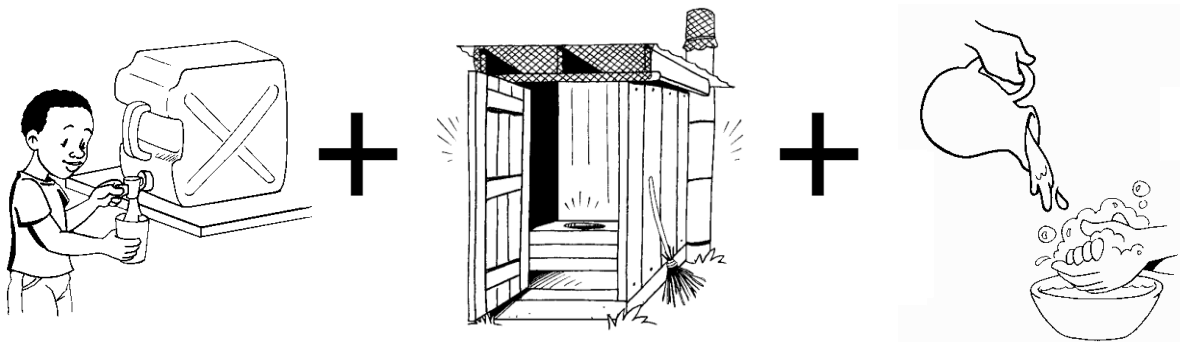


Literature Summary: Impacts of WASH on Reproductive, Maternal, Newborn and Child Health

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1 Introduction

This literature summary includes research summaries for the impact of water, sanitation and hygiene (WASH) on reproductive, maternal, newborn and child health (RMNCH). The research summaries include short information about individual studies and the results. Some summaries include a CAWST summary with what you need to know as a practitioner about the study.

CAWST has several other resources focused on health and WASH at www.cawst.org/resources. These resources include more information about individual diseases and their impact on health.

- **Technical Brief on RMNCH and WASH-Related Diseases:** This Technical Brief introduces WASH-related diseases of concern for reproductive, maternal, newborn and child health (RMNCH). It also discusses the impacts of these diseases on RMNCH.
- **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

For the purpose of this Technical Brief:

- Maternal includes pregnant women, from the time the child is conceived to six weeks after birth.
- A fetus is a child that is in the later stages of development in the pregnant woman.
- A newborn is a child that is between 0 – 28 days old.
- An infant is a child that is between 1 – 12 months old.
- A child is a person that is between 1 – 5 years old.

2 Anemia

Bakhtiar, U.J., Khan, Y., & Nasar, R. (2007). Relationship between maternal hemoglobin and perinatal outcome. *Rawal Medical Journal*, 32(2), 102-104.

Summary – This study evaluated the impact of anemia in pregnant women on babies, shortly before and after birth. The study showed that anemia in mothers was related to premature birth,

low birth weight, slowed growth of the fetus, and death of the baby. Babies born to women with anemia had more than three times the death rate in the perinatal period (a few days before or after birth). Pregnant women with anemia had more than three times the risk of giving birth to a premature baby.

CAWST Analysis - The results of this study highlight the importance of anemia to pregnant women and their babies.

Balarajan, Y., Ramakrishnan, U., Özaltın, E., Shankar, A.H., & Subramanian, S.V. (2011). Anaemia in low-income and middle-income countries. *The Lancet*, 378, 2123–2135. doi:10.1016/S0140-6736(10)62304-5

Summary – This is an overview article about anemia that notes that children and women of reproductive age are most at risk of anemia. The article notes that globally 47% of children younger than five years of age are anemic as are 42% of pregnant women. It also points out that Africa and Asia account for more than 85% of the anemia burden in high risk groups, and that anemia is estimated to contribute to more than 115,000 maternal deaths and 591,000 deaths of babies globally each year. The effects of chronic anemia include loss of productivity from reduced work capacity, learning impairment, and increased susceptibility to infection. This leads to a substantial economic burden. The analysis found that anemia has many causes, including infection with soil transmitted helminths.

Black, R.E., Allen, L.H., Bhutta, Z.A., Caulfield, L.E., de Onis, M., . . . Rivera, J. (2008). Maternal and child undernutrition: global and regional exposures and health consequences. *The Lancet*, 371, 243–260. doi:10.1016/S0140-6736(07)61690-0

Summary – This study estimates the effects of maternal and child undernutrition on disease and death rates. It concludes that diarrhea is a very important risk for stunting; that stunting increases diarrhea-related deaths of children; and that both stunting and anemia increase maternal death rates.

