mental disability, and seizures. • Fetuses of pregnant women who were infected with toxoplasmosis have an increased chance of premature birth. In one study, the risk of premature birth was more than three times greater if the mother had toxoplasmosis (Li et al., 2014).
Children	<ul style="list-style-type: none"> • Children may appear healthy at birth. However, <i>Toxoplasma</i> infection before birth can result in visual and hearing loss, seizures, blood problems as the child grows (Montoya et al., 2008).

4.12 Trachoma

Trachoma is a water-washed disease caused by a bacteria called *Chlamydia trachomatis*. Trachoma is an eye infection that may result in blindness, after repeated infections. Trachoma is found worldwide. Blinding trachoma is most common in the Middle East, northern and sub-Saharan Africa, southeastern Asia and China, and parts of the Indian sub-continent (Heymann, 2008). “Trachoma spreads easily from person to person and is frequently passed from child to child and from child to mother within the family.” (WHO, 2014e)

Impact on	Health Impact
Pregnant Women	<ul style="list-style-type: none"> • Women, including pregnant women, are at higher risk of trachoma. Women spend more time close to children. Women are two to four times more likely to become blind from trachoma than men (Courtright et al., 2014).
Children	<ul style="list-style-type: none"> • Children are the most vulnerable to infection because of poor hygiene practices, but the most severe symptoms (e.g., blindness) may not appear until adulthood (WHO, 2014e).

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

4.13 Typhoid Fever

Typhoid fever is a waterborne disease that is caused by a bacteria called *Salmonella typhi*. Typhoid fever is found worldwide. It causes about 17 million cases and 600,000 deaths each year (Heymann, 2008).

Impact on	Health Impact
Pregnant Women	<ul style="list-style-type: none"> In one study, being pregnant was a risk factor for infection with typhoid fever. However, there were no adverse pregnancy outcomes (Sulaiman et al., 2007).
Children	<ul style="list-style-type: none"> In one study in Bangladesh, children less than one year old had the highest risk of death from typhoid fever compared to older children and adults. 11% of children less than one year old infected with typhoid fever died (Butler et al., 1991).

5 Chemical WASH-Related Diseases

In this section, we describe the health impacts of chemical WASH-related diseases on pregnant women, fetuses, newborns and children.

5.1 Arsenicosis

Arsenicosis is a disease caused by drinking water or eating food contaminated with arsenic for several years. People who are exposed develop chronic health problems called arsenicosis. Arsenic can naturally occur in groundwater and some surface water. It is one of the greatest chemical problems in developing countries. The WHO considers arsenic to be a high priority for screening in drinking water sources (WHO, 2006b). It is estimated that more than 226 million people worldwide have been exposed to [high levels of] arsenic (Murcott, 2012). Arsenic is poisonous to all living things and can be particularly dangerous to pregnant women and children.

Impact on	Health Impact
Fetuses	<ul style="list-style-type: none"> Two studies found that fetuses were two to three times more likely to die if their mother was exposed to arsenic as compared to mothers who were not exposed to arsenic (Ahmad et al., 2001; Milton et. al., 2005). Preterm births are also two to three times higher in pregnant women exposed to arsenic (Ahmad et al., 2001; Milton et. al., 2005).
Newborns	<ul style="list-style-type: none"> Newborns born to women who had been exposed to arsenic during their pregnancies had an 80% greater risk of dying in their first 30 days (Milton et al., 2005).
Children	<ul style="list-style-type: none"> This study found that children exposed to arsenic have a greater risk of lower respiratory tract infections than children with no exposure to arsenic (Rahman et al., 2011).

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

5.2 Fluorosis

Fluorosis is a disease caused by drinking water or eating food contaminated with high levels of fluoride for several years. Fluoride is a naturally occurring chemical that may be found in groundwater and some surface water. Small amounts of fluoride are generally good for people's teeth. But it can damage people's teeth by increasing decay over time if people are exposed to levels that are too high. Eventually, if the exposure levels are high, fluoride can build up in people's bones and cause crippling skeletal damage. Infants and young children are most at risk from high amounts of fluoride since their bodies are still growing and developing. It is believed that fluorosis affects millions of people around the world, but there are no accurate figures estimating the problem (WHO, 2006a).