Radlowski, E.C. & Johnson, R.W. (2013). Perinatal iron deficiency and neurocognitive development. *Frontiers in Human Neuroscience*, 7:585. doi: 10.3389/fnhum.2013.00585

Summary – Maternal anemia during pregnancy is a problem for the fetus because iron is needed for proper development of the brain. Maternal anemia also increases the risk of low birth weight either due to premature birth or growth restriction. Low birth weight is associated with delayed intellectual development and psychiatric illness.

3 Hepatitis E

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.

Summary – During a hepatitis E (HEV) outbreak in the Dadaab Refugee Camp 13% of pregnant women with HEV died. In comparison, 3% of HEV patients died overall.

CAWST Analysis – There was a delay of almost a month between implementation of WASH activities and a reduction in cases. This is consistent with the incubation period for HEV which is 15 to 60 days. This study shows the importance of having good WASH to **prevent** outbreaks rather than just responding to outbreaks.

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

Summary – Hepatitis E (HEV) study of pregnant women in Kathmandu, Nepal. HEV increased death rates in the mother and risks of premature birth and/or low birth weight for the baby: 20% of the pregnant women died, 53% of the births were premature, and 33% of newborns had low birth weight. The maternal mortality rate in Nepal is about 190 women per 100,000 live births. In this study, the maternal mortality rate was 100 times higher for pregnant women with Hepatitis E.

Gurley, E.S., Halder, A.K., Streatfield, P.K., Sazzad, H.M., Huda, T.M., Hossain, M.J., & Luby, S.P. (2012). Estimating the burden of maternal and neonatal deaths associated with jaundice in Bangladesh: possible role of hepatitis E infection. *American Journal of Public Health*, 102(12), 2248-2254. doi: 10.2105/AJPH.2012.300749

Summary – Study estimated the rates of maternal and neonatal (newborn) death associated with hepatitis E (HEV) in Bangladesh and found that about 20% of all maternal deaths and 10% of all neonatal deaths were the result of hepatitis in pregnant women. The study also found that for those maternal hepatitis deaths, 58% were from HEV.

CAWST Analysis – HEV is a major cause of maternal death in Bangladesh and other countries where outbreaks occur.

Guthmann, J.P., Klovstad, H., Boccia, D., Hamid, N., Pinoges, L., Nizou, J.Y., . . . Guerin, P.J. (2006). A large outbreak of hepatitis E among a displaced population in Darfur, Sudan, 2004: the role of water treatment methods. *Clinical Infectious Disease*, 42(12), 1685–1691.

Summary – This study investigated a large outbreak of hepatitis E (HEV) infection in a displaced persons camp in Darfur, Sudan. HEV infection risk factors included (a) sometimes collecting water from the river (67% increase in HEV) and (b) drinking chlorinated surface water (more than double the risk compared to using water from boreholes).

CAWST Analysis – This study raises the question of whether higher free chlorine levels are needed to kill HEV. A free chlorine residual in water of at least 1.0 mg/L should be maintained during HEV outbreaks. Surface water, even when treated, is likely a greater risk for transmission of HEV. In this study, using a latrine and washing hands did not reduce HEV rates. This indicates that drinking contaminated water was probably the primary transmission route.

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

Summary – This study looked at urban slum areas during a reported hepatitis outbreak. 77% of hepatitis cases were Hepatitis E (HEV). Pregnant women with hepatitis were almost five times as likely to die and more than twice as likely to suffer a spontaneous abortion (miscarriage). Newborns were almost three times as likely to die shortly after birth.

CAWST Analysis – Even moderate levels of fecal coliform bacteria in the tap water were associated with the contamination of the urban water system with hepatitis. This demonstrates the importance of household water treatment, even for piped water supplies.

Pelosi, E. & Clarke, I. (2008). Hepatitis E: a complex and global disease. *Emerging Health Threats Journal*, 1:e8. doi:10.3134/ehthj.08.008

Summary – This article discusses the global Hepatitis E (HEV) situation, including risks and sensitive groups. The article highlights the importance of water and sanitation to prevent HEV outbreaks and states that HEV in Africa and Asia results in high death rates of pregnant women. Other impacts include: increased rates of spontaneous abortion (miscarriage), premature birth, stillbirth, and death of the newborn after birth.

CAWST Analysis – This article notes that HEV is different than Hepatitis A because direct person-to-person transmission is uncommon.

Rayis, D.A., Jumaa, A.M., Gasim, G.I., Karsany, M.S., & Adam, I. (2013). An outbreak of hepatitis E and high maternal mortality at Port Sudan, Eastern Sudan. *Pathogens and Global Health*, 107(2), 66-68. doi: 10.1179/2047773213Y.0000000076

Summary – This is a study of pregnant women during a Hepatitis E (HEV) outbreak in Sudan. 28% of the HEV infected pregnant women died (more than 70 times the normal maternal mortality rate in Sudan). 36% of fetuses died prior to birth. 23% of the newborns of the HEV positive mothers were premature births.

CAWST Analysis – Pregnant women should be particularly careful about WASH practices so as to avoid HEV, particularly relative to drinking water.

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.

Summary – This is a study of a Hepatitis E (HEV) outbreak that began during the rainy season in 2012 at four refugee camps in South Sudan. HEV infection led to high death rates for pregnant women of 10.4%. Pregnant women had a risk of death from HEV that was about 4.8 times higher than non-pregnant women, in the three most affected camps.

CAWST Analysis - The best approach in areas that have a history of HEV outbreak is for women of childbearing age to always drink treated water, using a multi-barrier approach. The authors noted that “implementing outbreak control measures in displaced persons camps often

is extremely challenging” but that, despite the challenges, targeted WASH interventions remain the main strategy to interrupt HEV transmission.

Vyas, S., Parikh, S., Kapoor, R., Patel, V, & Solanki, A. (2010). Investigation of an epidemic of hepatitis in Ahmedabad city. *National Journal of Community Medicine*, 35(2), 294-297.

Summary – In this study, they conducted a household survey, during an urban outbreak of hepatitis. Blood testing proved that Hepatitis E (HEV) was the cause of the outbreak. Infected individuals were fifteen times more likely to drink turbid water than clear water. The turbid water came from a piped water supply. Women of childbearing age were much more likely to be infected with HEV than girls less than 12 years old.

CAWST Analysis – HEV can be transmitted in piped water supplies. Contamination can be due to cross connections with sewage, especially when system pressure is low or flow is intermittent. Turbid water can shield the virus from chlorine or other disinfection methods in piped water supplies.

4 Helminths

Boel, M., Carrara, V.I., Rijken, M., Proux, S., Nacher, M., Pimanpanarak, M., . . . McGready, R. (2010). Complex Interactions between Soil-Transmitted Helminths and Malaria in Pregnant Women on the Thai-Burmese Border. *PLOS Neglected Tropical Diseases*, 4(11), e887. doi:10.1371/journal.pntd.0000887

Summary – This study evaluated the connections between soil-transmitted helminth infections and anemia in pregnant women. Pregnant women infected with the hookworm (a soil transmitted helminth) had more than double the risk of anemia. Hookworm infection in the mother was also associated with 80% increased risk of a low birth weight newborn. In 2007, 62% of pregnant women were infected with at least one type of helminth. The study found that the severity of anemia was greater when pregnant women infected with a soil-transmitted helminth were also infected with malaria.

CAWST Analysis – The benefits of routine deworming of pregnant women is unclear, with different studies presenting different results. In this study, the authors state that it is unclear whether deworming would benefit pregnant women, but they did find there were clear negative impacts to pregnant women from hookworm infection (e.g., increase in anemia). Because of the impact of sanitation on reducing hookworm infections, these women would likely have benefited from improved sanitation.

Hotez, P.J. & Kamath, A. (2009). Neglected Tropical Diseases in Sub-Saharan Africa: Review of their Prevalence, Distribution, and Disease Burden. *PLOS Neglected Tropical Diseases*, 3(8), e412. doi:10.1371/journal.pntd.0000412

Summary – This study was a review of soil-transmitted helminths, trachoma and other tropical diseases in Africa. Hookworm (a soil transmitted helminth) is an important cause of anemia and illness in pregnant women in sub-Saharan Africa. Up to one-third of pregnant women (some 7 million women), in the region, are infected with hookworm, and this is a leading cause of anemia for them. Hookworm is also a leading cause of anemia among children. Among school aged

children in Zanzibar, 35% of anemia and 73% of severe anemia was due to hookworm. Hookworm infection in pregnant women was associated with low birth weight. There was an 81% increased risk of a woman with hookworm having a low birth weight newborn.