Impact on	Health Impact
Pregnant Women	<ul style="list-style-type: none"> High fluoride in drinking water may reduce birth rates (Frenia, 1994).
Children	<ul style="list-style-type: none"> Findings from a meta-analysis of 27 studies published over 22 years found that children who lived in areas with high exposure to fluoride had lower IQ scores than those who lived in low exposure areas (Choi et al., 2012). IQ or intelligence quotient is one measure of human intelligence.

5.3 Methaemoglobinaemia

Methaemoglobinaemia (also known as blue baby syndrome), is an illness caused by high nitrate and nitrite levels in drinking water. Nitrate in groundwater and surface water is normally low, but can reach high levels if there is contamination from agricultural fertilizers or from human and animal feces. Methaemoglobinaemia is a particular concern for babies less than three months old that are bottle fed with formula prepared with drinking water. Methaemoglobinaemia is now rare in most of the industrialized countries. It is a risk in developing countries, for example where the drinking water is from shallow wells in farming areas. There is no reliable estimate of the extent of the problem worldwide. The World Health Organization (WHO) is presently collecting information in order to make such an estimate (WHO, n.d.).

Impact on	Health Impact
Newborns and Infants	<ul style="list-style-type: none"> Bottle-fed infants less than three months of age are particularly at risk (WHO, n.d.) Malnutrition and infection seem to increase the risk of methaemoglobinaemia (McDonald & Kay, 1988 cited in WHO, n.d.). Can cause serious illness and even death (WHO, n.d.). Babies with methaemoglobinaemia often also have gastrointestinal illness (e.g., diarrhea) at the same time. (WHO, n.d.).

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

6 Additional Resources

CAWST resources. Available at: www.cawst.org/resources

- Health and WASH: research summaries and WASH-related diseases.
- General WASH: household water treatment and safe storage, community WASH promotion, environmental sanitation, latrine design and selection, and handwashing.

The Partnership for Maternal, Newborn, & Child Health (2014). PMNCH Knowledge Summary #30 Water, sanitation and hygiene - the impact on RMNCH. Available at: www.who.int/pmnch/knowledge/publications/summaries/ks30/en/

- This research summary identifies links between water, sanitation and hygiene and maternal, newborn and child health. It summarizes WASH interventions for RMNCH and their impact.

Yardley, S. (2010) "Joining the Dots: Why Better Water, Sanitation and Hygiene are Necessary for Progress on Maternal, Newborn and Child Health." *Tearfund*

- This report identifies links between water, sanitation and hygiene and maternal, newborn and child health.

UNICEF (2009) "Diarrhoea: Why Children Are Still Dying and What Can Be Done". *United Nations Children's Fund/World Health Organization*.

- This report focuses on prevention and management of diarrheal diseases in children.

7 References

Ahmad et al. (2001). Arsenic in drinking water and pregnancy outcomes. *Environmental Health Perspectives*, 109(6) 629-31.

Ahmed, J.A., Moturi, E., Spiegel, P., Schilperood, M., Burton, W., Kassim, N.H., . . . Marano, N. (2013). Hepatitis E Outbreak, Dadaab Refugee Camp, Kenya, 2012. *Emerging Infectious Diseases*, (19)6, 1010-1012.

Ajanga, A., Lwambo, N.J., Blair, L., Nyandindi, U., Fenwick, A. & Brooker, S. (2006). *Schistosoma mansoni* in pregnancy and associations with anaemia in northwest Tanzania. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, Jan;100(1), 59-63. doi:10.1016/j.trstmh.2005.06.024

Ali, M., Lopez, A.L., You, Y.A., Kim, Y.E., Sah, B., Maskery, B., & Clemens, J. (2012). The global burden of cholera. *Bulletin of the World Health Organization*, 2012;90, 209-218A. doi:10.2471/BLT.11.093427

Bartelt, L.A., Roche, J., Kolling, G., Bolick, D., Noronha, F., Naylor, C., . . . Guerrant, R. (2013). Persistent *G. lamblia* impairs growth in a murine malnutrition model. *The Journal of Clinical Investigation*, 123(6), 2672-2684. doi:10.1172/JCI67294

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

Beniwal, M., Kumar, A., Kar, P., Jilani, N., & Sharma, J.B. (2003). Prevalence and severity of acute viral hepatitis and fulminant hepatitis during pregnancy: A prospective study from north India. *Indian Journal Medical Microbiology*, 21, 184-185.