CAWST Analysis – The article points out that there is little data on some very important waterborne protozoan infections, e.g., amoebiasis, toxoplasmosis and bacterial infections such as typhoid fever and non-typhoidal salmonellosis. The article also notes that the study of toxoplasmosis has been neglected in sub-Saharan Africa, but that investigations conducted in Sudan and Burkina Faso “indicate a high seroprevalence among pregnant women”. A high seroprevalence means that many pregnant women have been exposed to toxoplasmosis. Schistosomiasis causes anemia and may increase HIV transmission rates. Schistosomiasis prevention includes improved WASH. Improved WASH (especially sanitation) is a critical part of reducing hookworm infections.

Rodriguez-Morales, A.J., Barbella, R.A., Case, C., Arria, M., Ravelo, M., Perez, H., . . . Rifakis, P. (2006). Intestinal Parasitic Infections among Pregnant Women in Venezuela. *Infectious Diseases in Obstetrics and Gynecology*, 2006:23125, 1–5.
doi.org/10.1155/IDOG/2006/23125

Summary – This is a study of the impact of parasite infections on the risk of anemia risks in pregnant women. Infection with WASH-related parasites greatly increased anemia rates in pregnant women.

5 Cholera

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

Summary – In 2009, cholera was detected in the north of Cameroon and the reported case fatality rate was very high - 12%. (WHO states that with proper treatment the case fatality rate should remain below 1% during cholera outbreaks.) Pregnant women were more than twice as likely to die from cholera as non-pregnant women of similar age.

Ciglonecki, I., Bichet, M., Tena, J., Mondesir, E., Bastard, M., Tran, N., . . . Staderini, N. (2013). Cholera in Pregnancy: Outcomes from a Specialized Cholera Treatment Unit for Pregnant Women in Léogâne, Haiti. *PLOS Neglected Tropical Diseases*, 7(8), e2368.
doi:10.1371/journal.pntd.0002368

Summary – This study looked at the impact of cholera infection in pregnant women on the risk of death of the fetus. The risk of death of the fetus was associated with the severity of the cholera episode. The strongest risk factor for fetal death was severe maternal dehydration followed by severe vomiting. In this study, severe dehydration of the mother due to a severe case of cholera resulted in more than a nine times greater risk of death of the fetus.

Hirschhorn, N., Chowdhury, A.K.M.A., & Lindenbaum, J. (1969). Cholera in pregnant women. *The Lancet*, 293(7608), 1230-1232. doi:10.1016/S0140-6736(69)92115-1

Summary – In this study, in Pakistan, 50% of pregnant women in their third trimester infected with cholera had stillborn babies. Cholera in the third trimester was associated with significantly greater dehydration. In this study, the rate of stillbirth was ten times higher than the average rate of stillbirths in Pakistan.

6 Cryptosporidium, Giardia, Toxoplasma, and Entamoeba Histolytica

Ertug, S., Okyay, P., Turkmen, M., & Yuksel, H. (2005). Seroprevalence and risk factors for *toxoplasma* infection among pregnant women in Aydin province, Turkey. *BMC Public Health*, 5(66). doi:10.1186/1471-2458-5-66

Summary – This is a study of risk factors for *Toxoplasma* infection in pregnant women in Aydin, Turkey (population of about 1 million). Pregnant women who drank municipal, piped water were about twice as likely to have antibodies to *Toxoplasma* than pregnant women who drank bottled water.

CAWST Analysis – The municipal network water in Aydin is collected “from open springs next to a few villages”. Because *Toxoplasma* is resistant to chlorine, municipal water systems that do not practice effective filtration can be a source of toxoplasmosis in pregnant women, with the significant impacts for the fetus and child. This is true even for large systems such as Aydin, a city of one million people.

Galvan-Ramirez, M.d.I.L., Troyo, R., Roman, S., Calvillo-Sanchez, C., & Bernal-Redondo, R. (2012). A systematic review and meta-analysis of *Toxoplasma gondii* infection among the Mexican population. *Parasites and Vectors*, 5:271.

Summary – Comparisons among different risk groups showed that the rate of toxoplasmosis was higher in women with spontaneous abortions (36%) [miscarriage] than in either the general population or pregnant women (16%) as a whole.

CAWST Analysis – This meta-analysis indicates that toxoplasmosis is likely a significant cause of spontaneous abortions (miscarriages) in Mexico.

Gebremedhin, E.Z., Abebe, A.H., Tessema, T.S., Tullu, K.D., Medhin, G., Vitale, M., . . . Dorny, P. (2013). Seroepidemiology of *Toxoplasma gondii* infection in women of child-bearing age in central Ethiopia. *BMC Infectious Diseases*, 13(101).

Summary – The study was conducted with the goals of estimating the rates and potential risk factors for toxoplasmosis by women of child-bearing age in Central Ethiopia. Not handwashing after handling raw meat or using well or river water (compared to tap water) were risk factors. Rates of toxoplasmosis were twice as high in pregnant women as women of a similar age.

CAWST Analysis – WASH is important to the prevention of toxoplasmosis during pregnancy. It should include filtering water (or the equivalent) for removing any *Toxoplasma* oocysts (egg like

forms) in drinking water. *Toxoplasma* oocysts are larger than *Cryptosporidium* oocysts and are also resistant to chlorine. Therefore WASH steps to control cryptosporidiosis should also prevent toxoplasmosis.

Masungu, P., Dube, T. & Makaka, C. (2010). A survey of the diversity of human enteric protoctistan parasites and the associated risk factors in urban Zvishavane, Zimbabwe. *Agriculture and Biology Journal of North America*, 1(5), 985-991.
doi:10.5251/abjna.2010.1.5.985.991

Summary – Infection rates were higher in high density areas than in low density areas. “Risk factors included age, host density, pregnancy, infection by HIV, or recent surgery.”

CAWST Analysis – *Cryptosporidium* and *Giardia* were detected in the drinking water during the rainy season (October to February), but not during the dry season. *Cryptosporidium* contamination of the urban water supply in a country with high HIV rates is a serious public health problem as the impact on people living with HIV/AIDS results in chronic diarrhea and increased mortality, including pregnant women and young children.

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

Summary – Toxoplasmosis infections during pregnancy can be passed on to the fetus. This can result in visual and hearing loss, seizures, blood problems, or death of the newborn. Toxoplasmosis can result from undercooked meat or contaminated food or water. Toxoplasmosis in pregnant women usually goes unnoticed because of the lack of symptoms. Although most infants appear to be healthy at birth, important problems may become obvious months or years later.

CAWST Analysis – WASH is important to the prevention of toxoplasmosis during pregnancy. It should include filtering water (or the equivalent) for removing any *Toxoplasma* oocysts (egg like forms) in drinking water. *Toxoplasma* oocysts are larger than *Cryptosporidium* oocysts and are also resistant to chlorine. Therefore WASH steps to control cryptosporidiosis should also prevent toxoplasmosis.

Wainwright, K.E., Miller, M.A., Barr, B.C., Gardner, I.A., Melli, A.C., Essert, T., . . . Conrad, P.A. (2007). Chemical inactivation of *Toxoplasma gondii* oocysts in water. *The Journal of Parasitology*, 93, 925-931.

Summary – This study evaluated whether free chlorine at high levels (levels greater than 50 times higher than typical for chlorination) for 24 hours would kill (inactivate) *Toxoplasma gondii*. All mice became infected with *Toxoplasma gondii* even after the water was disinfected with high doses of chlorine. This demonstrated that chlorine was not effective at killing *Toxoplasma gondii*.

CAWST Analysis – WASH is important to the prevention of toxoplasmosis during pregnancy. It should include filtering water (or the equivalent) for removing any *Toxoplasma* oocysts (egg like

forms) in drinking water. *Toxoplasma* oocysts are larger than *Cryptosporidium* oocysts and are also resistant to chlorine. Therefore WASH steps to control cryptosporidiosis should also prevent toxoplasmosis.

7 Schistosomiasis

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

Summary – Evidence increasingly suggests that female genital schistosomiasis increases the risk of HIV infection.

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

Summary – Schistosomiasis affects about 10 million women in Africa. Pregnant women and children are at high risk. Pregnant women develop severe anemia, have low birth weight infants, higher rates of spontaneous abortions (miscarriages), and an increased infant and maternal death rate. Schistosomiasis effects include anemia, malnutrition, and severe fatigue. It also results in reduced physical fitness and intellectual growth.