Bista, B.K. & Rana, A. (2006). Acute Hepatitis E in Pregnancy - Study of 16 Cases. *Journal of Nepal Medical Association*, 45(161), 182-185.

Boccia, D., Guthmann, J.P., Klovdstad, H., Hamid, N., Tatay, M., Ciglenecki, I., . . . Guerin, P.J. (2006). High mortality associated with an outbreak of hepatitis E among displaced persons in Darfur, Sudan. *Clinical Infectious Diseases*, Jun 15;42(12), 1679-1684.

Butler, T., Islam, A., Kabir, I., & Jones, P.K. (1991). Patterns of morbidity and mortality in typhoid fever dependent on age and gender: review of 552 hospitalized patients with diarrhea. *Reviews of Infectious Diseases*, 13(1), 85-90. doi:10.2307/4455769

Cairncross, S. & Feachem, R. (1996). *Environmental Health Engineering in the Tropics*. (Second ed.). West Sussex, England: John Wiley & Sons Ltd.

Carlo, W.A., Goudar, S.S., Jehan, I., Chomba, E., Tshefu, A., Garces, A., . . . Wright, L.L. (2010). High Mortality Rates for Very Low Birth Weight Infants in Developing Countries Despite Training. *Pediatrics*, 126(5), e1072-e1080. doi:10.1542/peds.2010-1183

Cartwright, E.J., Patel, M.K., Mbopi-Keou, F.X., Ayers, T., Haenke, B., Wagenaar, B.H., . . . Quick, R. (2013). Recurrent epidemic cholera with high mortality in Cameroon: persistent challenges 40 years into the seventh pandemic. *Epidemiology and Infection*, 141(10), 1-11. doi:10.1017/S0950268812002932

Centers for Disease Control and Prevention (CDC). (page last updated July 13, 2012). *Parasites - Giardia - Disease*. Retrieved from <http://www.cdc.gov/parasites/giardia/disease.html>

Centers for Disease Control and Prevention (CDC). (page last reviewed January 10, 2013). *Parasites - Toxoplasmosis (Toxoplasma infection) - Epidemiology & Risk Factors*. Retrieved from <http://www.cdc.gov/parasites/toxoplasmosis/epi.html>

Choi, A.L., Sun, G., Zhang, Y., & Grandjean, P. (2012). Developmental fluoride neurotoxicity: a systematic review and meta-analysis. *Environmental Health Perspectives*, 120(10), 1362-1368. doi:10.1289/ehp.1104912.

Courtright, P. & West, S.K. (2004). Contribution of Sex-linked Biology and Gender Roles to Disparities with Trachoma. *Emerging Infectious Diseases*, 10(11), 2012-2016. doi:10.3201/eid1011.040353

Deribew, K., Tekeste, Z., Petros, B., & Huat, L.B. (2013). Urinary schistosomiasis and malaria associated anemia in Ethiopia. *The Asian Pacific Journal of Tropical Biomedicine*, 3(4), 307-310. doi:10.1016/S2221-1691(13)60068-4

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

Dreyfuss, M.L., Msamanga, G.I., Spiegelman, D., Hunter, D.J., Urassa, E.J.N., Hertzmark, E, & Fawzi, W.W. (2001). Determinants of low birth weight among HIV-infected pregnant women in Tanzania. *American Journal for Clinical Nutrition*, 74, 814–826.

DuPont, H.L. (2013). *Giardia*: both a harmless commensal and a devastating pathogen. *The Journal of Clinical Investigation*, 123(6), 2352-2354. doi:10.1172/JCI69932

Fairley, J.K., Bisanzio, D., King, C.H., Kitron, U., Mungai, P., Muchiri, E., . . . Malhotra, I. (2013). Birthweight in offspring of mothers with high prevalence of helminth and malaria infection in coastal Kenya. *The American Journal of Tropical Medicine and Hygiene*, 88(1), 48–53. doi:10.4269/ajtmh.2012.12-0371

Fewtrell, L., Kaufmann R.B., Kay D., Enanoria W., Haller L., Colford J.M. (2005). Water, Sanitation, and Hygiene Interventions to Reduce Diarrhoea in Less Developed Countries: A systematic review and meta-analysis. *The Lancet Infectious Diseases*, 5:1; 42-52

Freni, S.C. (1994). Exposure to high fluoride concentrations in drinking water is associated with decreased birth rates. *Journal of Toxicology and Environmental Health*. 42(1), 109-121. doi:10.1080/15287399409531866

Guerrant, D.I., Moore, S.R., Lima, A.A., Patrick, P.D., Schorling, J.B. & Guerrant, R.L. (1999). Association of early childhood diarrhea and cryptosporidiosis with impaired physical fitness and cognitive function four-seven years later in a poor urban community in northeast Brazil. *The American Journal of Tropical Medicine and Hygiene*, 61(5), 707–713.