CAWST Analysis – Open defecation contaminates stagnant waters leading to schistosomiasis. Improved sanitation greatly reduces rates of this disease. Treating water for use in the household reduces exposure. Health messages should warn families that children swimming in stagnant waters in affected areas are at risk. Women and children (peaking at age 10 to 19 years) are at high risk. Children play in water and women use water for their daily chores, increasing the risk of infection.

8 Arsenic

Ahmad, S.A., Sayed, M.H., Barua, S., Khan, M.H., Faruquee, M.H., Jalili, A., . . . Talukder, H.K. (2001). Arsenic in drinking water and pregnancy outcomes. *Environmental Health Perspectives*, 109(6), 629-631.

Summary – Rates of spontaneous abortion (miscarriage), stillbirth, and premature birth were two to three times higher in pregnant women exposed to arsenic than women who were not exposed to arsenic. The rates of poor pregnancy outcomes were higher among women who had been drinking arsenic contaminated water for more than fifteen years compared to less than fifteen years.

CAWST Analysis - Pregnant women are more sensitive to contaminated water than other people. The study found that the longer women drink arsenic contaminated water prior to the pregnancy, the more likely that it will cause problems during pregnancy. In high arsenic areas, safe water for pregnant women is a priority.

Farzan, S., Korrick, S.A., Li, Z., Enelow, R., Gandolfi, A.J., Madan, J., . . . Karagas, M. (2013). In utero arsenic exposure and infant infection in a United States cohort: A prospective study. *Environmental Research*, 126, 24–30. doi:10.1016/j.envres.2013.05.001

Summary – This study investigated how exposure to arsenic by the fetus (in-the-womb) affects health risks to infants after birth. Arsenic exposure was associated with infant's respiratory symptoms, upper respiratory infections, and colds. Higher concentrations of arsenic in a pregnant woman's urine were associated with respiratory symptoms (four times the risk), upper respiratory infections (60% increase in risk), and colds treated with prescription medication (more than double the risk) in the infant.

CAWST Analysis - Drinking water arsenic concentrations were relatively low, they averaged 5 ppb (range 0.01–67.5 ppb) so this study is potentially relevant to a number of countries. Women who are or plan on becoming pregnant should know the arsenic level in their water source. If the level is high, they should either switch sources or use arsenic removal technology for cooking and drinking water.

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.

Summary – In this study, much higher risks for spontaneous abortion (miscarriage) and stillbirths occurred among pregnant women exposed to high concentrations of arsenic in drinking water. Women who drank water with arsenic greater than 50 ppb (the Bangladesh standard) had the following increased risks: more than double the rates of spontaneous abortion (miscarriage) and stillbirths, and 80% higher risk of death of the newborn.

Naujokas, M.F., Anderson, B., Ahsan, H., Aposhian, H.V., Graziano, J.H., Thompson, C., & Suk, W.A. (2013). The Broad Scope of Health Effects from Chronic Arsenic Exposure: Update on a Worldwide Public Health Problem. *Environmental Health Perspectives*, 121(3), 295-302. doi: 10.1289/ehp.1205875

Summary – This article reviewed recent information on the many different health impacts of arsenic, and focuses on the impact of arsenic during pregnancy and early life. There is increasing awareness that arsenic might be affecting more people and increasing disease more than previously thought.

CAWST Analysis – Natural arsenic contamination of drinking water from wells is common in many countries, particularly in Asia and Latin America.

Rahman, A., Vahter, M., Ekström, E.C., & Persson, L.Å. (2010). Arsenic Exposure in Pregnancy Increases the Risk of Lower Respiratory Tract Infection and Diarrhea during Infancy in Bangladesh. *Environmental Health Perspectives*, 119, 719–724. doi:10.1289/ehp.1002265

Summary – This is a study of the relationship between pre-natal arsenic exposure and rates of lower respiratory tract infection and diarrhea, in the child after birth. The risk of lower respiratory tract infection increased by 69%, severe lower respiratory tract infection increased by 54%, and diarrhea by 20% in infants. These were infants born to mothers with high levels of arsenic in their urine: the highest 20% (versus the lowest).

Sen, J. & Chauduri, A.B.D. (2008). Arsenic exposure through drinking water and its effect on pregnancy outcome in Bengali women. *Archives of Industrial Hygiene and Toxicology*, 59, 271-275. doi:10.2478/10004-1254-59-2008-1871

Summary – In this study, they collected data from pregnant women living in arsenic-affected villages. The comparison or control group was pregnant women in a village with arsenic levels in drinking water less than 10 ppb. Pregnant women in the arsenic-affected villages had an average of 70% higher rates of stillbirths and more than double the rate of spontaneous abortions (miscarriages). One of the arsenic-affected villages only had levels from 10 to 80 ppb, and still experienced more than double the rates of stillbirths and spontaneous abortions (miscarriages).

Sohel, N., Vahter, M., Ali, M., Rahman, M., Rahman, A., Streatfield, P.K., . . . Persson, L.Å. (2010). Spatial patterns of fetal loss and infant death in an arsenic-affected area in Bangladesh. *International Journal of Health Geographics*, 9:53. doi:10.1186/1476-072X-9-53

Summary – This study identified the relationship between spontaneous abortions (miscarriage) and/or infant deaths and areas of high and low arsenic concentrations in tube-well water used for drinking. The study found a 42% higher risk of miscarriage and infant death in areas with high arsenic levels when compared to lower arsenic level areas.

9 Handwashing and Hygiene

Rhee, V., Mullany, L.C., Khatry, S.K., Katz, J., LeClerq, M.P.H., Darmstadt, M.D., & Tielsch, J.M. (2008). Impact of Maternal and Birth Attendant Hand-washing on Neonatal Mortality in Southern Nepal. *Archives of Pediatrics and Adolescent Medicine*, 162(7), 603–608.

Summary - The objective of this study was to estimate the impact of handwashing by birth attendants and mothers on death rates of newborns (first seven days) in rural Nepal. Death rates were significantly lower for newborns whose birth attendant and/or mother washed their hands with soap and water. Newborns whose birth attendant washed hands before assisting with delivery had a 25% lower risk of death. The risk of newborn death was 17% lower among newborns whose mothers sometimes or always washed hands with soap and water before handling their child. The risk of newborn death was 30% lower when both birth attendant and mothers practiced handwashing. The benefits of handwashing were greater among newborns living in households with low economic status, were born with low birth weight, or were born prematurely.

CAWST Analysis – Handwashing is commonly included in WASH messages. Educating mothers and birth attendants about the importance of handwashing and how and when to wash their hands is important.

Sheth, A.N., Russo, E.T., Menon, M., Wannemuehler, K., Weinger, M., Kudzula, A.C., . . . Quick, R. (2010). Impact of the Integration of Water Treatment and Handwashing Incentives with Antenatal Services on Hygiene Practices of Pregnant Women in Malawi. *American Journal of Tropical Medicine and Hygiene*, 83(6), 1315-1321.

Summary – This study evaluated a pre-birth clinic-based program as a new strategy for promoting water treatment and hygiene among pregnant women. It found that including water treatment and handwashing education and products with the existing pre-birth care system resulted in significant improvements in the use of water treatment and hygiene at home.

CAWST Analysis – This study highlights one of the many ways in which the WASH and health sectors can work together for positive results. Such cooperation can be especially beneficial to pregnant women because of their greater vulnerability to WASH-related infections.

10 Climate Change

Rylander, C., Odland, J.Ø., & Sandanger, T.M. (2013). Climate change and the potential effects on maternal and pregnancy outcomes: an assessment of the most vulnerable - the mother, fetus, and newborn child. *Global Health Action*, 6:19538. doi: 10.3402/gha.v6i0.19538

Summary – This article states that climate change will increase the risk of infant and maternal death and birth complications by increasing flooding in some areas, causing fecal contamination of water supplies. In addition, warmer temperatures increase growth rates of bacteria and can also increase rates of dehydration, which can be deadly.

CAWST Analysis - In the future, WASH will be even more important due to climate change. Pregnant women, fetuses and newborns are vulnerable groups, so it's important to anticipate how communities will need to adapt to address growing WASH concerns, in affected regions.

11 Additional Resources

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

- Health and WASH: WASH-related diseases and their impact on health.
- General WASH: household water treatment and safe storage, community WASH promotion, environmental sanitation, latrine design and selection, and handwashing.

PMNCH (2014). PMNCH Knowledge Summary #30 Water, sanitation and hygiene - the impact on RMNCH.

- 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.

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