Heymann, D.L. (Ed.) (2008). *Control of Communicable Diseases Manual*. (19th ed.). Washington, DC: American Public Health Association.

Iannotti, L.L., Trehan, I., Clitheroe, K.L., & Manary, M.J. (2014). Diagnosis and treatment of severely malnourished children with diarrhoea. *Journal of Paediatrics and Child Health*, 2014 Sep 5. doi:10.1111/jpc.12711

icddr,b (2009). Outbreak of hepatitis E in a low income urban community in Bangladesh. *Health and Science Bulletin*, 7(3).

Jaiswal, S.P., Jain, A.K., Naik, G., Soni, N., & Chitnis, D.S. (2001). Viral hepatitis during pregnancy. *International Journal of Gynecology & Obstetrics*, Feb;72(2), 103-108.

Kirkpatrick, B.D., Daniels, M.M., Jean, S.S., Pape, J.W., Karp, C., Littenberg, B., . . . Sears, C.L. (2002). Cryptosporidiosis Stimulates an Inflammatory Intestinal Response in Malnourished Haitian Children. *Journal of Infectious Diseases*, 186(1), 94-101. doi:10.1086/341296

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

Kotloff, K.L., Nataro, J.P., Blackwelder, W.C., Nasrin, D., Farag, T.H., Panchalingam, S., . . . Levine, M.M. (2013). Burden and aetiology of diarrhoeal disease in infants and young children in developing countries (the Global Enteric Multicenter Study, GEMS): a prospective, case-control study. *The Lancet*, 382(9888), 209 – 222. doi:10.1016/S0140-6736(13)60844-2

Krain, L. J., Atwell, J. E., Nelson, K. E., & Labrique, A. B. (2014). Fetal and Neonatal Health Consequences of Vertically Transmitted Hepatitis E Virus Infection. *American Journal of Tropical Medicine and Hygiene*, 90(2), 365–370. <http://doi.org/10.4269/ajtmh.13-0265>

Labrique, A.B., Sikder, S.S., Krain, L.J., West, K.P., Christian, P., Rashid, M., & Nelson, K.E. (2012). Hepatitis E, a Vaccine-Preventable Cause of Maternal Deaths. *Emerging Infectious Diseases*, 18(9), 1401.

Li, X-L., Wei, H-X., Zhang, H., Peng, H-J., & Lindsay, D.S. (2014). A Meta Analysis on Risks of Adverse Pregnancy Outcomes in *Toxoplasma gondii* Infection. *PLoS ONE*, 9(5): e97775. doi: 10.1371/journal.pone.0097775

McDonald, A.T. & Kay, D. Water resources issues and strategies. UK: Longman Scientific and Technical, 1988, p 146-148

Mahin, T. & Peletz, R. (2009, May). Cryptosporidium contamination of water in Africa - Impact on mortality rates for children with HIV/AIDS. Paper presented at the 34th WEDC International Conference, Addis Ababa, Ethiopia. Retrieved from wedc.lboro.ac.uk/resources/conference/34/Mahin_T_-_316.pdf

Mbabazi, P.S., Andan, O., Fitzgerald, D.W., Chitsulo, L., Engels, D., & Downs, J.A. (2011). Examining the Relationship between Urogenital Schistosomiasis and HIV Infection. *PLoS Neglected Tropical Diseases*, 5(12), e1396. doi:10.1371/journal.pntd.0001396

Milton, A.H., Smith, W., Rahman, B., Hasan, Z., Kulsum, U., Dear, K., ...Ali, A. (2005) Chronic Arsenic Exposure and Adverse Pregnancy Outcomes in Bangladesh. *Epidemiology*, 16 (1), 82-86.

Montoya, J.S. & Remington, J.S. (2008). Management of *Toxoplasma gondii* Infection during Pregnancy. *Clinical Infectious Diseases*, 47, 554–566.

Medicins Sans Frontieres (MSF). (2011, November). Cholera and Pregnancy - *Pregnancy outcomes from a specialized cholera treatment unit for pregnant women in Léogâne, Haiti*. Presented at the 13th Inter-agency Working Group on Reproductive Health in Crises (IAWG) Conference, Istanbul, Turkey. Retrieved from http://www.unicef.org/cholera/Chapter_8_case_management/11_IAWG_Cholera_in_pregnancy_Haiti.pdf

Muhsen, K. & Levine, M.M. (2012). A Systematic Review and Meta-analysis of the Association Between *Giardia lamblia* and Endemic Pediatric Diarrhea in Developing Countries. *Clinical Infectious Diseases*, 55(4), S271-S293. doi:10.1093/cid/cis762

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

Murcott, S. (2012). *Arsenic Contamination in the World: An International Sourcebook*. London: IWA Publishing.

Niehaus, M.D., Moore, S.R., Patrick, P.D., Derr, .L.L., Lorntz, B., Lima, A.A., & Guerrant, R.L. (2002). Early childhood diarrhea is associated with diminished cognitive function 4 to 7 years later in children in a northeast Brazilian shantytown. *The American Journal of Tropical Medicine and Hygiene*, 66(5), 590-593.

Nour, N.M. (2010). Schistosomiasis: Health Effects on Women. *Obstetrics & Gynecology*, 3(1), 28-32.

Ochoa, T.J., Barletta, F., Contreras, C., & Mercado, E. (2008). New insights into the epidemiology of enteropathogenic *Escherichia coli* infection. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 102(9), 852–856. doi:10.1016/j.trstmh.2008.03.017

Patra, S., Kumar, A., Trivedi, S.S., Puri, M., & Sarin, S.K. (2007). Maternal and Fetal Outcomes in Pregnant Women with Acute Hepatitis E Virus Infection. *Annals Internal Medicine*, 147(1), 28-33. doi:10.7326/0003-4819-147-1-200707030-00005

The Partnership for Maternal, Newborn, & Child Health (PMNCH). (2014). *PMNCH Knowledge Summary #30 Water, sanitation and hygiene - the impact on RMNCH*. Retrieved from <http://www.who.int/pmnch/knowledge/publications/summaries/ks30/en/>

Prüss-Ustün, A., Bartram, J., Clasen, T., Colford, J.M., Cumming, O., Curtis, V., . . . Cairncross, S. (2014). Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: a retrospective analysis of data from 145 countries. *Tropical Medicine and International Health*. 19(8), 894-905 doi: [10.1111/tmi.12329](https://doi.org/10.1111/tmi.12329)

Qadri, F., Svennerholm, A-M., Faruque, A.S.G., & Sack, R.B. (2005). Enterotoxigenic *Escherichia coli* in Developing Countries: Epidemiology, Microbiology, Clinical Features, Treatment, and Prevention. *Clinical Microbiology Review*, 18(3), 465-483. doi:10.1128/CMR.18.3.465-483.2005

Rahman, A., Vahter, M., Ekström, E.C., & Persson, L.A. (2011). Arsenic exposure in pregnancy increases the risk of lower respiratory tract infection and diarrhea during infancy in Bangladesh. *Environmental Health Perspectives*, 119, 719–724.

South Australian Maternal & Neonatal Clinical Network, Department of Health, Government of South Australia. (11 February 2014). *South Australian Perinatal Practice Guidelines – Giardiasis* (PDS reference CG130). Retrieved from http://www.sahealth.sa.gov.au/wps/wcm/connect/f3ac4d804ee47b91804b8dd150ce4f37/Giardiasis_May2014.pdf?MOD=AJPERES

Shrestha, N.S., Shrestha, S.K., Singh, A., Malla, K., & Thapa, L.B. (2011). Maternal and Perinatal Outcome of Pregnancy with Hepatitis E Infection. *Journal of South Asian Federation of Obstetrics and Gynecology*, 2011;3(1), 17-20. doi: 10.5005/jp-journals-10006-1115

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

Siza, J.E. (2008). Risk factors associated with low birth weight of neonates among pregnant women attending a referral hospital in northern Tanzania. *Tanzania Journal of Health Research*, 10(1).

Siegrist, D., & Siegrist-Obimpeh, P. (1992). *Schistosoma haematobium* infection in pregnancy. *Acta Tropica*, 50(4), 317–321.

Singh, S., Mohanty, A., Joshi Y.K., Deka, D., Mohanty, S., & Panda, S.K. (2003). Mother-to-child transmission of hepatitis E virus infection. *Indian Journal of Pediatrics*, Jan;70(1), 37–39.

Sulaiman, K. and Sarwari, A.R. (2007) Culture-confirmed typhoid fever and pregnancy. *International Journal of Infectious Diseases*, Vol 11, Issue 4, Pages 337–341.

Thomson, K., Dvorzak, J.L., Lagu, J., Laku, R., Dineen, B., Schilperood, M., . . . Clarke, K. (2013). Investigation of Hepatitis E Outbreak Among Refugees — Upper Nile, South Sudan, 2012-2013. *Morbidity and Mortality Weekly Report*, 62(29), 581-586.

Tumwine, J.K., Kekitiinwa, A., Nabukeera, N., Akiyoshi, D.E., Rich, S.M., Widmer, G., . . . Tzipori, S. (2003). *Cryptosporidium parvum* in children with diarrhea in Mulago Hospital, Kampala, Uganda. *The American Journal of Tropical Medicine and Hygiene*, 68(6), 710-715.

Tsega, E., Hansson, B.G., Krawczynski, K., & Nordenfelt, E. (1992). Acute sporadic viral hepatitis in Ethiopia: causes, risk factors, and effects on pregnancy. *Clinical Infectious Diseases*, Apr;14(4), 961-965.

USAID (2014a). (page last reviewed June 5, 2014) *Target Diseases – Soil Transmitted Helminths – Hookworm*. Retrieved from http://www.neglecteddiseases.gov/target_diseases/soil_transmitted_helminthiasis/hookworm/

USAID (2014b). (page last reviewed June 5, 2014) *Target Diseases – Soil Transmitted Helminths – Schistosomiasis*. Retrieved from http://www.neglecteddiseases.gov/target_diseases/schistosomiasis/index.html

WHO (no date). (page last reviewed May 2015) *Water-related diseases: Methaemoglobinaemia*. Geneva, Switzerland. Retrieved from http://www.who.int/water_sanitation_health/diseases/methaemoglob/en/

WHO (2006a). Fluoride in drinking water. Geneva, Switzerland. Retrieved from http://www.who.int/water_sanitation_health/publications/fluoride_drinking_water/en/

WHO (2006b). Guidelines for Drinking Water Quality, Third Edition. Geneva, Switzerland. Retrieved from www.who.int/water_sanitation_health/dwq/gdwq3rev/en/index.html

WHO (2013a). (page last reviewed – no date). *Malaria – Areas of work - High-risk groups*. Retrieved from http://www.who.int/malaria/areas/high_risk_groups/en/

Technical Brief: Reproductive, Maternal, Newborn and Child Health and WASH-Related Diseases

WHO (2013b). (page last reviewed – no date). *Malaria – Areas of work - Malaria in children under five*. Retrieved from http://www.who.int/malaria/areas/high_risk_groups/children/en/

WHO (2013c). World Malaria Report 2013. Geneva, Switzerland. Retrieved from http://www.who.int/malaria/publications/world_malaria_report_2013/report/en/

WHO (2014a). (page last reviewed February 2014) *Media Centre – Fact sheets - Cholera*. Retrieved from <http://www.who.int/mediacentre/factsheets/fs107/en/>

WHO (2014b). (page last reviewed June 2014) *Media Centre – Fact sheets - Hepatitis E*. Retrieved from <http://www.who.int/mediacentre/factsheets/fs280/en/>

WHO (2014c). (page last reviewed January 27, 2014) *Vaccines and diseases - Rotavirus*. Retrieved from <http://www.who.int/immunization/diseases/rotavirus/en/>

WHO (2014d). (page last reviewed no date) *Schistosomiasis*. Retrieved from <http://www.who.int/schistosomiasis/en/>

WHO (2014e). (page last reviewed no date). *Water Sanitation Health - Water-related Diseases - Trachoma*. Retrieved from http://www.who.int/water_sanitation_health/diseases/trachoma/en/

Yasmin, S., Osrin, D., Paul, E., & Costello, A. (2001). Neonatal mortality of low-birth-weight infants in Bangladesh. *Bulletin of the World Health Organization*, 79 (7)

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